DOT/FAA/AR-96/125

Office of Aviation Research
Washington, D.C. 20591

Video Landing Parameter Survey—John F. Kennedy International Airport

Thomas DeFiore
Richard Micklos
Federal Aviation Administration
Airworthiness Assurance Research and Development Branch
William J. Hughes Technical Center
Atlantic City International Airport, NJ

July 1997

Final Report

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U.S. Department of Transportation
Federal Aviation Administration

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/AR-96/125		

4. Title and Subtitle	5. Report Date
VIDEO LANDING PARAMETER SURVEY—JOHN F. KENNEDY INTERNATIONAL AIRPORT	July 1997
	6. Performing Organization Code AAR-432
7. Author(s) *Terence Barnes, Thomas DeFiore, Richard Micklos	8. Performing Organization Report No. DOT/FAA/AR-96/125
9. Performing Organization Name and Address *Naval Air Warfare Center Aircraft Division Patuxant River, MD Federal Aviation Administration Airworthiness Assurance Research and Development Branch William J. Hughes Technical Center Atlantic City International Airport New Jersey 08405	10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Office of Aviation Research Washington, DC 20591	13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code

15. Supplementary Notes

This video landing parameter survey was conducted jointly by personnel from the William J. Hughes Technical Center and the Naval Air Warfare Center, Aircraft Division, Patuxant River, MD. The FAA Technical Manager was Thomas DeFiore, AAR-432.

16. Abstract

The Federal Aviation Administration William J. Hughes Technical Center is conducting a series of video landing parameter surveys at high-capacity commercial airports to acquire a better understanding of typical contact conditions for a wide variety of aircraft and airports as they relate to current aircraft design criteria and practices.

The initial parameter landing survey was conducted at John F. Kennedy (JFK) International Airport in June 1994. Four video cameras were temporarily installed along the north apron of runway 13L. Video images of 614 transport (242 wide-body, 264 narrow-body, and 108 commuter aircraft) were captured, analyzed, and the results presented herein. Landing parameters presented include sink rate; approach speed; touchdown pitch, roll, and yaw angles and rates; off-center distance; and the distance from the runway to the threshold. Wind and weather conditions were also recorded and landing weights were available for most landings. Since this program is only concerned with the overall statistical usage information, all data were processed and are presented without regard to the airline or the flight number.

Subsequent surveys have been conducted at Washington National runway 36 and at Honolulu International runway 8L, and these results will be reported in future technical reports.

17. Key Words	18. Distribution Statement
Landing parameters, Sink rate, Approach velocity, Pitch, Roll, and Yaw angles and rates	This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	65	N/A

Form DOT F1700.7 (8-72) Reproduction of completed page authorized

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EXECUTIVE SUMMARY

The Federal Aviation Administration William J. Hughes Technical Center is conducting a series of video landing parameter surveys at high-activity commercial airports to acquire a better understanding of typical landing contact conditions for a wide variety of aircraft and airports as they relate to current aircraft design criteria and practices.

The initial landing parameter survey was conducted at John F Kennedy (JFK) International airport in June 1994. Four video cameras were temporarily installed along the north apron of runway 13L. Video images of 614 transports (242 wide-body, 264 narrow-body, and 108 commuter aircraft) were captured, analyzed, and the results presented herein. Landing parameters presented include sink rate; approach speed; touchdown pitch, roll, and yaw angles and rates; off-center distance; and the distance from the runway threshold. Wind and weather conditions were also recorded and landing weights were available for most landings. Since this program is only concerned with overall statistical usage information, all data were processed and are presented without regard to the airline or flight number.

Subsequent surveys have been conducted at Washington National runway 36 and at Honolulu International runway 8L, and these results will be reported in future technical reports.

1. INTRODUCTION.

In an effort to better understand and document the actual operational environment of commercial jet transport aircraft landing impact conditions, the Federal Aviation Administration William J. Hughes Technical Center initiated a series of aircraft video landing parameter surveys at high-activity commercial airports. 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 a valuable resource in developing design requirements for future jet transports.

The use of image data to evaluate the landing performance of aircraft has been used since jet aircraft were introduced. The US Navy developed a system to characterize the typical carrier landing environment and develop and implement procedures to make carrier arrested landings safer. The Navy developed a system to acquire aircraft landing and approach data from the tracking and analysis of recorded 16-mm film images of the arrestment. The basic concept was developed in 1947 [1]. The National Aeronautics and Space Administration (NASA), in 1954, developed a similar system using a 35-mm camera and conducted a number of surveys of commercial airplanes, the last one in 1959 [2-7]. The significant difference between the two systems was that the Navy photographed from a head-on aspect along the runway apron, while NASA's camera was positioned perpendicular to the runway, approximately 900 feet from the runway center line.

In 1967, the Navy enhanced its system by replacing the 16-mm cameras with 70-mm cameras. This provided considerably greater image resolution and consequently greater accuracy [8]. Using these systems, the Navy conducted over 40 landing parameter surveys and has an active carrier landing survey program. However, the data reduction phase of the research was labor intensive and limited the number of surveys which could be conducted. The search for a new improved system was concluded in 1992 when the 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 9 and 10. Shortly thereafter, the Federal Aviation Administration (FAA) and the Navy established an interagency agreement to transition this newly developed video technology to commercial operations [11].

Preliminary results from this work were presented at the 1995 ICAF Symposium [12], the 1995 FAA Airports Conference [13], the 1995 International Society of Air Safety Investigators Conference [14], and the 1995 USAF ASIP Conference [15].

The FAA landing parameter survey program is being conducted 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 1950s, (2) provide detailed characterization of typical transport airplane landing velocities and angular displacements, and (3) determine if there is a trend towards higher sink rates at higher gross weights.

The first commercial aircraft video landing survey was conducted at John F. Kennedy International Airport (JFK) in New York to collect large quantities of wide-body jet aircraft data.

The prior NASA surveys collected only data from narrow-body B-707 and DC-8 airplanes. It has been suggested that typical sink rates increase with airplane weight. Data from these surveys could be useful in the design and certification of a very large transport aircraft.

This report documents the findings from the initial FAA landing parameter survey performed at the JFK airport. The data were collected on runway 13 left (13L) over a two-week period in June 1994.

Video images of aircraft landing on runway 13L were recorded by a series of four cameras temporarily installed on the edge of the runway. 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 William J. Hughes Technical Center.

Since the primary goal of this survey 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.

Recent developments in video technology have permitted the Navy to transition its landing parameter data analysis system from using photographic film to one using video technology. The Navy video system is known as the Naval Aircraft Approach and Landing Data Acquisition System, NAALDAS. 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 using 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, but more efficient than the 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 the commercial application, the FAA funded the design and development of a modified, multiple-camera configuration of NAALDAS using four video cameras located along the edge of the runway. The images from these cameras are recorded sequentially as the aircraft passes through their field of view. This modification expands the system coverage area to 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, Atlantic City International Airport (ACY), New Jersey. Figure 1 shows a camera in operation on a commercial runway.

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

The video cameras are installed on the edge of the runway, usually facing toward the approaching aircraft. The cameras are located approximately 500 feet apart, starting 1000 feet from the end of the runway, and usually located in line with the runway edge lights, which at Atlantic City International Airport are approximately 110 ft off the runway center line. The camera is aimed at the center of the targeted touchdown area. The camera's aim is fixed and does not track the aircraft. Figure 2 is a schematic of the multiple camera configuration.

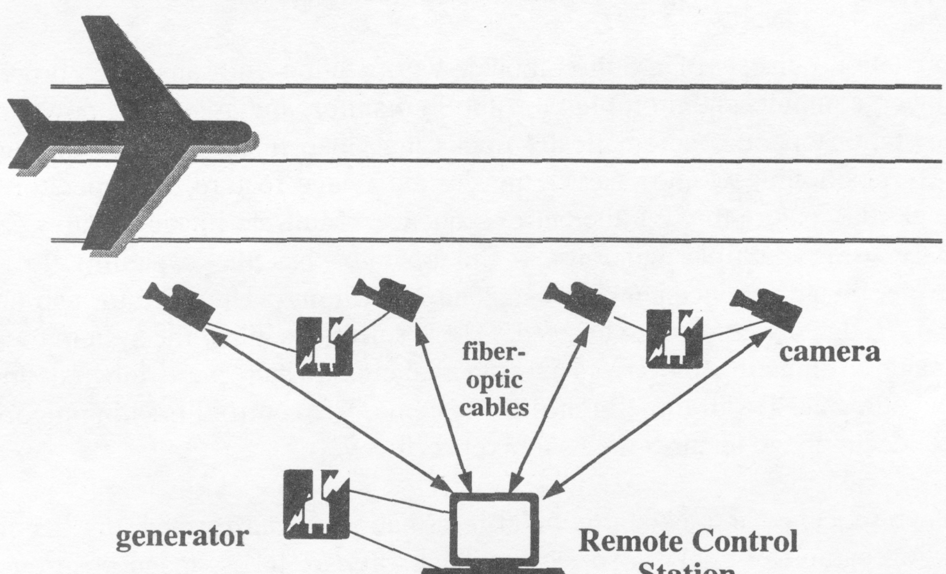


FIGURE 2. FAA LANDING LOADS CAMERA SETUP

The NAALDAS video cameras have a fixed field of view. Each camera is aligned and calibrated against targets which are placed on the runway for that purpose. These targets are placed in surveyed locations, and the target images are recorded as a calibration sequence. This sequence is processed to generate a transformation matrix to relate image measurements to the runway.

The NAALDAS data recording system is operated from a vehicle parked in a safe location near the touchdown region of the survey runway. Judicious selection of this parking location is required to prevent any interference with airport operations. At ACY and JFK this was 350 ft from the runway center line. Temporary cabling is run from the vehicle to the cameras and the vehicle remains in the chosen location during flight operations. The system is powered entirely with portable electrical generators. NAALDAS is limited to coverage of one end of a runway and cannot be relocated to accommodate runway changes. This restriction exists since the cameras must be precisely aimed and recalibrated if they are relocated, which requires the runway be closed.

The aircraft image is captured on an optical laser disk recorder for subsequent analysis on the NAALDAS analysis system work station. Approximately 60 landings can be stored on a disk. An identity number is assigned to the disk, and event numbers are assigned to each video sequence. The use of video disks eliminates film processing cost and time.

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

The analysis station consists of a Sun computer work station 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. By positioning windows over the desired image feature, the operator prepares the system to track that feature through the entire sequence. Multiple-image features can be tracked simultaneously using multiple windows. The operator has the capability to select image threshold levels, image enhancement formats, and algorithms. The operator can also select the type of tracking (edge or centroid) to be used. These selections allow the system to automatically track the image, eliminating the errors in data reduction which were inherent in the manual tracking procedures used with the 70-mm film system. The centroid tracking algorithm enables the system to locate image features with subpixel accuracy.

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 at a rate of 30 frames per second, and generates position time curves for the feature.

The system demonstration at the William J. Hughes Technical Center in February 1994 confirmed the ability of NAALDAS to collect landing data in adverse weather conditions. This was not possible with the 70-mm film system, and the successful video recording of a series of landings under instrument landing system conditions in a snow storm with 15-knot crosswinds showed the versatility and durability of the new recording system.

In addition to the video images, from which the ground contact parameters are derived, other data describing each landing are collected during the video survey to determine which set of geometric data to use in the analysis. Detailed hourly weather summaries are also obtained, and an estimate of the touchdown landing weight is provided by the operators.

3. DISCUSSION.

A total of 621 landings from the survey at the JFK International Airport were processed. A total of 506 jet transport aircraft landings were analyzed, along with 108 turbo prop commuter aircraft, and seven landings of the Concorde supersonic transport.

The video landing survey data acquisition equipment was installed on the north side of runway 13L, a 150-foot-wide, 10,000-foot-long runway. This runway was selected after reviewing historical landing runway operations data and determining that suitable camera positions were available. Once the survey cameras were installed and calibrated, they cannot be moved to adjust to changes in operation caused by wind shifts. Unfortunately, during the survey the winds frequently favored operations on the other set of parallel runways, and a large number of wide-body jets landed on runway 22L.

During peak operating periods, the very high volume of flight operations at the JFK International Airport makes it necessary for aircraft to land on two runways. The airport has two sets of two parallel runways; these runway pairs are perpendicular to each other. Since one runway was used primarily for takeoffs (either runway 13R or 22R depending on wind conditions), the second landing runway used for landings can experience significant crosswinds (some of the landings videoed during the survey occurred with over 20-knot crosswind components). During this survey, runway 13L was subject to many of these crosswind landing conditions. This situation existed daily, thus it was a real world operational environment and as the sink speed data indicate, resulted in some interesting observations. The approach to runway 13L also required a right turn onto final approach and this may have contributed to some of the variation observed in the landing parameters.

The analysis of image data provided the aircraft's closure speed with respect to the camera. The reported value of approach speed is the sum of closure speed and the component of wind parallel to the center line of the runway. The wind speed and direction information from the hourly summaries were used to calculate the approach speed.

Landing parameters for 242 wide-body jet transports, 264 narrow-body transports, and 108 commuter aircraft landings were calculated. In addition, data from seven Concorde landings were also processed. Table 1 summarizes the primary landing parameters determined by this survey. The table provides the mean and standard deviation and the number of observations for selected landing parameters by aircraft model. Scatter plots of aircraft sink speed versus landing weight and approach speed versus landing weight are presented in figures 3 and 4.

TABLE 1. SURVEY PARAMETER COMPARISON BY AIRCRAFT MODEL

NARROW-BODY JET TRANSPORTS										
Aircraft Model	Number of Events		Engaging Speed	Approach Speed	Sink Speed	Pitch Angle	Roll Angle	Yaw Angle	Runway Off-Center Distance
A-310	3	Mean	135.1	138.8	2.16	6.23	0.97	-4	2.33
		Std. Dev.	10.27	13.52	0.67	1.39	1.02	1.04	9.84
B-727	98	Mean	135	139.65	2.16	5.48	1.61	-2.51	1.96
		Std. Dev.	8.32	8.17	1.52	1.48	1.92	2.93	7.06
B-737	9	Mean	134.6	139	0.89	5.01	0.48	-1.27	-0.78
		Std. Dev.	7.02	4.51	1.3	0.77	1.31	3.14	6.76
B-757	80	Mean	126.2	131.3	2.02	5.02	2.13	-1.41	1.71
		Std. Dev.	8.7	8.12	1.45	1.24	1.86	2.43	7.34
DC-9	16	Mean	133.9	138	1.62	5.98	1.35	-3.59	4.69
		Std. Dev.	7.47	8.02	1.45	1.38	1.08	1.77	5.54
MD-80	61	Mean	134.6	138.9	2.31	5.21	1.3	-2.47	1.69
		Std. Dev.	8.34	8.02	1.78	1.76	1.25	3.11	6.2
SUPERSONIC JET TRANSPORTS									
CONCORDE	7	Mean	160.5	163.7	2.84	11	-0.03	-2.14	-5.29
		Std. Dev.	8.62	10.94	2.01	0.48	1.26	2.2	6.3
WIDE-BODY JET TRANSPORTS									
A-300	35	Mean	130.8	134.3	2.23	7.36	1.66	-1.59	-0.29
		Std. Dev.	7.99	8.26	1.26	0.84	1.52	2.72	5.79
B-747	51	Mean	141.4	145.6	3.24	4.75	1.28	-0.49	2.16
		Std. Dev.	10.78	9.25	1.99	4.46	1.41	2.42	7.07
B-767	99	Mean	130	135.7	2.44	5.58	1.11	-1.71	2.37
		Std. Dev.	8.53	7.55	1.68	1.24	1.47	2.75	6.41
DC10	12	Mean	137	142	2.53	6.55	1.44	-1.95	1.58
		Std. Dev.	9.2	8.15	1.84	0.92	0.86	1.72	4.35
MD-11	12	Mean	145.4	150.1	3.45	5.49	0.47	-1.17	-2.58
		Std. Dev.	12.99	13.35	1.81	1.04	1.84	1.63	5.17
L-1011	30	Mean	138.1	142.4	2.72	7.65	2.01	-2	2.5
		Std. Dev.	11.75	11.93	1.84	1.09	1.5	4.74	6.59

Although the primary objective of this survey was to determine typical landing parameters for wide-body jet transports, significant numbers of narrow-body jet transports and commuter types were videoed. Commuter aircraft were recorded and analyzed but were not a primary area of interest in this survey.

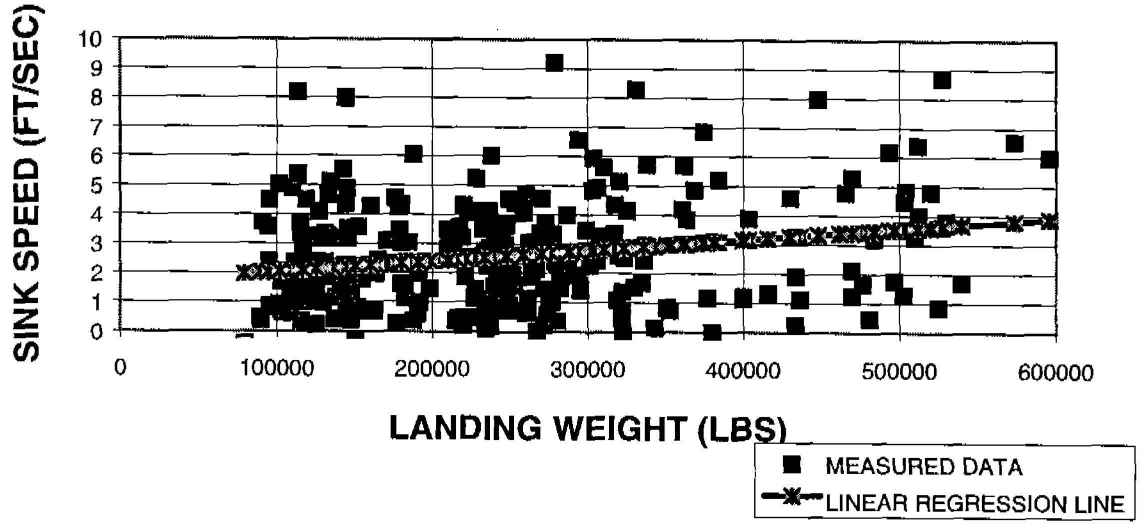


FIGURE 3. AVERAGE MAIN WHEEL SINK SPEED VERSUS LANDING WEIGHT, ALL JET TRANSPORTS

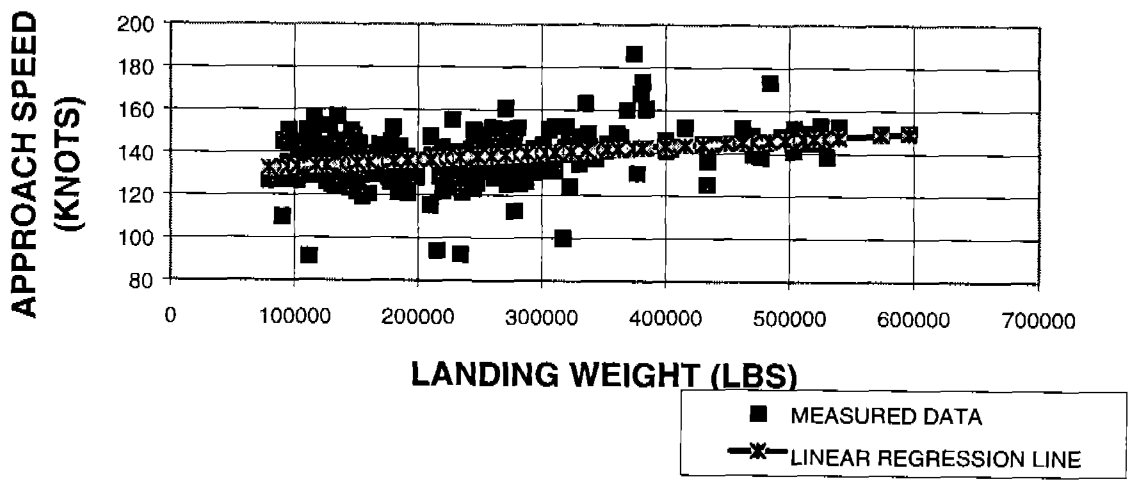
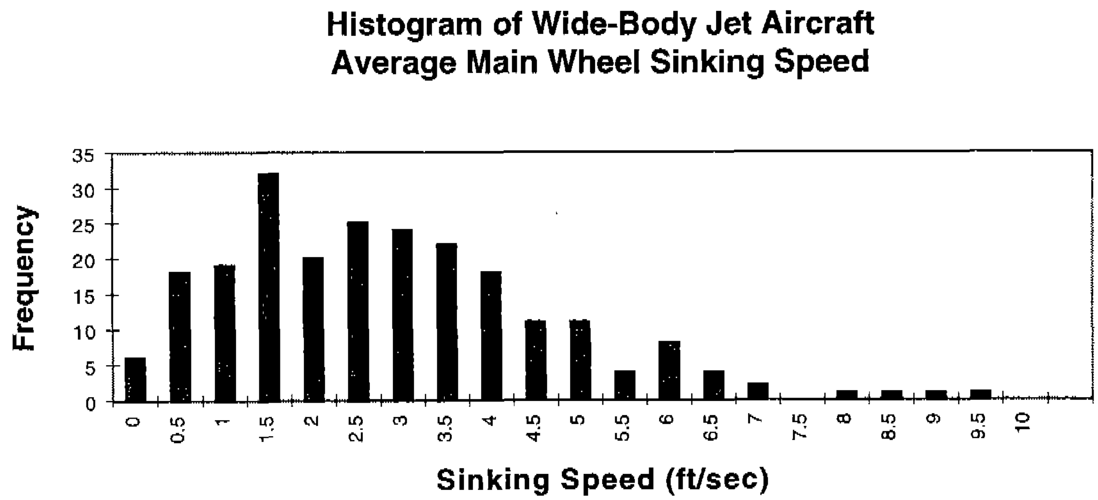


FIGURE 4. APPROACH SPEED VERSUS LANDING WEIGHT, ALL JET TRANSPORTS

An unexpected number of high sink speed landings were observed during this survey. While the Navy routinely observes aircraft sink speeds of 10 ft/sec during carrier operations, it was anticipated that an event over 4 ft/sec would be rather rare in commercial operations. The results of this survey have identified that over 90 landings (over 15%) had sink speeds in excess of 4 ft/sec and 6 landings were in the 8- to 9-ft/sec range. The design limit descent velocity is 10 ft/sec. The military specification MIL-A-8866 for similar aircraft assumes a 10-ft/sec landing occurs once every two thousand landings and a 9-ft/sec landing once every two thousand landings.

A trend that is apparent from figure 3 is the increase in sink speeds and the wide dispersion of sink speeds of aircraft with higher landing weights. For this survey, the mean value of sinking speed increases with aircraft category. The commuters landed at a mean value of 1.5 ft/sec, the narrow-bodied jets at 2.1 ft/sec, and the wide-bodied jets at 2.7 ft/sec. This is a statistically significant difference and warrants additional investigations. Figure 5 provides histograms on the sink speed distributions recorded during this survey for both wide-body and narrow-body aircraft.



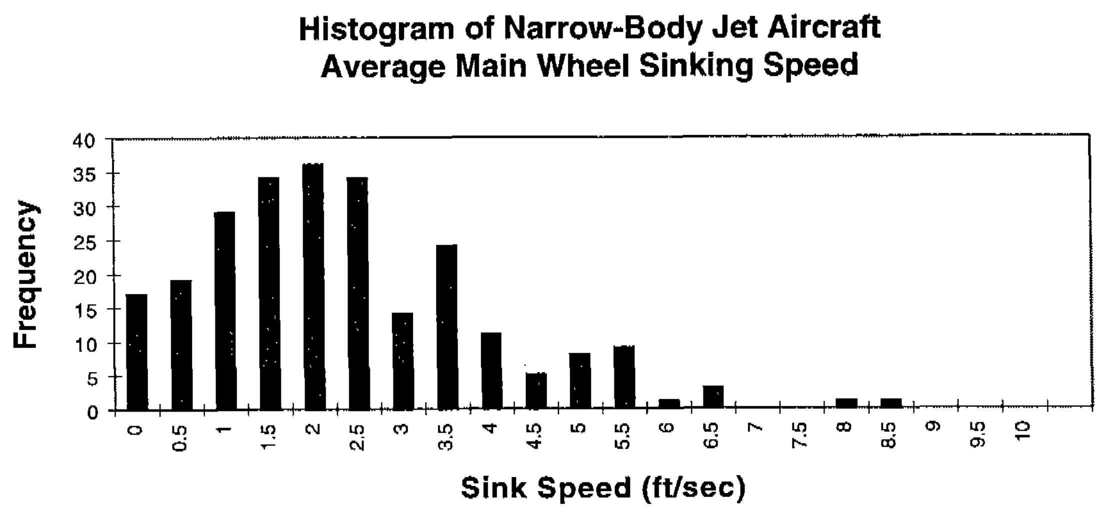


FIGURE 5. HISTOGRAMS OF AVERAGE SINK SPEED BY AIRCRAFT CATEGORY

The observed sink speeds are compared with the distributions from military specification, since there is no equivalent commercial specification. Commercial manufacturers estimate the anticipated usage of the aircraft during the airplanes design phase. Figure 6 is a plot of the probability that an aircraft's sink speed would reach a particular value. The military specifications are identified as the MIL-A-8866 curve. Separate curves are included for commuter, narrow-body, and wide-body aircraft based on observed sink speeds. Figure 6 shows that the observed sink speeds for wide-body aircraft exceed the distribution assumed in the military design specification.

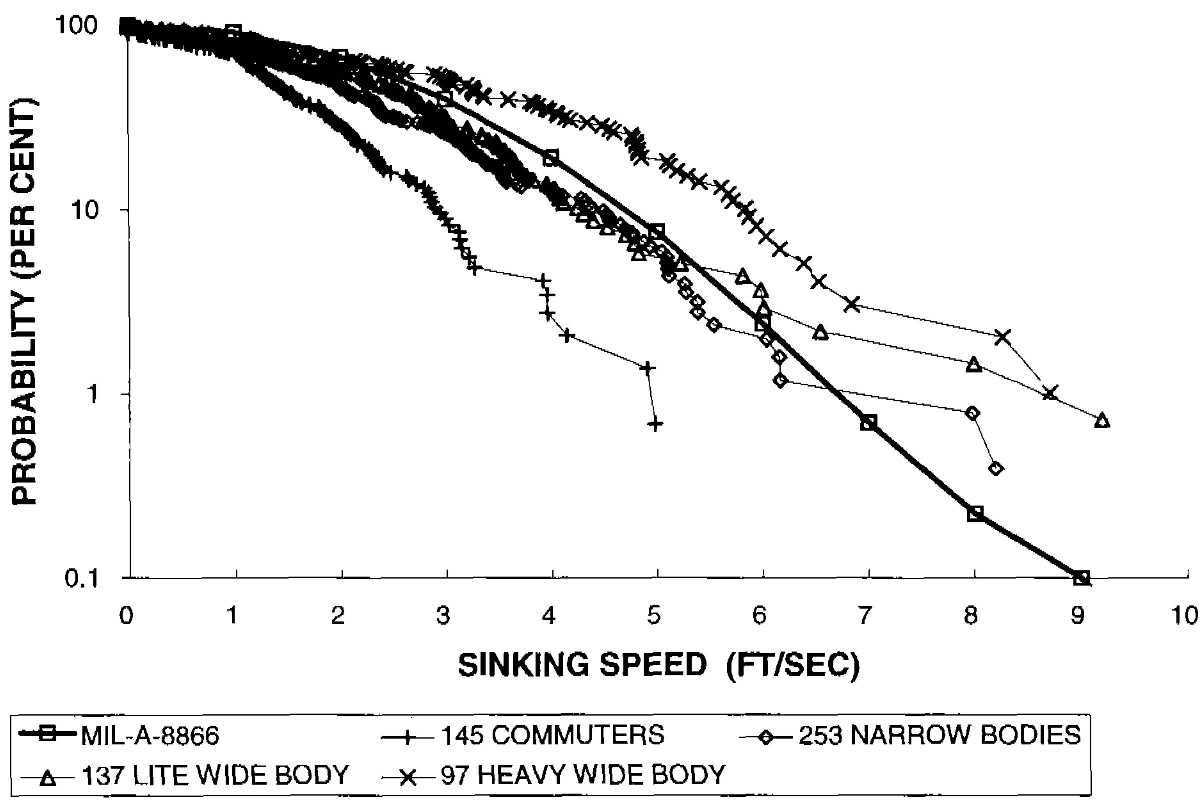


FIGURE 6. PROBABILITY DISTRIBUTION OF THE JFK INTERNATIONAL AIRPORT SURVEY SINKING SPEEDS

The fact that the commuter aircraft operations were intermixed with the jet transport operations may have influenced the commuter aircraft landing performance. The landings on a 10,000-ft runway are likely not representative of the landing performance of these aircraft on the shorter runways normally used during commuter operation. Thus, the complete statistical information on the landing parameters of these aircraft are not provided in this report.

Statistical information for the principal landing parameters for each model of jet transport aircraft are provided in appendix A. In addition, the landing parameters determined for each aircraft landing, including commuter aircraft, are provided by model type in appendix B. Landing parameter survey definitions in appendix C provide an explanation of the symbols and definition of parameters used in this report. The recent video system accuracy check procedure is provided as appendix D. The analysis in appendix D demonstrates that the assumptions used to size and configure the camera and lens system are effective and accurate.

4. CONCLUDING REMARKS.

This survey was the initial effort in a planned series of landing parameter surveys designed to assess current design and regulatory requirements for aircraft landing gear and support structure. Results of this survey are as follows.

- The video landing data acquisition system proved to be a practical, cost-effective technique for collecting large quantities of typical landing parameter data at a major commercial airport.

- The rather limited number of large jet transports aircraft (Boeing 747, McDonnell Douglas MD-11, and DC 10 models) included in this study suggest that additional data on these aircraft must be collected before any conclusions concerning their landing performance can be made.

- The data collected for commuter aircraft during this survey may not reflect typical operations for this category of aircraft since the aircraft landed on a 10,000-foot runway and with heavy jet aircraft in the landing pattern.

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JOHN F. KENNEDY INTERNATIONAL AIRPORT

AIRCRAFT MODEL AIRBUS A-310

PARAMETER	MEAN VALUE	STANDARD DEVIATION	MEASUREMENT UNITS	NUMBER OF LANDINGS
Sinking Speed				
Port Wheel	2.05	1.12	ft/sec	3
Starboard Wheel	2.21	0.87	ft/sec	3
Avgerage of Main Wheels	2.16	0.67	ft/sec	3
Closure Speed (Measured to Camera)	135.1	10.27	knots	3
Approach Speed	138.8	13.52	knots	3
Wind Speed				
Parallel Component	3.7	3.79	knots	3
Perpendicular Component	10	2.65	knots	3
Pitch Angle at Touchdown	6.23	1.39	degrees	3
Pitch Rate at Touchdown	1.33	2.24	degrees/sec	3
Roll Angle at Touchdown	0.97	1.02	degrees	3
Roll Rate at Touchdown	6.7	6.36	degrees/sec	3
Yaw Angle at Touchdown	-4	1.04	degrees	3
Calculated Glide Slope Angle	0.54	0.15	degree	3
Distance From Touchdown to Runway Threshold	1342	380.6	feet	3
Off-Center Distance at Touchdown	2.33	9.84	feet	3
Aircraft Reported Landing Weight	249709	8984	pounds	3

JOHN F. KENNEDY INTERNATIONAL AIRPORT

AIRCRAFT MODEL BOEING-727

PARAMETER	MEAN VALUE	STANDARD DEVIATION	MEASUREMENT UNITS	NUMBER OF LANDINGS
Sinking Speed				
Port Wheel	2.14	1.43	ft/sec	98
Starboard Wheel	2.12	1.64	ft/sec	98
Avgerage of Main Wheels	2.16	1.52	ft/sec	98
Closure Speed (Measured to Camera)	135	8.32	knots	98
Approach Speed	139.6	8.17	knots	98
Wind Speed				
Parallel Component	4.48	4.11	knots	98
Perpendicular Component	9.97	5.88	knots	98
Pitch Angle at Touchdown	5.48	1.48	degrees	98
Pitch Rate at Touchdown	-0.46	2.21	degrees/sec	98
Roll Angle at Touchdown	1.61	1.92	degrees	98
Roll Rate at Touchdown	1.54	6.97	degrees/sec	98
Yaw Angle at Touchdown	-2.51	2.93	degrees	98
Calculated Glide Slope Angle	0.55	0.39	degree	98
Distance From Touchdown to Runway Threshold	1747	845	feet	98
Off-Center Distance at Touchdown	1.96	7.06	feet	98
Aircraft Reported Landing Weight	140883	7026	pounds	74

JOHN F. KENNEDY INTERNATIONAL AIRPORT

AIRCRAFT MODEL BOEING-737

PARAMETER	MEAN VALUE	STANDARD DEVIATION	MEASUREMENT UNITS	NUMBER OF LANDINGS
Sinking Speed				
Port Wheel	0.77	1.19	ft/sec	9
Starboard Wheel	0.86	1.44	ft/sec	9
Avgerage of Main Wheels	0.89	1.3	ft/sec	9
Closure Speed (Measured to Camera)	134.6	7.02	knots	9
Approach Speed	139	4.51	knots	9
Wind Speed				
Parallel Component	4.36	3.94	knots	9
Perpendicular Component	6.11	5.67	knots	9
Pitch Angle at Touchdown	5.01	0.77	degrees	9
Pitch Rate at Touchdown	1.16	2.7	degrees/sec	9
Roll Angle at Touchdown	0.48	1.31	degrees	9
Roll Rate at Touchdown	2.64	5.1	degrees/sec	9
Yaw Angle at Touchdown	-1.27	3.14	degrees	9
Calculated Glide Slope Angle	0.22	0.62	degree	9
Distance From Touchdown to Runway Threshold	1884	407.5	feet	9
Off-Center Distance at Touchdown	-0.78	6.76	feet	9
Aircraft Reported Landing Weight	101200	4681	pounds	6

JOHN F. KENNEDY INTERNATIONAL AIRPORT

AIRCRAFT MODEL BOEING-747

PARAMETER	MEAN VALUE	STANDARD DEVIATION	MEASUREMENT UNITS	NUMBER OF LANDINGS
Sinking Speed				
Port Wheel	3.02	1.95	ft/sec	51
Starboard Wheel	3.07	2.15	ft/sec	51
Avgerage of Main Wheels	3.24	1.99	ft/sec	51
Closure Speed (Measured to Camera)	141.4	10.78	knots	51
Approach Speed	145.6	9.25	knots	51
Wind Speed				
Parallel Component	4.16	4.46	knots	51
Perpendicular Component	7.91	6.02	knots	51
Pitch Angle at Touchdown	4.75	1.83	degrees	51
Pitch Rate at Touchdown	-0.85	2.55	degrees/sec	51
Roll Angle at Touchdown	1.28	1.41	degrees	51
Roll Rate at Touchdown	1.8	6.13	degrees/sec	51
Yaw Angle at Touchdown	-0.49	2.42	degrees	51
Calculated Glide Slope Angle	0.78	0.48	degree	51
Distance From Touchdown to Runway Threshold	1624	810	feet	51
Off-Center Distance at Touchdown	2.16	7.07	feet	51
Aircraft Reported Landing Weight	489082	44561	pounds	30

JOHN F. KENNEDY INTERNATIONAL AIRPORT

AIRCRAFT MODEL BOEING-757

PARAMETER	MEAN VALUE	STANDARD DEVIATION	MEASUREMENT UNITS	NUMBER OF LANDINGS
Sinking Speed				
Port Wheel	1.97	1.33	ft/sec	80
Starboard Wheel	2.06	1.62	ft/sec	80
Avgerage of Main Wheels	2.02	1.45	ft/sec	80
Closure Speed (Measured to Camera)	126.2	8.7	knots	80
Approach Speed	131.3	8.12	knots	80
Wind Speed				80
Parallel Component	5.15	4.22	knots	80
Perpendicular Component	9.34	6.63	knots	80
Pitch Angle at Touchdown	5.02	1.24	degrees	80
Pitch Rate at Touchdown	-0.54	1.99	degrees/sec	80
Roll Angle at Touchdown	2.13	1.86	degrees	80
Roll Rate at Touchdown	0.06	4.86	degrees/sec	80
Yaw Angle at Touchdown	-1.41	2.43	degrees	80
Calculated Glide Slope Angle	0.55	0.39	degree	80
Distance From Touchdown to Runway Threshold	1852	653	feet	80
Off-Center Distance at Touchdown	1.71	7.34	feet	80
Aircraft Reported Landing Weight	173951	31190	pounds	58

JOHN F. KENNEDY INTERNATIONAL AIRPORT

AIRCRAFT MODEL BOEING-767

PARAMETER	MEAN VALUE	STANDARD DEVIATION	MEASUREMENT UNITS	NUMBER OF LANDINGS
Sinking Speed				
Port Wheel	2.35	1.77	ft/sec	99
Starboard Wheel	2.36	1.73	ft/sec	99
Avgerage of Main Wheels	2.44	1.68	ft/sec	99
Closure Speed (Measured to Camera)	130	8.53	knots	99
Approach Speed	135.7	7.55	knots	99
Wind Speed				
Parallel Component	5.67	4.15	knots	99
Perpendicular Component	7.91	6.97	knots	99
Pitch Angle at Touchdown	5.58	1.24	degrees	99
Pitch Rate at Touchdown	-0.11	2.01	degrees/sec	99
Roll Angle at Touchdown	1.11	1.47	degrees	99
Roll Rate at Touchdown	1.98	5.33	degrees/sec	99
Yaw Angle at Touchdown	-1.71	2.75	degrees	99
Calculated Glide Slope Angle	0.64	0.45	degree	99
Distance From Touchdown to Runway Threshold	1529	630.2	feet	99
Off-Center Distance at Touchdown	2.37	6.41	feet	99
Aircraft Reported Landing Weight	247242	21160	pounds	87

JOHN F. KENNEDY INTERNATIONAL AIRPORT

AIRCRAFT MODEL CONCORDE

PARAMETER	MEAN VALUE	STANDARD DEVIATION	MEASUREMENT UNITS	NUMBER OF LANDINGS
Sinking Speed				
Port Wheel	2.6	1.55	ft/sec	7
Starboard Wheel	2.79	2.17	ft/sec	7
Avgerage of Main Wheels	2.84	2.01	ft/sec	7
Closure Speed (Measured to Camera)	160.5	8.62	knots	7
Approach Speed	163.7	10.94	knots	7
Wind Speed				
Parallel Component	3.21	4.2	knots	7
Perpendicular Component	8.28	2.36	knots	7
Pitch Angle at Touchdown	11	0.48	degrees	7
Pitch Rate at Touchdown	-0.5	1.69	degrees/sec	7
Roll Angle at Touchdown	-0.03	1.26	degrees	7
Roll Rate at Touchdown	0.19	7.76	degrees/sec	7
Yaw Angle at Touchdown	-2.14	2.2	degrees	7
Calculated Glide Slope Angle	0.6	0.43	degree	7
Distance From Touchdown to Runway Threshold	1879	984.5	feet	7
Off-Center Distance at Touchdown	-5.29	6.3	feet	7
Aircraft Reported Landing Weight	Not Recorded	Not Recorded	pounds	

JOHN F. KENNEDY INTERNATIONAL AIRPORT

AIRCRAFT MODEL LOCKHEED L-1011

PARAMETER	MEAN VALUE	STANDARD DEVIATION	MEASUREMENT UNITS	NUMBER OF LANDINGS
Sinking Speed				
Port Wheel	2.59	1.87	ft/sec	30
Starboard Wheel	2.76	1.96	ft/sec	30
Avgerage of Main Wheels	2.72	1.84	ft/sec	30
Closure Speed (Measured to Camera)	138.1	11.75	knots	30
Approach Speed	142.4	11.93	knots	30
Wind Speed				
Parallel Component	4.32	4.4	knots	30
Perpendicular Component	8.33	6.02	knots	30
Pitch Angle at Touchdown	7.65	1.09	degrees	30
Pitch Rate at Touchdown	-0.58	3.21	degrees/sec	30
Roll Angle at Touchdown	2.01	1.5	degrees	30
Roll Rate at Touchdown	0.04	4.48	degrees/sec	30
Yaw Angle at Touchdown	-2	4.74	degrees	30
Calculated Glide Slope Angle	0.68	0.46	degree	30
Distance From Touchdown to Runway Threshold	1559.6	822	feet	30
Off-Center Distance at Touchdown	2.5	6.59	feet	30
Aircraft Reported Landing Weight	329877	31108	pounds	25

JOHN F. KENNEDY INTERNATIONAL AIRPORT

AIRCRAFT MODEL DOUGLAS DC-9

PARAMETER	MEAN VALUE	STANDARD DEVIATION	MEASUREMENT UNITS	NUMBER OF LANDINGS
Sinking Speed				
Port Wheel	1.52	1.24	ft/sec	16
Starboard Wheel	1.57	1.46	ft/sec	16
Avgerage of Main Wheels	1.62	1.45	ft/sec	16
Closure Speed (Measured to Camera)	133.9	7.47	knots	16
Approach Speed	138	8.02	knots	16
Wind Speed				
Parallel Component	4.1	4.4	knots	16
Perpendicular Component	8.56	5.12	knots	16
Pitch Angle at Touchdown	5.98	1.38	degrees	16
Pitch Rate at Touchdown	0.54	1.93	degrees/sec	16
Roll Angle at Touchdown	1.35	1.08	degrees	16
Roll Rate at Touchdown	2.79	4.11	degrees/sec	16
Yaw Angle at Touchdown	-3.59	1.77	degrees	16
Calculated Glide Slope Angle	0.4	0.35	degree	16
Distance From Touchdown to Runway Threshold	1405	579	feet	16
Off-Center Distance at Touchdown	4.69	5.54	feet	16
Aircraft Reported Landing Weight	105429	32565	pounds	12

JOHN F. KENNEDY INTERNATIONAL AIRPORT

AIRCRAFT MODEL DOUGLAS DC-10

PARAMETER	MEAN VALUE	STANDARD DEVIATION	MEASUREMENT UNITS	NUMBER OF LANDINGS
Sinking Speed				
Port Wheel	2.36	1.77	ft/sec	12
Starboard Wheel	2.6	1.87	ft/sec	12
Avgerage of Main Wheels	2.53	1.84	ft/sec	12
Closure Speed (Measured to Camera)	137	9.2	knots	12
Approach Speed	142	8.15	knots	12
Wind Speed				
Parallel Component	4.95	3.51	knots	12
Perpendicular Component	10.33	8.25	knots	12
Pitch Angle at Touchdown	6.55	0.92	degrees	12
Pitch Rate at Touchdown	0.42	1.38	degrees/sec	12
Roll Angle at Touchdown	1.44	0.86	degrees	12
Roll Rate at Touchdown	0.79	1.91	degrees/sec	12
Yaw Angle at Touchdown	-1.95	1.72	degrees	12
Calculated Glide Slope Angle	0.62	0.45	degree	12
Distance From Touchdown to Runway Threshold	1320	575.2	feet	12
Off-Center Distance at Touchdown	1.58	4.35	feet	12
Aircraft Reported Landing Weight	329712	27748	pounds	10

JOHN F. KENNEDY INTERNATIONAL AIRPORT

AIRCRAFT MODEL McDONNELL DOUGLAS MD-11

PARAMETER	MEAN VALUE	STANDARD DEVIATION	MEASUREMENT UNITS	NUMBER OF LANDINGS
Sinking Speed				
Port Wheel	3.29	1.76	ft/sec	12
Starboard Wheel	3.36	2.07	ft/sec	12
Avgerage of Main Wheels	3.45	1.81	ft/sec	12
Closure Speed (Measured to Camera)	145.4	12.99	knots	12
Approach Speed	150.1	13.35	knots	12
Wind Speed				
Parallel Component	4.76	5.12	knots	12
Perpendicular Component	7.92	5.5	knots	12
Pitch Angle at Touchdown	5.49	1.04	degrees	12
Pitch Rate at Touchdown	-0.07	1.71	degrees/sec	12
Roll Angle at Touchdown	0.47	1.84	degrees	12
Roll Rate at Touchdown	0.76	3.77	degrees/sec	12
Yaw Angle at Touchdown	-1.17	1.63	degrees	12
Calculated Glide Slope Angle	0.8	0.43	degree	12
Distance From Touchdown to Runway Threshold	1409	547.6	feet	12
Off-Center Distance at Touchdown	-2.58	5.17	feet	12
Aircraft Reported Landing Weight	360420	32841	pounds	10

APPENDIX B—LISTING OF INDIVIDUAL AIRCRAFT LANDING PARAMETERS BY MODEL, FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LANDING DATA MODEL AIRBUS A-300 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN PORT FT/SEC	SINKING SPEED AT TOUCHDOWN STBD FT/SEC	SINKING SPEED AT TOUCHDOWN AVG FT/SEC	WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
91	135	127	1.7	2.1	2.3	263900	2050	-3	0.6	5.8	3.6	0.0	-4.8	-6.2	8	3
92	138	129	0.9	1.6	1.4	295410	2217	-3	0.4	7.7	2.6	0.5	-1.0	0.5	8	3
96	113	103	1.3	4.6	3.3	277900	1859	-4	1.1	8.4	-2.6	0.4	-3.4	8.2	10	4
119	131	127	1.6	0.8	1.2	376990	1754	1	0.3	8.4	-0.2	1.4	1.2	-6.6	4	11
121	140	136	1.2	2.0	2.0	287300	1734	-1	0.5	6.2	0.5	-0.2	1.0	-1.0	4	11
147	147	141	1.9	0.4	1.1	261600	2250	2	0.3	6.4	-0.4	-0.2	2.3	-3.4	6	10
190	131	128	3.3	2.4	2.8	236900	2094	-5	0.8	6.3	-2.6	-0.3	2.7	-1.2	3	9
192	125	122	0.3	0.4	1.5	271800	2003	-6	0.4	8.7	-7.2	-0.3	5.3	1.8	3	9
212	131	128	2.1	1.5	1.7	275400	2176	-6	0.5	7.1	1.1	0.9	-1.2	-1.2	3	8
215	145	142	2.5	1.8	1.9	263900	2241	-3	0.5	6.4	-1.3	0.1	0.9	-0.3	3	8
268	143	138	3.3	3.5	3.4		701	1	0.8	6.8	0.9	4.6	0.2	2.4	5	13
360	128	121	0.8	2.0	1.4	281100	2115	4	0.4	7.5	1.7	2.6	5.5	-3.0	7	8
430	148	139	0.2	0.2	0.2	277500	1521	1	0.0	7.5	1.9	0.8	-5.5	-2.2	10	-5
472	152	143	0.6	0.2	0.4	280434	694	-3	0.1	7.5	2.2	1.4	-3.6	-1.2	9	15
487	140	134	1.0	4.3	3.5	298900	702	1	0.9	8.4	9.3	3.1	-4.7	-1.9	6	17
504	140	131	5.1	2.2	3.7	272900	922	-8	1.0	7.4	-1.6	0.7	1.6	-1.6	9	16
551	133	132	1.6	2.5	2.1	279800	1887	1	0.5	8.7	-0.7	1.0	-2.4	-3.8	1	8
565	128	135	0.6	0.6	0.6	254600	1931	7	0.1	8.3	-1.2	2.1	0.5	-1.8	-7	12
589	137	131	1.8	2.3	2.0	246900	2397	-5	0.5	6.2	2.3	3.7	1.1	-0.2	5	15
613	144	137	1.2	3.3	2.2	301100	1754	7	0.6	8.0	-4.0	5.9	-6.4	-3.8	6	18
696	130	125	2.3	3.0	2.7	280100	1614	13	0.7	8.2	6.9	3.3	6.9	-6.4	5	14
755	123	125	2.7	2.3	2.5	244400	741	-5	0.7	7.1	-1.3	0.7	-0.9	-2.0	-2	12
765	134	136	2.8	3.2	3.0	274500	916	-2	0.8	7.6	-0.2	3.0	1.1	-1.4	-2	12
776	135	138	0.3	0.9	0.6	272000	2069	-9	0.1	7.3	0.7	3.8	0.4	-4.1	-2	12
843	130	127	1.9	1.0	1.6	280100	2156	-5	0.4	6.1	2.0	1.0	1.1	-1.7	3	8
848	138	135	2.0	1.9	2.1	292600	703	-2	0.5	7.0	0.7	-0.1	5.6	0.0	3	8
870	128	126	1.9	4.2	3.0	258700	2058	1	0.8	6.4	0.4	2.7	0.8	-0.8	1	7
895	136	135	1.2	0.9	1.0		1946	0	0.3	7.5	3.6	2.4	-2.1	-0.1	1	7
898	144	140	2.6	2.1	2.4		2226	-6	0.6	7.9	-0.3	2.0	2.0	0.2	3	9
931	127	123	4.4	4.4	4.4		901	-8	1.2	7.1	-1.2	0.2	5.0	-1.6	4	10
941	142	137	2.8	1.8	1.9	293500	2094	3	0.5	7.0	-1.0	1.6	6.6	-0.2	5	9
948	124	119	2.6	3.4	3.5	232300	714	4	1.0	7.4	0.1	1.4	1.0	-2.6	5	9
962	132	137	5.3	7.1	6.6	293900	836	3	1.6	7.0	0.1	3.2	-1.1	-0.7	-5	4
983	125	126	1.5	2.4	2.0	281900	1984	18	0.5	9.3	0.3	2.6	-1.9	-6.3	-1	6
1028	127	128	2.3	2.6	2.4	284500	2303	7	0.6	6.9	-0.7	2.2	-0.7	-1.5	-1	8

LANDING DATA MODEL BOEING 737-200 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN			WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS	CROSS-WIND KNOTS
		PORT FT/SEC	STBD FT/SEC	AVG FT/SEC										AT TOUCHDOWN	
133	124	0.7	1.6	1.1	102300	2391	-10	0.3	6.5	0.1	1.0	0.8	2.9	9	3
138	128	1.7	1.5	1.7	103000	946	3	0.4	4.4	-1.6	1.3	8.8	-3.8	10	4
140	137	1.7	0.3	1.1		2090	-7	0.3	5.3	5.4	-1.7	4.3	4.2	3	9
145	142	3.2	4.2	3.7	90900	2094	-1	0.9	5.4	2.1	-0.3	-4.7	1.0	4	10
140	132	0.4	0.8	0.5		2199	-8	0.1	3.5	0.3	-1.3	7.1	-1.2	8	-7
135	134	0.6	0.4	0.8	105000	2051	-3	0.2	4.7	5.1	2.0	-2.3	-5.3	1	8
145	147	0.2	0.5	0.4	103000	1583	11	0.2	4.9	-2.4	-0.2	6.6	-1.4	-2	12
142	141	0.9	1.1	1.0	103000	1660	8	-0.3	5.1	2.8	1.7	7.7	-3.8	1	7
132	129	0.4	0.4	0.4		1941	0	-0.1	5.3	-1.4	1.8	-4.5	-4.0	3	9

CROSS-WIND KNOTS
AT [C]HDOWN
13
9
8

LANDING DATA MODEL BOEING 747 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN PORT FT/SEC	SINKING SPEED AT TOUCHDOWN STBD FT/SEC	SINKING SPEED AT TOUCHDOWN AVG FT/SEC	WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
27	141	132	1.7	4.9	4.5	503124	1524	-7	1.2	4.7	-1.0	-1.0	-6.9	2.0	9	3
79	139	128	1.6	3.6	3.8	530000	558	-2	1.0	7.4	-1.9	-0.2	-5.3	2.6	10	4
156	144	139	0.8	1.7	1.3	502650	2362	-12	0.3	5.3	0.7	2.2	-2.1	-0.2	6	10
169	145	139	1.6	0.7	1.1	436434	1661	-1	0.3	6.9	-1.3	1.3	1.9	0.4	6	10
181	149	144	6.2	6.9	6.5	573637	934	6	1.5	6.2	-2.1	3.5	-1.3	1.5	6	10
187	150	147	6.0	6.0	6.0	595840	1840	10	1.4	4.0	0.5	0.1	1.7	-1.8	3	9
198	145	142	4.6	4.4	4.8	465750	1634	6	1.1	4.8	-6.9	0.0	0.8	5.5	3	9
216	151	148	4.8	4.7	4.8	503760	713	5	1.1	4.2	0.5	-0.2	7.9	-1.6	3	8
241	148	143	1.8	1.8	1.8	496600	2365	-8	0.4	1.8	1.9	1.3	1.4	0.9	5	8
283	139	135	4.5	5.6	5.3	470015	735	1	1.3	8.9	-1.8	1.6	5.4	-0.7	5	13
293	146	141	7.8	8.9	8.7	527543	793	-8	2.1	5.0	0.9	1.9	6.6	2.5	5	13
358	145	138	3.1	4.8	4.6	430000	791	7	1.1	3.8	1.3	2.1	4.5	-0.7	7	8
363	128	121	1.4	1.9	2.9		2153	-1	0.8	3.1	3.0	0.1	15.3	-3.4	7	8
365	153	146	1.4	0.4	0.9	525000	662	5	0.2	6.8	-6.1	0.7	-2.2	2.9	7	8
377	153	146	1.2	1.7	1.7	539700	1576	-4	0.4	3.8	0.8	1.5	-5.0	0.6	7	8
396	140	132	3.0	4.3	4.1		1766	2	1.0	4.2	0.4	2.3	-4.9	1.2	8	-7
405	148	139	5.2	5.4	6.2	493617	850	-15	1.5	2.9	0.6	0.5	-8.0	2.7	10	-5
410	145	136	3.1	4.4	4.0	512000	2088	-1	1.0	6.3	-2.1	2.2	-6.7	1.5	10	-5
424	138	129	2.0	1.3	1.6	476600	1874	1	0.4	8.1	-0.5	0.2	6.2	-1.1	10	-5
427	136	127	1.6	1.9	1.9	433500	2258	5	0.5	7.2	2.8	0.9	-0.2	3.4	10	-5
456	145	134	2.5	1.2	1.8	481000	1728	5	0.1	4.5	-4.7	-0.9	13.5	3.8	11	-6
481	147	141	4.0	2.6	3.3	510000	939	-1	0.8	5.1	-1.6	1.7	5.1	0.4	6	17
560	152	151	0.2	1.5	1.3	415789	1608	10	0.3	7.2	-7.1	1.8	20.6	-7.6	1	8
570	140	147	2.0	2.4	2.2		4296	15	0.5	-1.7	1.7	2.5	-1.6	-1.2	-7	12
584	145	139	2.8	1.6	2.2		1879	-1	0.5	4.6	-2.3	0.0	6.1	-3.4	7	11
633	146	138	2.1	2.2	2.1	469391	2173	12	0.5	6.1	-4.7	4.3	0.7	-1.2	8	22
647	149	141	6.7	6.1	6.4	511877	712	5	1.5	4.7	-1.5	1.7	5.6	-4.0	8	22
677	150	148	0.3	1.6	0.9		1635	5	0.1	4.1	4.0	1.7	-5.5	-1.5	2	11
691	145	140	5.0	4.9	4.8	520000	907	-2	1.2	4.3	-1.1	1.9	3.6	-1.0	5	14
735	173	173	3.3	3.1	3.2	484048	1600	10	0.6	4.4	-5.2	4.0	14.2	-0.8	0	10
753	144	147	6.3	5.7	6.0		818	-13	1.4	4.2	1.5	-0.4	4.6	1.4	-2	12
767	132	134	1.8	2.6	2.2	441387	2388	-3	0.6	5.5	-1.7	3.1	4.5	-0.6	-2	12
803	149	155	5.2	4.3	4.8		2073	5	1.0	3.7	-4.4	2.0	5.3	-2.4	-6	8
809	146	153	2.4	0.0	1.2	400000	1642	12	0.3	3.6	2.4	2.3	-13.2	-5.0	-6	8
833	149	138	1.5	0.7	1.2	469748	793	-6	0.3	4.5	3.6	1.0	2.9	0.3	11	9
836	128	118	0.3	0.1	0.2		1726	11	-0.1	5.1	-0.8	1.4	-0.6	-0.6	11	9
841	143	140	0.1	0.9	0.5		2378	5	0.1	3.3	-0.4	1.3	2.2	-2.1	3	8
846	125	122	0.6	0.0	0.3	433412	1922	13	0.1	5.7	-1.9	1.6	1.2	-4.6	3	8
862	133	130	3.0	3.0	3.0		885	-8	0.8	5.2	-1.5	-2.5	1.7	0.7	3	8

LANDING DATA MODEL BOEING 747 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN PORT FT/SEC	SINKING SPEED AT TOUCHDOWN STBD FT/SEC	SINKING SPEED AT TOUCHDOWN AVG FT/SEC	WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
875	150	149	3.9	3.0	3.5		900	2	0.8	4.0	-0.6	1.0	0.8	-0.4	1	7
879	143	142	5.5	6.3	5.9		864	1	1.4	4.8	-5.6	2.6	-3.3	0.0	1	7
881	159	157	1.6	3.1	2.3		2137	10	0.5	4.4	0.5	1.9	1.4	-1.7	1	7
899	163	160	1.9	2.5	2.2		2404	1	0.5	3.9	-0.6	2.0	-0.1	0.5	3	9
902	150	146	1.1	1.9	1.5		1824	16	0.3	1.3	-0.2	-0.6	-7.9	-4.7	3	9
903	148	144	5.7	6.0	5.8		2285	6	1.4	1.9	0.7	1.6	4.5	-1.5	3	9
911	177	174	2.2	2.4	2.4		2074	3	0.5	2.6	-0.1	0.6	3.8	-3.7	3	9
913	145	142	3.6	2.3	2.6		804	-5	0.6	6.1	1.5	1.9	5.8	-0.1	3	9
933	138	134	3.1	3.5	3.3		2413	4	0.8	5.1	-0.7	1.8	1.1	0.3	4	10
936	143	140	4.3	4.0	5.1		659	3	1.2	6.9	-1.8	0.6	4.5	-1.1	4	10
963	142	147	3.8	4.3	4.1		941	-1	0.9	4.1	-0.5	4.4	-2.6	-0.6	-5	4
1029	139	141	5.2	4.0	4.6	520028	4299	7	1.1	7.5	0.2	-2.0	3.9	-0.9	-1	8

LANDING DATA MODEL BOEING 757 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN PORT FT/SEC	SINKING SPEED AT TOUCHDOWN STBD FT/SEC	SINKING SPEED AT TOUCHDOWN AVG FT/SEC	WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
10	116	107	1.9	3.4	2.8		828	-5	0.9	6.9	-1.2	1.5	-8.4	1.7	9	3
21	121	112	2.1	2.5	2.4	183688	1479	-3	0.7	7.2	-3.6	1.8	-7.0	-4.2	9	3
22	132	123	1.9	1.4	1.6	181503	2457	3	0.5	5.1	0.0	2.4	-1.1	-0.9	9	3
29	121	111	2.2	2.5	2.1	159300	2032	4	0.7	6.2	-0.3	1.2	2.9	2.0	9	3
43	124	114	0.0	0.3	0.3	150300	1660	-6	0.1	4.5	1.3	-1.0	-0.9	2.1	11	2
54	152	141	1.6	1.5	1.6	179600	1859	-3	0.4	4.4	-0.9	0.5	2.6	-0.5	11	2
68	128	118	1.5	1.3	1.5	198266	880	2	0.4	4.5	-0.7	-1.0	1.5	-4.6	10	4
106	128	118	4.9	4.0	4.6	176000	2299	9	1.3	6.2	-0.9	2.4	-2.3	0.0	10	4
120	142	138	3.1	2.7	3.0	185000	2337	-6	0.7	4.0	0.0	2.7	1.6	2.2	4	11
130	132	127	2.2	2.5	2.3	280000	775	-1	0.6	3.7	-0.4	3.8	-2.1	-0.7	6	10
135	127	121	4.0	4.0	4.0	286600	2446	1	1.1	3.4	-2.3	0.5	1.5	-1.7	6	10
137	130	124	2.3	2.6	2.4	165154	2429	-5	0.7	4.4	1.0	3.1	0.8	0.7	6	10
146	132	126	1.1	0.7	0.7	159300	2200	-9	0.2	5.0	0.6	-0.5	3.2	-0.8	6	10
170	134	129	1.2	1.0	1.1	179600	2410	-8	0.0	4.9	0.1	3.4	5.2	-0.5	6	10
178	138	133	2.2	2.3	2.0	190550	2178	-5	0.5	5.5	-1.0	2.6	0.2	-1.0	6	10
205	165	162	1.4	0.1	0.2		1687	-7	0.0	3.1	0.8	4.4	7.7	-1.6	3	9
221	133	130	6.2	6.2	6.2	157900	1808	-12	1.6	3.1	-3.2	-1.4	-1.5	1.1	3	8
229	123	120	1.1	2.0	3.8	155700	1636	-1	1.1	5.9	-4.3	-2.3	22.7	-7.9	3	8
245	129	125	1.9	1.6	1.8		2442	1	0.5	7.5	-1.3	2.5	5.5	-1.3	5	8
257	133	130	1.5	0.6	1.0	192000	1931	-3	0.3	6.1	-3.1	1.4	-1.1	1.2	4	10
285	144	139	2.2	3.1	2.3	168709	2114	7	0.6	2.5	-0.8	5.3	-6.6	-2.9	5	13
286	141	137	1.2	2.9	2.1	29300	4111	15	0.5	8.1	8.1	4.3	-3.4	-4.0	5	13
300	135	131	2.8	1.7	2.1		2007	1	0.5	5.0	2.9	0.8	8.0	-1.1	5	13
304	137	131	2.3	4.3	3.1	170600	878	4	0.8	3.4	-0.5	3.9	-0.4	1.0	6	10
371	122	115	1.1	1.5	1.2		2307	-4	0.4	4.6	-1.5	2.6	0.5	1.3	7	8
372	125	118	1.4	0.9	1.0	129800	2294	-5	0.3	5.2	-1.2	3.1	4.0	-1.3	7	8
382	128	117	0.7	0.1	0.4	187700	1527	4	0.1	7.0	-0.2	0.4	0.0	-4.6	11	-6
386	133	122	0.8	0.4	1.0		592	-12	0.3	5.9	2.0	-0.2	-2.3	1.7	11	-6
391	124	116	2.9	2.7	3.0		817	-7	0.9	6.5	0.2	-0.1	-4.4	1.8	8	-7
401	133	125	2.3	3.9	3.2		2065	-7	0.9	3.1	-2.2	0.3	2.7	3.5	8	-7
408	124	114	0.9	1.1	1.0		1966	1	0.3	6.8	0.3	0.5	-1.9	-0.1	10	-5
433	133	123	1.5	1.2	1.3		1841	-1	0.4	4.8	-1.3	0.2	0.3	0.1	10	-5
459	151	140	2.3	3.1	2.6		1529	-7	0.6	4.0	-2.3	1.4	3.3	-1.6	11	-6
470	138	129	0.8	1.1	1.0	184300	2358	3	-0.3	4.4	0.3	3.3	-1.3	-2.8	9	15
473	145	136	2.8	4.3	3.5	188318	2185	-3	0.9	4.6	-1.4	4.3	-3.9	0.4	9	15
488	127	121	3.7	2.0	2.9		1850	5	0.8	5.4	-3.3	-2.6	1.7	-3.0	6	17
489	133	126	1.4	2.5	1.4		1742	-2	0.4	4.8	-4.3	6.8	-16.2	-3.5	6	17
495	119	110	2.5	1.5	1.8	154600	1835	9	0.5	5.0	-3.0	0.9	4.8	-3.8	9	16
500	131	122	1.3	0.0	0.6	190661	1964	10	0.2	7.5	-4.6	1.6	2.4	-1.1	9	16
503	140	131	1.7	1.1	1.4	182337	837	5	0.4	5.0	0.0	1.3	2.9	-4.1	9	16

LANDING DATA MODEL BOEING 757 AIRCRAFT
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LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN PORT FT/SEC	SINKING SPEED AT TOUCHDOWN STBD FT/SEC	SINKING SPEED AT TOUCHDOWN AVG FT/SEC	WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
513	139	130	4.1	4.6	4.3	179900	719	7	1.1	4.5	3.1	4.9	-1.7	-0.1	9	16
523	137	135	1.7	0.8	1.1	182600	1758	3	0.3	4.6	0.0	0.7	3.5	-3.6	2	12
557	135	133	0.3	0.9	0.6		1931	4	0.2	4.4	-0.3	0.6	-1.4	-1.0	1	8
577	140	147	1.2	0.5	0.7	163000	1901	15	0.2	3.3	-0.5	0.0	0.2	-1.3	-7	12
586	127	122	0.8	0.9	0.7		1839	12	0.2	5.5	-1.4	1.3	2.2	-4.5	5	15
587	128	123	0.8	1.2	1.0	156200	2411	-10	0.3	4.2	-0.8	2.7	-3.0	2.0	5	15
600	134	128	0.9	1.1	1.0	185600	4287	22	0.3	4.6	-0.4	3.0	2.8	-5.9	5	15
605	130	124	4.8	5.8	5.1	181004	1684	16	1.4	6.2	-2.8	3.1	-13.3	-2.8	6	18
614	138	131	3.6	2.1	2.8		2445	2	0.7	5.2	0.6	0.9	7.0	-3.1	6	18
629	136	128	1.5	1.0	1.1		1649	7	0.3	6.6	-1.1	3.5	-2.5	0.3	8	22
632	122	114	0.5	1.1	0.8	150300	1773	10	0.2	5.9	0.8	4.9	-0.8	-3.1	8	22
638	129	122	1.8	1.5	2.0	163500	1716	12	0.6	6.3	-1.1	1.6	2.1	-5.3	8	22
658	132	124	0.2	0.8	0.5	181700	2465	11	0.1	5.9	2.7	6.4	1.1	-4.1	8	22
673	126	124	0.5	0.0	0.3	177065	1847	4	0.1	5.3	0.9	6.0	-0.6	-2.5	2	11
679	128	128	2.5	4.0	3.2	178100	1974	-8	0.9	5.0	-2.8	3.6	-5.4	1.8	0	12
687	135	130	3.0	1.0	2.3	170228	2167	-8	0.6	3.1	0.5	0.1	6.4	-0.3	5	14
693	132	127	2.0	3.5	2.7		1781	8	0.7	6.0	-1.5	3.0	-2.5	-1.8	5	14
711	122	120	2.2	2.9	2.6		1986	7	0.7	4.1	-0.4	2.4	-3.1	0.2	2	12
713	131	129	5.4	6.7	6.0	187679	980	6	1.6	5.8	-1.7	4.3	-2.0	-4.1	2	12
715	124	122	4.0	4.6	4.7	165600	756	6	1.3	4.2	0.7	1.3	3.7	-3.4	2	12
727	134	132	4.3	4.1	4.3	160000	664	-2	1.1	5.7	0.3	3.0	1.4	0.6	2	12
737	129	129	3.0	4.0	3.5	178800	990	5	0.9	5.9	-0.8	3.8	-3.7	-1.8	0	10
754	130	132	2.7	3.7	3.2	150000	820	1	0.8	5.2	-4.2	3.9	-0.5	-3.1	-2	12
773	120	122	3.0	3.8	3.5		2061	1	1.0	4.6	5.2	3.5	0.8	-2.4	-2	12
804	127	133	1.3	2.0	1.6	156400	1678	9	0.4	3.6	0.1	1.4	-0.8	-0.2	-6	8
814	143	138	1.8	2.1	2.0	150300	1759	7	0.5	5.0	-0.4	2.8	-4.2	-3.6	5	9
821	136	125	0.6	0.1	0.3	183769	2435	-4	0.1	6.6	-1.4	1.1	0.6	2.5	11	9
826	137	126	1.7	2.0	1.9	188400	2406	-9	0.5	6.2	0.0	0.9	0.3	1.5	11	9
834	125	114	1.2	1.7	1.4	160300	1653	7	0.4	5.1	-2.2	0.3	2.2	-2.3	11	9
888	128	126	1.0	2.1	1.5	160500	2411	-4	0.4	4.1	-1.4	3.1	-1.8	0.2	1	7
896	128	127	3.9	2.5	3.4	163500	2036	-4	0.9	3.7	2.4	0.6	8.1	-0.7	1	7
929	129	125	2.7	3.8	3.2		1934	-6	0.9	5.5	-3.1	2.7	-2.9	-1.6	4	10
938	127	123	0.1	0.2	0.2	161900	1984	12	0.0	4.7	1.0	2.1	-4.0	-5.2	4	10
954	121	125	2.0	2.4	2.1	191013	867	-3	0.6	4.6	-0.7	2.8	3.7	0.5	-5	4
986	131	132	2.1	2.5	2.3	171300	2450	9	0.6	2.7	-0.4	3.1	3.2	-8.3	-1	6
999	126	126	2.3	2.5	2.3	165425	2183	16	0.6	4.8	-0.2	4.0	-1.7	0.7	0	7
1003	143	143	0.6	0.5	0.6	184922	1930	6	-0.1	2.7	0.6	2.1	-4.7	-1.7	0	7
1004	120	120	2.9	3.2	3.0	186683	2433	9	0.9	7.0	-0.6	3.1	-2.1	-3.7	0	7
1007	122	122	0.1	1.1	0.6	186700	1829	2	-0.2	5.2	-0.4	3.5	1.3	-3.8	0	7
1027	125	127	0.8	0.8	0.8		965	-3	0.2	2.7	0.4	2.0	-4.5	1.1	-1	8

LANDING DATA MODEL BOEING 767 AIRCRAFT
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LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN PORT FT/SEC	SINKING SPEED AT TOUCHDOWN STBD FT/SEC	SINKING SPEED AT TOUCHDOWN AVG FT/SEC	WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
14	131	122	3.8	1.8	2.2	287300	1498	5	0.6	8.7	8.9	3.8	-2.0	-4.7	9	3
18	142	132	3.1	2.7	2.9	242778	670	3	0.7	4.9	-0.9	-0.6	1.9	-2.3	9	3
30	131	122	2.7	3.7	3.7	247988	865	2	1.0	6.3	-0.3	0.8	1.1	-2.8	9	3
33	128	119	1.5	0.3	0.8	261600	2171	2	0.2	7.4	0.8	-1.7	6.2	-0.5	9	3
34	132	123	0.6	0.9	1.3	248200	1693	-9	0.4	5.6	1.9	0.3	-1.1	2.4	9	3
47	132	122	3.0	3.0	2.6	225787	1946	-1	0.7	4.2	-0.7	2.0	5.9	4.7	11	2
51	139	128	3.2	2.6	2.9	246900	1584	-5	0.8	6.5	-0.1	-0.7	2.0	-1.9	11	2
59	126	115	0.9	1.5	1.7		2281	1	0.5	7.3	3.3	-0.3	-3.4	-1.0	11	2
71	115	105	3.9	3.2	3.5	209680	573	0	1.1	6.1	-0.9	-0.3	-6.8	-5.4	10	4
76	136	126	2.5	4.6	3.6	217392	1643	-8	1.0	6.1	0.1	2.5	-1.5	4.5	10	4
78	151	141	0.2	0.2	0.2	271800	2413	-2	0.1	5.5	0.6	-1.1	-1.8	-1.0	10	4
80	122	112	0.6	0.1	0.2	219636	2241	1	0.1	6.8	-2.2	-0.9	2.8	-2.7	10	4
83	134	123	1.4	1.8	1.5	275300	1626	1	0.4	6.6	-1.8	1.1	-0.3	0.0	10	4
100	139	129	4.2	3.6	4.1	258850	882	-2	1.1	5.7	2.4	-0.8	2.7	-1.9	10	4
142	139	133	3.2	3.6	3.4	210900	944	2	0.9	4.3	-0.6	2.3	4.4	-1.5	6	10
151	152	147	1.1	2.5	2.5	230580	1887	-2	0.6	5.7	-1.0	2.5	24.0	-1.0	6	10
166	140	134	4.5	2.7	3.6	236400	946	-1	0.9	4.3	0.1	0.2	3.8	-1.5	6	10
168	144	139	4.2	3.0	3.6	246900	1542	-1	0.9	7.5	-3.4	0.5	13.2	-2.3	6	10
180	140	135	1.0	1.0	1.0	275300	2273	6	0.3	5.2	0.0	1.2	-1.4	-2.9	6	10
226	142	139	0.7	1.3	1.0	276943	1654	6	0.2	4.6	-1.2	0.6	-2.2	-3.5	3	8
234	135	130	2.2	2.5	2.4	249833	1801	6	0.6	6.9	-0.5	0.6	-1.8	-2.7	5	8
238	131	126	8.8	9.3	9.2	278660	544	-2	2.5	9.1	-3.7	0.3	6.2	-5.5	5	8
239	137	133	1.2	0.3	1.6	252500	2325	-2	0.4	5.2	0.4	0.2	5.4	-0.5	5	8
240	123	119	2.7	3.9	3.3	249000	4121	3	0.9	9.3	-0.6	2.3	-3.4	-1.5	5	8
265	138	133	4.5	3.3	4.0	253366	785	5	1.0	6.2	1.5	0.5	6.1	-3.1	5	13
269	141	136	3.0	3.5	3.4	269300	707	5	0.8	6.4	0.5	1.5	1.8	-2.2	5	13
270	140	136	0.4	2.0	2.4	278825	647	0	0.6	5.4	-1.0	2.4	-4.8	4.9	5	13
273	139	135	4.1	3.2	3.8	233700	637	4	1.0	6.2	1.6	0.8	3.7	1.7	5	13
298	139	135	0.1	1.0	0.5	229554	2154	-3	0.1	5.2	0.3	-0.1	0.3	-2.2	5	13
303	139	133	2.9	2.2	2.5	230010	1887	-1	0.6	4.3	0.8	1.1	5.8	-1.9	6	10
315	127	121	1.6	1.5	1.2	245800	1579	6	0.3	7.5	-1.7	0.2	-0.5	0.4	6	10
318	132	126	2.6	2.0	2.2	266400	1894	-19	0.6	5.5	-1.5	1.5	4.8	-3.5	6	10
319	140	134	3.3	3.7	4.1	229333	736	7	1.0	5.6	1.6	1.6	3.9	-3.4	6	10
339	130	123	3.1	4.4	4.3	220117	1810	3	1.2	6.6	2.7	3.0	0.0	-3.6	8	9
341	156	148	0.2	0.3	1.6	227616	1585	-2	0.3	6.8	0.0	1.0	12.2	2.5	8	9
353	138	130	2.1	2.5	2.7	213753	663	3	0.7	5.8	1.0	2.8	-6.1	3.0	8	9
355	140	133	1.2	0.3	0.8	247663	1746	0	0.2	4.1	-0.5	1.0	1.4	2.0	7	8
376	138	131	2.9	2.4	2.7	288117	775	-8	0.7	6.6	2.2	1.4	4.1	-2.0	7	8
383	129	118	0.6	0.4	0.5	216900	1748	9	0.1	5.0	-0.4	2.6	-4.3	-1.1	11	-6

LANDING DATA MODEL BOEING 767 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN PORT FT/SEC	SINKING SPEED AT TOUCHDOWN STBD FT/SEC	SINKING SPEED AT TOUCHDOWN AVG FT/SEC	WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
390	141	133	0.0	0.7	0.2		1588	7	0.1	6.2	2.7	-0.9	2.3	-1.3	8	-7
412	132	123	1.4	1.7	1.9		2101	-13	0.5	6.3	1.0	0.7	-0.9	3.8	10	-5
415	132	122	0.5	1.5	0.4		700	-8	0.1	5.3	0.6	-2.1	5.6	-2.2	10	-5
419	134	125	0.2	0.1	0.2	237000	1861	9	0.0	4.5	-2.1	0.3	0.2	-0.3	10	-5
423	143	134	2.9	1.4	2.2	264900	1665	5	0.6	7.2	-0.9	-0.7	2.5	-1.6	10	-5
429	134	124	0.1	0.1	0.1		1796	-1	0.0	3.9	0.8	-0.1	0.8	-0.8	10	-5
431	147	138	2.8	2.3	2.8		894	-7	0.7	4.6	3.5	0.1	-1.5	-1.2	10	-5
436	131	121	1.6	1.2	1.5	239700	1859	-3	0.4	6.4	0.6	0.8	1.9	-0.8	10	-5
437	136	126	2.7	3.4	3.1		1619	5	0.8	7.3	0.3	0.7	0.2	-2.0	10	-5
448	137	127	2.2	3.2	2.8		904	-6	0.7	4.9	1.3	1.3	-6.3	2.2	10	-5
454	128	119	0.3	0.6	0.5	224700	2125	-9	0.1	3.7	-0.2	-0.3	-1.6	0.9	9	-2
465	128	117	3.1	2.1	2.5	233200	1881	7	0.7	4.1	-1.4	0.6	5.0	1.6	11	-6
468	129	121	4.9	5.6	5.2	228339	871	0	1.5	5.9	-2.3	2.6	1.5	-2.0	9	15
506	137	128	3.5	4.3	3.2	272000	2125	5	0.9	5.3	-1.4	3.2	4.0	-2.6	9	16
508	142	133	5.5	5.7	5.8		886	9	1.5	7.1	-2.8	2.1	3.5	-5.4	9	16
509	146	137	2.5	2.4	3.2	245000	1886	11	0.8	6.4	-6.3	3.0	17.6	0.6	9	16
512	131	122	2.0	2.1	2.1	241400	2223	1	0.6	3.4	1.3	-1.6	7.0	-9.6	9	16
532	130	128	2.7	3.2	2.8	246100	2030	-2	0.7	7.0	-1.6	4.0	-3.7	-0.1	2	12
537	137	135	1.1	1.9	1.5	282600	1733	8	0.4	5.8	-0.2	0.5	-1.5	-4.8	2	12
540	137	135	0.4	1.5	0.7	256227	1601	7	0.2	3.6	2.8	3.1	9.1	-3.0	2	12
545	148	147	0.3	3.4	1.9	248672	1655	12	0.4	4.9	-3.7	3.4	-3.7	-3.1	1	8
580	145	152	0.9	0.8	0.8		1812	9	0.2	5.7	-2.5	0.3	2.4	-6.5	-7	12
615	140	134	0.7	0.7	0.6	237367	1885	12	0.2	3.9	1.3	0.1	5.3	-6.3	6	18
631	126	118	3.0	2.7	3.0	247100	818	4	0.9	5.3	-1.3	1.1	3.8	-4.0	8	22
637	148	141	0.8	1.2	1.7	268474	1603	3	0.4	5.2	3.5	1.4	8.7	1.5	8	22
644	134	126	2.6	5.7	4.1	268600	679	4	1.1	7.3	0.9	5.9	-3.7	-3.3	8	22
652	139	131	3.9	4.8	4.5	249400	824	-7	1.2	5.1	0.5	3.6	-2.5	-1.7	8	22
655	121	114	8.9	3.3	7.0	235218	1665	12	2.1	2.2	1.6	2.9	13.9	-5.1	8	22
667	137	130	1.5	0.1	1.1	238564	1769	7	0.3	4.8	-0.8	2.8	1.0	-3.2	8	22
669	143	135	1.3	3.0	2.1	266500	2271	11	0.5	3.8	0.4	0.7	0.8	-7.6	8	22
680	141	141	1.0	0.8	0.9	249500	2477	11	0.2	2.8	-0.7	1.5	2.5	-3.3	0	12
698	135	130	1.2	1.4	2.0	240654	746	-4	0.5	5.3	0.6	1.9	2.2	1.1	5	14
710	127	125	6.6	5.9	6.0	237900	551	2	1.6	5.3	3.0	3.0	21.4	0.7	2	12
720	135	133	3.8	3.0	3.6	237100	687	-1	0.9	6.5	0.3	2.4	4.1	1.4	2	12
729	136	134	4.1	4.1	4.1	222639	2251	-4	1.0	5.6	-1.8	4.7	-0.2	1.2	2	12
739	133	133	2.7	2.7	2.7	233500	1607	7	0.7	3.8	-5.2	0.0	-5.1	-3.8	0	10
759	143	145	4.2	2.4	3.2	219307	1575	9	0.8	6.1	-0.3	0.3	-0.7	4.4	-2	12
775	127	129	0.4	0.8	1.1	212758	1846	5	0.3	6.6	0.6	0.1	-2.2	-0.6	-2	12
813	149	144	2.5	4.1	2.6	267149	850	-12	0.6	5.3	0.5	1.4	-5.8	-1.9	5	9

LANDING DATA MODEL BOEING 767 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN			WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
			PORT FT/SEC	STBD FT/SEC	AVG FT/SEC											
817	161	156	0.3	-0.2	0.1	260000	1849	8	0.0	5.6	0.7	0.2	2.5	-4.2	5	9
822	131	120	0.7	0.5	0.5	254800	1853	0	0.2	7.3	-2.0	0.2	0.4	-4.0	11	9
831	132	121	2.2	2.2	1.9	231200	1677	7	0.5	4.3	-1.6	0.4	-1.2	-3.2	11	9
839	142	131	0.8	0.4	0.6	260263	1699	1	0.2	5.3	-1.9	-0.9	-2.3	-4.3	11	9
840	130	127	0.3	0.2	0.2	280600	1663	12	-0.5	6.5	1.6	0.5	2.5	-2.3	3	8
852	133	130	4.0	4.9	4.4		847	7	1.2	4.3	-1.6	1.9	-2.8	-0.7	3	8
868	127	126	1.4	2.2	1.9	255100	1716	7	0.5	4.8	-1.3	0.3	-0.5	-2.5	1	7
872	135	134	2.8	3.2	3.0	263300	712	3	0.8	4.9	0.0	-0.4	3.8	-3.1	1	7
908	136	133	0.4	0.8	0.5	239962	1750	0	0.1	4.7	-0.5	2.3	-2.0	-1.7	3	9
914	146	142	2.1	2.0	2.1		2437	4	0.5	5.3	-0.7	2.3	-2.1	-0.2	3	9
964	130	135	0.7	0.8	1.5	248145	1635	13	0.4	4.5	1.9	1.4	5.4	1.5	-5	4
974	128	129	3.7	3.8	3.7	237869	681	6	1.0	4.7	1.1	0.2	5.1	-4.9	-1	6
977	131	132	1.8	2.8	2.3	270400	2493	16	0.6	4.2	-1.5	3.8	-7.5	-4.0	-1	6
985	129	130	0.7	1.3	1.0	233882	1869	0	0.3	5.3	0.4	0.5	1.1	1.0	-1	6
987	136	137	5.5	6.4	6.0	269300	663	0	1.5	5.6	-0.9	0.8	3.3	-3.7	-1	6
990	137	138	5.4	4.0	4.8	302861	780	-3	1.2	5.9	2.4	1.0	6.6	-3.0	-1	6
1005	130	130	3.8	3.8	3.8	254771	1183	11	1.0	5.3	-3.0	1.5	2.8	-7.8	0	7
1009	132	132	3.1	2.3	2.7	246200	941	-3	0.7	5.5	0.8	3.2	5.7	0.5	0	7
1013	130	130	3.8	2.9	3.4	259500	956	18	0.9	5.6	-2.5	0.0	-1.0	-2.0	0	7
1019	128	128	3.5	3.0	3.2	180000	2160	4	0.8	5.7	-0.7	0.0	2.8	-4.8	0	7
1022	124	125	1.3	0.1	0.7	239657	2418	7	0.2	5.4	-2.3	-0.7	3.1	-3.4	-1	8

LANDING DATA MODEL CONCORDE AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN PORT FT/SEC	SINKING SPEED AT TOUCHDOWN STBD FT/SEC	SINKING SPEED AT TOUCHDOWN AVG FT/SEC	WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
62	168	157	4.2	5.8	5.9	Not	831	-5	1.3	11.0	-2.1	-1.1	0.2	-0.9	10	4
186	170	166	4.6	5.6	5.1	Recorded	4110	-6	1.0	10.1	-2.6	1.4	-14.2	-2.6	3	9
333	180	173	2.8	2.7	2.8		1897	-9	0.6	11.3	0.3	0.3	10.5	1.8	8	9
544	173	171	0.7	0.4	0.6		1760	4	0.1	11.1	0.4	-0.8	4.4	-4.5	1	8
758	151	153	1.6	0.4	1.0		1966	-15	0.2	10.7	1.0	-1.9	7.9	-1.2	-2	12
850	155	152	0.6	0.8	0.7		1337	3	0.2	11.8	-2.4	1.9	-3.9	-5.3	3	8
1024	151	152	3.8	3.8	3.8		1252	-9	0.9	11.0	1.9	0.0	-3.6	-2.3	-1	8

LANDING DATA MODEL LOCKHEED L-1011 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN			WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
			PORT FT/SEC	STBD FT/SEC	AVG FT/SEC											
38	138	129	3.2	3.1	3.0	307840	2212	1	0.8	8.3	0.3	-0.1	1.4	-1.4	9	3
93	139	131	2.1	2.3	2.5	336141	754	5	0.6	8.7	4.0	1.5	-2.3	-1.9	8	3
125	151	147	2.0	2.8	2.4	305767	2412	-4	0.6	6.5	-2.7	2.6	0.1	0.6	4	11
149	148	143	9.0	7.5	8.3	331102	916	10	2.0	7.5	-0.9	5.0	4.3	-4.9	6	10
262	163	158	1.9	1.5	1.7	334771	2433	4	0.4	6.0	-0.9	1.0	2.4	-0.7	5	13
324	143	137	0.4	1.2	0.7	322160	2014	-2	0.2	8.6	-3.8	1.5	-9.3	-0.7	6	10
335	146	139	1.4	1.9	1.7	327897	2440	9	0.4	7.1	1.4	2.4	-1.8	-1.5	8	9
434	168	159	2.0	0.6	1.2		2190	-5	0.3	6.8	-3.1	0.3	-0.8	8.7	10	-5
439	143	134	5.5	5.9	5.7	338200	690	-6	1.5	9.6	-1.2	0.2	-0.3	2.2	10	-5
450	152	143	0.0	1.0	0.6	461941	1717	16	-0.2	6.3	-0.1	0.7	3.4	-2.4	10	-5
520	149	140	1.1	2.8	2.0		2246	6	0.5	8.8	2.0	5.2	-1.7	-2.5	9	16
583	124	118	0.5	1.2	1.4	322443	1680	8	0.4	8.8	-1.0	1.6	7.8	-8.5	7	11
617	143	137	3.1	2.0	2.5	323514	2425	8	0.6	9.1	-1.9	2.5	3.1	-6.3	6	18
657	149	141	2.7	5.2	4.0		748	5	1.0	6.3	1.5	5.1	0.1	-3.5	8	22
719	140	138	1.6	1.0	1.3	276176	1911	8	0.3	7.7	-2.4	1.5	-0.3	-0.9	2	12
721	140	138	4.4	4.3	4.3	317302	868	3	1.1	8.5	1.7	0.0	-1.2	1.9	2	12
724	135	133	5.7	6.2	5.9	303539	911	-12	1.5	8.0	-0.8	2.3	-1.7	0.2	2	12
728	141	139	4.1	5.0	5.1	320448	769	2	1.3	7.1	2.5	2.8	5.9	-2.0	2	12
741	100	100	3.1	4.4	3.4	317092	653	1	1.1	8.5	-14.6	3.5	-15.9	-21.8	0	10
781	151	158	0.3	1.8	1.1	347852	2416	-1	0.2	6.0	0.5	4.2	-1.2	-1.8	-6	8
820	140	129	3.5	3.1	3.3	314701	861	-9	0.9	8.6	-2.3	0.9	-0.3	-0.7	11	9
825	139	128	1.7	1.9	1.8	314553	793	-5	0.5	9.0	-0.7	0.8	3.0	-1.1	11	9
921	148	143	2.9	3.1	3.0		1909	-4	0.7	6.8	0.8	0.4	-0.8	1.3	5	9
967	143	144	1.9	1.8	1.9	343192	941	3	0.4	5.5	-0.6	2.3	-2.0	0.3	-1	6
980	137	138	2.0	1.7	1.9	343161	1752	12	0.0	6.8	-1.9	0.4	6.1	-5.6	-1	6
991	143	144	3.8	3.9	4.1	325140	757	10	1.0	6.7	2.6	3.1	5.6	-3.5	-1	6
998	126	126	3.1	3.0	3.4		806	-2	0.9	8.6	0.7	1.2	1.0	-2.3	0	7
1000	131	131	2.2	2.5	2.4	331286	4136	11	0.6	8.5	1.7	3.0	1.5	0.4	0	7
1010	150	150	0.0	2.2	1.1	343287	1621	4	0.2	7.4	-0.6	3.0	-3.8	-1.9	0	7
1014	149	149	2.6	3.0	3.0	337430	814	-1	0.7	7.4	2.5	1.4	-1.1	0.2	0	7

LANDING DATA MODEL DOUGLAS DC-9 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN PORT FT/SEC	STBD FT/SEC	AVG FT/SEC	WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
4	133	123	0.9	0.6	0.8	95300	811	-4	0.2	7.2	-1.2	-0.3	-0.6	-4.7	9	3
35	138	128	1.5	1.7	1.7		656	3	0.4	8.5	2.2	0.7	1.3	-5.0	9	3
124	135	131	2.8	3.7	3.2		2127	10	0.8	7.1	1.8	1.4	5.8	-7.1	4	11
172	150	144	1.7	0.8	1.2	115093	1960	-1	0.3	6.1	1.3	1.3	2.8	-3.1	6	10
179	148	142	0.8	2.6	2.8	210100	749	5	0.7	4.6	0.3	0.4	5.3	-3.6	6	10
219	122	119	0.1	0.7	0.3		2301	3	0.1	5.8	0.6	-0.5	0.4	-2.1	3	8
329	144	136	0.0	0.6	0.3	95300	1764	5	-0.2	5.2	1.8	3.5	5.2	-4.1	8	9
385	144	133	0.9	0.6	0.8	95300	1710	13	0.2	6.0	-4.1	0.6	2.0	-3.3	11	-6
534	133	131	3.1	1.8	2.4	95300	885	-3	0.6	6.5	0.8	2.0	7.6	-2.8	2	12
546	150	149	4.4	4.2	4.5	95300	647	4	1.0	8.0	-0.9	1.8	12.9	0.8	1	8
564	130	137	0.7	0.5	0.5	89692	1937	10	0.1	4.8	0.2	1.9	2.8	-2.7	-7	12
593	135	130	2.8	3.7	3.6	94593	805	-5	0.9	4.8	-0.6	3.2	-0.5	-3.8	5	15
684	139	133	1.8	2.5	2.3		875	7	0.6	3.8	3.4	1.0	1.1	-4.1	5	14
774	127	129	0.2	0.6	0.4	79171	1667	12	-0.1	3.7	3.4	0.8	-6.1	-3.6	-2	12
871	135	134	0.5	0.4	0.5	95000	1903	11	0.1	6.4	1.8	2.5	0.0	-1.9	1	7
905	145	142	2.4	2.4	2.4	105002	1687	5	0.6	7.2	-2.1	1.3	4.6	-6.4	3	9

LANDING DATA MODEL DOUGLAS DC-10 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN			WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
			PORT FT/SEC	STBD FT/SEC	AVG FT/SEC											
126	132	126	3.6	3.0	3.3	310000	883	3	0.9	6.5	-2.0	1.5	0.2	-1.9	6	10
128	153	147	2.5	2.7	2.6	319300	1568	-2	0.6	5.4	0.7	1.8	-2.2	-0.1	6	10
272	129	124	4.8	4.8	4.8	306472	817	1	1.3	8.0	-2.2	1.6	-0.4	-4.4	5	13
406	140	130	0.7	1.3	0.9		747	-3	0.2	5.4	2.8	1.5	0.5	0.8	10	-5
407	135	125	0.8	2.1	1.5	329700	1697	0	0.4	6.5	0.2	0.3	0.9	-0.1	10	-5
484	142	136	4.2	3.6	3.9	403445	897	-3	1.0	6.3	0.5	0.4	-1.1	-1.4	6	17
486	143	137	0.4	1.6	1.1	318900	1855	6	0.3	6.7	1.1	2.3	-1.2	-4.0	6	17
598	155	150	4.0	5.1	4.8		730	2	1.1	5.5	0.4	0.4	5.1	-3.1	5	15
622	144	136	0.2	0.5	0.4	322500	1788	12	0.0	7.7	0.2	0.7	2.9	-2.7	8	22
702	152	150	5.0	5.9	5.6	310300	596	-2	1.3	7.3	1.5	1.3	2.1	0.2	2	12
757	146	148	0.5	0.4	0.5	321900	2378	-1	0.1	5.6	-0.1	2.2	1.3	-3.1	-2	12
968	134	135	1.7	1.3	1.5	354600	1884	6	0.4	7.7	2.0	3.3	1.4	-3.6	-1	6

LANDING DATA MODEL MD-11 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN			WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
			PORT FT/SEC	STBD FT/SEC	AVG FT/SEC											
39	150	141	0.3	0.0	0.2	360700	2412	-3	0.0	5.3	0.7	3.0	-2.5	0.7	9	3
77	161	151	4.8	4.1	4.6	270500	1509	-13	1.0	4.7	-0.8	-0.6	8.3	-1.2	10	4
150	149	144	3.8	4.8	4.2	360700	1550	-7	1.0	5.8	-3.1	1.4	-3.2	-1.5	6	10
182	153	147	3.5	2.9	3.6		667	5	0.8	6.2	-0.1	0.2	-0.6	-4.2	6	10
301	160	154	4.8	4.6	4.9	368500	706	-9	1.1	5.9	2.4	0.4	4.9	-0.1	6	10
348	141	133	0.9	0.7	1.2	399900	1685	-3	0.3	6.7	3.3	0.7	0.4	0.6	8	9
380	144	133	1.2	0.5	0.7	352800	1824	5	0.2	7.1	-0.5	0.3	-0.8	-1.7	11	-6
582	117	124	2.8	6.8	4.7		1569	0	1.3	6.0	-0.7	2.8	-3.9	-0.4	-7	12
594	148	142	3.5	3.3	3.8	363500	750	1	0.9	3.8	0.7	0.9	3.3	-2.2	5	15
777	161	163	4.7	5.2	5.2	384200	735	1	1.1	6.2	0.1	1.8	-2.2	-0.4	-2	12
942	145	140	5.7	5.2	5.7	362000	1997	-4	1.4	3.9	-2.5	-0.9	-0.6	0.6	5	9
1011	173	173	4.1	2.1	3.1	381400	1508	-4	0.6	4.3	-0.4	-4.3	6.0	-4.2	0	7

LANDING DATA MODEL MD-80 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN			WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS	CROSS-WIND KNOTS
			PORT FT/SEC	STBD FT/SEC	AVG FT/SEC										AT TOUCHDOWN	
53	131	120	0.9	1.0	0.9	101467	2430	-2	0.3	4.6	0.6	1.8	-4.2	2.0	11	2
88	150	142	1.3	1.4	1.3	110171	1644	-1	0.3	5.0	-2.4	2.3	1.7	-5.2	8	3
123	157	153	3.0	3.7	3.3	115622	1495	-4	0.7	7.5	-2.9	0.9	2.1	-5.7	4	11
132	132	127	0.3	0.5	0.7	109105	1585	-7	0.2	4.8	1.8	0.5	-1.2	0.9	6	10
141	143	138	2.8	2.6	2.5	126247	896	-5	0.6	5.9	-0.8	1.3	2.1	-0.1	6	10
160	133	128	2.2	2.5	2.4	119486	1509	4	0.6	9.8	0.0	1.3	19.3	-5.8	6	10
211	137	134	2.4	2.4	2.4	117246	1520	8	0.6	4.4	-1.4	-0.7	-6.4	-2.0	3	8
255	146	142	1.7	2.3	2.1		1751	9	0.5	7.8	0.8	3.1	3.5	-6.8	4	10
274	130	126	1.2	2.1	1.4	108657	1661	2	0.4	4.0	-2.4	2.3	-2.6	-1.4	5	13
299	138	134	2.5	3.4	2.9	117070	782	3	0.7	3.8	-0.1	3.0	1.8	-1.6	5	13
312	135	129	2.9	3.2	3.1	117686	1913	-12	0.8	8.2	0.8	1.2	5.6	-5.6	6	10
326	142	136	4.9	5.4	5.1	112695	2083	-9	1.3	5.2	-2.1	2.5	6.2	1.6	6	10
351	164	156	5.1	4.4	4.9	112485	1716	-2	1.1	5.0	-0.7	0.9	-12.0	-2.1	8	9
361	143	136	1.8	1.4	1.6	117838	1867	1	0.4	3.7	-1.7	-0.1	-1.4	-1.4	7	8
366	137	130	1.3	0.4	1.3	124312	1760	-10	0.3	5.5	-0.4	-0.4	2.8	-0.5	7	8
387	143	132	2.7	2.5	2.6		1001	8	0.7	8.4	-1.7	0.8	1.0	-8.6	11	-6
402	135	126	0.4	0.7	0.6	117600	2401	-7	0.2	4.4	-0.8	2.5	-1.1	-0.1	8	-7
417	118	109	1.7	1.8	1.6		2243	-2	0.5	7.7	-4.6	0.2	5.5	-4.5	10	-5
428	140	130	2.5	2.5	2.6		2113	2	0.7	8.6	1.9	-0.3	7.3	-3.7	10	-5
438	152	142	0.0	0.0	0.0		1893	4	0.0	4.3	-0.7	-2.6	-0.5	0.0	10	-5
446	151	141	5.8	6.5	6.2	122700	1584	7	1.5	5.6	-2.0	0.7	-3.8	-1.7	10	-5
475	141	135	1.6	2.4	2.0		1917	15	0.5	6.6	-3.0	4.4	-4.0	-9.3	6	17
490	135	126	1.8	1.7	1.9		863	10	0.5	6.1	1.7	2.2	-2.0	-0.4	9	16
502	144	135	2.5	2.3	2.3		1753	10	0.6	6.0	-2.5	-0.3	3.2	-3.4	9	16
531	136	134	1.8	1.2	1.5	120919	838	-8	0.4	3.7	0.4	1.7	-4.2	-1.6	2	12
536	143	141	1.1	1.1	1.1	125254	1529	6	0.1	6.4	-1.9	0.9	-22.4	-9.6	2	12
538	132	130	1.1	2.4	1.9	114466	801	3	0.5	5.0	1.7	1.8	-2.3	-4.2	2	12
566	128	135	0.7	0.9	0.8		1950	8	0.2	7.4	0.4	0.8	-3.5	-6.1	-7	12
597	138	133	0.2	0.1	0.3		1815	8	-0.1	5.0	-0.8	2.9	3.4	-4.2	5	15
599	142	136	0.1	0.4	0.3		1928	5	0.1	2.6	0.5	2.0	-1.9	-0.3	5	15
612	141	134	7.0	8.3	8.2	113596	652	-9	2.1	6.8	-0.8	1.2	5.1	-2.4	6	18
650	130	123	1.1	1.9	1.5		673	4	0.4	3.4	-1.8	2.7	-3.0	-1.9	8	22
653	129	122	1.9	2.1	1.9	115803	933	4	0.5	5.1	-0.4	0.0	0.5	-1.2	8	22
660	144	136	4.9	5.8	5.4	113780	692	-2	1.3	5.5	-0.2	3.2	4.9	-2.1	8	22
661	145	138	5.2	5.5	5.3	113919	609	1	1.3	5.1	-3.2	0.8	4.0	0.1	8	22
671	138	137	3.8	3.8	4.1	126861	677	-5	1.0	4.5	0.1	1.6	3.6	-2.2	2	11
692	136	131	5.4	4.8	5.1	110100	931	-8	1.3	5.9	-1.4	2.1	8.1	0.9	5	14
709	134	132	0.0	1.0	0.6	104082	2091	-7	0.2	4.2	3.5	0.9	0.6	2.6	2	12
722	138	136	1.2	2.4	1.9	118703	892	1	0.5	4.5	2.7	2.4	-0.1	-2.5	2	12

LANDING DATA MODEL MD-80 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN PORT FT/SEC	SINKING SPEED AT TOUCHDOWN STBD FT/SEC	SINKING SPEED AT TOUCHDOWN AVG FT/SEC	WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
730	138	138	1.9	2.0	2.1	116099	818	3	0.5	3.6	0.0	0.6	5.9	-1.9	0	10
734	131	131	1.8	2.0	2.1	116579	2069	5	0.6	3.9	1.1	-0.3	3.4	-1.7	0	10
745	140	140	1.6	1.3	1.4	116981	2353	7	0.3	5.3	-1.0	1.7	0.4	-9.8	0	10
747	127	127	4.3	5.6	5.1	101940	900	-2	1.4	4.5	-1.7	2.4	0.9	-0.7	0	10
785	140	147	0.6	0.6	0.5	114830	1710	9	0.1	4.6	1.0	0.0	4.9	-1.9	-6	8
790	138	144	5.2	5.6	5.4		876	0	1.3	4.4	-0.4	0.9	-5.1	-0.4	-6	8
832	131	120	0.2	0.5	0.4	115749	1550	6	0.1	5.6	0.8	0.7	-1.3	0.4	11	9
842	134	131	0.1	0.4	0.2	109709	1895	3	0.0	3.9	-0.9	1.3	-3.2	-1.9	3	8
845	135	132	2.5	3.1	2.8	127525	895	-3	0.7	5.1	-0.6	0.7	-0.1	-1.0	3	8
849	147	144	0.3	0.7	0.5	99079	1772	10	0.1	5.0	-0.1	0.9	3.4	-0.6	3	8
884	131	129	4.1	3.4	4.4	113491	1575	11	1.2	5.1	2.8	-0.5	14.9	-10.5	1	7
886	155	154	2.6	2.5	2.5		1724	2	0.6	2.0	-3.2	0.5	0.2	-0.3	1	7
926	153	148	2.3	1.6	2.0	127964	2258	-3	0.4	4.8	-1.2	1.3	5.6	0.7	5	9
927	144	140	0.5	1.5	1.0		1942	5	0.2	9.8	-1.5	1.8	-4.3	-10.4	4	10
930	136	132	0.5	0.9	0.7	109100	2422	-3	0.2	2.9	0.1	2.6	2.8	0.6	4	10
949	145	140	4.5	4.7	4.6	118881	786	0	1.1	3.9	-1.2	0.9	5.7	-1.1	5	9
951	137	132	4.2	4.3	4.5		741	4	1.2	8.7	-4.5	-0.1	21.1	-2.1	5	9
978	141	142	2.3	2.5	2.4	128218	672	-2	0.6	3.7	0.4	4.3	5.8	-1.0	-1	6
988	126	127	1.9	1.3	1.5	125467	1868	11	0.4	5.2	-2.4	0.9	-2.1	-2.6	-1	6
1008	131	131	1.1	2.0	1.5	112706	2433	0	0.4	2.4	-1.6	2.7	-0.7	-0.9	0	7
1012	141	141	1.0	0.9	1.0	118276	1933	11	0.2	3.3	-0.4	0.9	-2.7	-3.2	0	7
1016	139	139	0.5	0.9	0.7	82600	1798	6	0.2	2.1	1.0	2.5	-0.8	0.0	0	7

LANDING DATA MODEL ATR-42 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN PORT FT/SEC	STBD FT/SEC	AVG FT/SEC	WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
28	101	92	2.1	1.6	1.9	32771	2397	-2	0.7	3.9	0.9	0.4	2.6	3.0	9	3
73	107	97	1.3	2.9	2.1		2459	-4	0.7	2.9	5.7	3.7	-3.8	-2.2	10	4
183	103	98	0.7	1.4	1.9	35000	2197	-6	0.6	5.5	-2.9	2.6	9.1	-5.6	6	10
253	96	93	1.6	2.3	2.0	36160	2439	-2	0.7	6.0	0.9	5.5	5.5	2.1	4	10
259	114	111	2.7	1.9	2.5	36160	2404	1	0.8	5.2	0.3	0.6	9.7	3.3	4	10
261	121	116	2.1	0.8	1.5	36160	743	-4	0.4	1.4	1.6	3.7	-5.6	1.0	5	13
323	115	109	1.2	1.2	1.2	36160	2422	-2	0.4	3.2	2.9	3.8	7.8	0.7	6	10
352	104	97	2.0	2.1	1.9	36160	2448	0	0.7	6.2	-4.3	1.7	-2.1	-1.5	8	9
379	109	98	0.4	0.1	0.2	35000	2399	-7	0.1	4.2	1.6	-1.5	9.3	1.3	11	-6
393	98	89	0.5	0.1	0.3	35000	2256	-1	0.1	2.1	-2.2	-1.4	8.2	-0.2	8	-7
409	111	102	1.9	2.0	2.0	32716	2447	-6	0.7	2.9	-2.2	0.1	-6.7	3.1	10	-5
420	118	109	1.4	1.0	1.2	35000	1869	2	0.4	5.4	-3.0	0.4	0.9	0.9	10	-5
478	108	102	1.8	1.0	1.4	34758	2012	4	0.5	6.0	-1.5	2.2	8.3	0.4	6	17
480	121	115	0.8	1.3	1.1	36160	1711	11	0.3	2.0	0.7	6.9	7.5	1.9	6	17
535	112	110	0.7	1.4	1.0	36160	2383	-2	0.3	2.0	0.7	3.5	-0.5	-1.3	2	12
590	109	103	0.7	1.5	1.1	33461	811	-4	0.4	4.8	-5.1	2.0	0.1	7.1	5	15
592	100	94	1.3	2.9	2.1	36160	1783	11	0.8	3.7	-4.3	7.2	2.6	-1.4	5	15
624	110	102	2.6	3.0	2.7	36160	1853	10	0.9	7.4	-5.4	2.6	2.7	-2.2	8	22
636	123	115	2.2	1.7	2.3	36814	1933	10	0.7	2.9	3.0	3.4	3.3	-3.0	8	22
670	129	122	0.6	0.5	0.6	33745	1584	7	0.2	1.2	-2.3	14.7	-5.2	2.1	8	22
690	117	112	1.9	1.6	1.8	35372	678	-5	0.5	0.0	0.4	1.7	5.9	-0.3	5	14
697	109	104	0.5	1.3	0.9	36160	2459	-2	0.3	2.9	3.4	7.3	-4.6	-0.6	5	14
699	111	106	2.5	3.2	2.8	36160	825	-4	0.9	3.6	-0.5	7.8	-3.5	-3.5	5	14
751	101	101	1.1	2.8	1.9	36160	866	-3	0.7	2.7	-4.0	4.9	0.9	-3.3	0	10
760	104	106	1.5	1.1	1.3	31350	1789	0	0.4	3.8	-3.1	4.5	0.6	0.6	-2	12
763	119	121	0.7	1.0	0.9	36160	2456	1	0.2	1.9	2.0	3.1	3.6	0.9	-2	12
793	106	113	0.9	0.3	0.6	36160	1864	4	-0.2	3.9	1.9	4.4	0.3	-3.4	-6	8
816	123	118	3.8	4.1	4.0	36160	2466	-2	1.1	2.2	-4.4	4.0	-5.5	-1.6	5	9
823	113	103	1.5	0.7	1.1		2331	-2	0.4	2.0	2.7	-0.9	-8.2	-1.2	11	9
867	106	105	0.2	0.3	0.2	35000	1914	-1	0.1	3.8	0.3	2.0	-2.3	2.3	1	7
876	114	113	1.3	0.9	1.1	35000	947	-4	0.3	4.2	0.5	2.3	13.7	3.0	1	7
912	114	111	1.2	1.7	1.5	32943	1012	3	0.5	2.9	3.9	5.3	8.6	-0.4	3	9
918	115	110	0.0	-0.7	-0.4	35000	2440	-5	-0.1	4.3	4.1	4.4	3.2	1.0	5	9
922	112	107	1.0	1.2	1.1	35000	2395	1	0.3	3.6	0.3	3.6	2.5	1.2	5	9
924	128	123	0.6	0.2	0.4	35000	1663	10	-0.1	2.8	-0.8	2.5	-0.7	1.0	5	9
940	114	109	1.7	1.3	1.5	33992	1868	5	0.5	4.3	-0.6	-3.0	1.1	-4.0	5	9
956	101	105	1.2	1.0	1.1	35000	2437	-2	0.4	2.1	-0.6	3.9	-0.6	-2.4	-5	4
958	94	99	-0.9	1.6	0.4	35108	1739	13	0.1	2.8	-4.7	10.6	-11.3	-4.6	-5	4
982	110	111	-0.3	0.1	-0.1	35000	2436	11	0.0	2.3	-0.7	7.1	9.6	-4.7	-1	6
994	100	102	0.3	0.9	0.6	35000	925	9	0.2	3.1	-2.7	4.7	-4.3	0.0	-1	6
1017	100	100	0.2	0.4	0.3	35000	1837	7	-0.1	4.7	0.6	6.5	4.2	0.3	0	7
1023	97	98	1.2	1.1	1.2	35000	1658	14	0.4	2.3	0.2	4.6	9.4	-0.6	-1	8

LANDING DATA MODEL DEHAVILLAND DASH-7 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN PORT FT/SEC	SINKING SPEED AT TOUCHDOWN STBD FT/SEC	SINKING SPEED AT TOUCHDOWN AVG FT/SEC	WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
9	77	67	0.3	0.9	0.6		1759	-6	0.3	6.3	-6.1	2.3	1.2	1.3	9	3
25	76	67	1.4	1.6	1.5		2150	-1	0.7	3.8	-1.9	-0.7	17	10	9	3
31	90	81	1.4	1.0	1.2		921	-1	0.5	1.1	0.2	1.1	-1.9	3.8	9	3
46	97	86	1.2	1.9	1.6		2449	-3	0.6	1.7	-0.7	4.3	-1	1.9	11	2
87	77	69	2.4	0.7	1.6		1873	-4	0.8	3.4	-5.2	-3.7	10.3	-3.8	8	3
140	99	93	1.4	1.3	1.4	35000	1507	-3	0.5	3.9	-0.1	3.2	-0.3	0.7	6	10
153	95	89	3.1	1.5	2.3	35000	2425	-3	0.9	-0.1	-1.7	1.5	6.2	3.7	6	10
201	88	85	5.3	4.6	4.9	42000	2395	-6	2	1.1	-1.9	-0.3	0.3	-1.9	3	9
225	90	87	2.0	0.7	1.5	42000	1742	2	0.6	1.4	4.9	2.5	24.6	14	3	8
292	97	92	3.5	4.8	4.1	42000	2398	-2	1.5	4.9	-4.9	7.3	1.7	0.8	5	13
302	78	72	0.8	3.4	2.1	42000	2096	2	1	4.7	-2.7	0.1	16.6	-14	6	10
347	88	81	1.2	3.1	2.2	42000	1445	1	0.9	4	-7.8	4.8	-5.9	0.5	8	9
426	91	81	3.2	3.2	3.2	35000	2253	-7	1.3	5.1	-0.6	-0.2	-13.8	-1.2	10	-5
517	96	87	3.6	3.0	2.9	42000	2011	0	1.1	1.8	3.5	5	9.1	-4.8	9	16
518	106	97	1.5	1.1	1.5	42000	2117	4	0.5	3.3	2.3	3.6	4.6	-4.4	9	16
526	129	127	1.4	0.8	1.1	42000	1969	0	0.3	6.6	7.5	3.6	4.1	-0.2	2	12
550	114	113	2.7	2.2	2.5	42000	1944	-1	0.7	3.3	1.8	6.2	6.3	3.3	1	8
601	91	85	3.3	4.6	3.9	42000	1892	7	1.6	3.7	-2.7	4.8	-5.2	-1.5	6	18
630	99	91	1.9	1.2	1.6	42000	2112	0	0.6	5.7	-0.1	5.9	4	1.5	8	22
654	90	82	3.8	2.8	3.1	42000	1599	12	1.3	4.9	-0.8	1.8	3.1	1.8	8	22
744	90	90	1.7	0.8	1.2	42000	2136	-12	0.5	4.5	-1.7	4.9	1.9	4.5	0	10
811	97	92	1.1	0.5	0.9	42000	619	-7	0.3	-0.7	-1.5	0.5	2.7	1.7	5	9
900	88	85	1.1	2.0	1.6		2419	1	0.6	2.7	-1.9	4	0.6	0	3	9
923	87	82	1.4	3.0	2.2	35000	892	-1	0.9	3.8	-2.3	5.2	-4.5	-0.2	5	9
932	90	87	1.8	1.6	1.7	35000	2428	0	0.7	3.4	0	1.7	-1.8	-0.6	4	10
950	81	76	1.8	2.3	2.0	35000	2458	0	0.9	-0.5	-3.4	2.7	-5.2	-3	5	9

LANDING DATA MODEL DEHAVILLAND DASH-8 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN			WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS (AT TOUCHDOWN)	CROSS-WIND KNOTS (AT TOUCHDOWN)
			PORT FT/SEC	STBD FT/SEC	AVG FT/SEC											
3	74	65	0.0	0.6	0.3		1788	-1	0.2	6.7	-0.7	2.7	-4.0	-1.0	9	3
171	122	117	2.9	4.5	4.0		688	-21	1.2	6.1	3.0	0.9	-3.8	-2.5	6	10
374	95	88	1.5	1.3	1.7		675	-3	0.7	3.2	-1.3	0.3	3.6	-0.2	7	8
388	86	77	0.9	0.3	0.6		1876	5	0.3	5.2	0.9	-0.1	4.0	-2.2	8	-7
466	115	107	1.0	1.2	1.1	42000	2333	0	0.4	5.1	-2.7	4.7	-1.0	-1.1	9	15
588	105	100	0.3	0.1	0.2		1946	10	0.0	7.5	-1.2	3.9	0.7	-3.1	5	15
676	89	88	1.8	2.0	2.0		2160	-1	0.8	5.6	-0.2	6.2	1.5	-1.2	2	11
682	101	101	0.2	0.4	0.3		1860	6	-0.1	5.7	-4.0	3.9	-0.6	0.4	0	12
810	92	99	0.3	0.1	0.2		1846	9	-0.1	5.2	-2.5	4.1	-2.2	-2.0	-6	8
939	112	107	2.0	1.6	1.8		2095	-1	0.6	7.3	3.5	0.2	3.3	-4.2	5	9

LANDING DATA MODEL SAAB SF-340 AIRCRAFT
FAA SURVEY JOHN F. KENNEDY INTERNATIONAL AIRPORT

LNDG NO.	POWER APPROACH AIRSPEED KNOTS	CLOSURE SPEED KN	SINKING SPEED AT TOUCHDOWN PORT FT/SEC	STBD FT/SEC	AVG FT/SEC	WEIGHT LBS	RAMP TO TD DIST FT	RUNWAY OFF-CENTER FEET	GLIDE SLOPE ANGLE TD DEGREE	PITCH ANGLE TD DEGREE	PITCH RATE TD DEG/SEC	ROLL ANGLE TD DEGREE	ROLL RATE TD DEG/SEC	YAW ANGLE TD DEGREE	HEAD WIND KNOTS AT TOUCHDOWN	CROSS-WIND KNOTS AT TOUCHDOWN
8	116	106	1.6	2.6	2.3	22750	1735	-4	0.7	3.6	-4.2	5.0	-5.8	2.4	9	3
65	122	112	1.1	1.3	1.2	23000	1979	0	0.4	5.0	-2.4	-0.7	1.4	-4.8	10	4
129	122	116	0.2	1.6	0.9	33442	1790	-2	0.3	1.2	-1.2	4.8	-3.5	-1.6	6	10
145	105	99	1.6	1.1	1.3	22000	1695	0	0.4	3.9	0.9	-0.7	9.0	-2.1	6	10
327	113	107	0.9	0.3	0.2		2279	-1	0.1	3.4	0.4	2.9	1.2	-2.4	6	10
337	109	102	0.7	1.5	1.1		1858	0	0.4	5.1	-1.5	5.5	-1.6	-0.4	8	9
356	113	106	0.3	1.1	0.7		1693	-5	0.2	5.5	-2.9	3.7	-5.8	0.6	7	8
400	113	104	0.1	0.1	0.1		1581	3	0.0	3.7	0.3	-0.1	0.9	-4.2	8	-7
413	132	123	0.2	1.2	0.7	26267	2149	4	0.2	5.5	-2.8	0.0	-6.0	-0.7	10	-5
442	112	103	0.9	1.0	0.9	25500	885	-5	0.3	1.8	1.0	-0.7	-6.8	1.5	10	-5
492	120	111	1.7	0.2	1.1	25791	2081	-2	0.3	6.7	3.4	2.1	7.8	0.8	9	16
501	109	100	1.4	0.1	0.7		826	-6	0.2	3.5	1.0	5.9	-0.7	-3.1	9	16
558	116	115	0.9	1.3	1.1		2322	-1	0.3	2.6	0.7	6.6	1.0	-0.2	1	8
595	98	93	2.5	3.5	3.0	22500	685	0	1.1	4.7	1.6	5.1	6.7	-0.7	5	15
611	116	109	1.0	3.3	2.1	25100	1974	4	0.7	4.5	-4.1	1.5	-14.2	-1.4	6	18
625	115	107	0.2	0.2	0.2	25403	1797	9	0.0	1.0	0.1	5.8	1.6	-6.0	8	22
666	118	110	2.4	2.3	2.3	23000	762	13	0.7	3.9	-0.1	7.8	1.0	-5.0	8	22
701	115	113	1.5	1.4	1.4	35536	948	2	0.4	2.3	-0.5	4.8	5.0	-0.6	2	12
768	114	116	1.5	1.1	1.4		2463	-1	0.4	5.1	1.9	4.5	4.9	0.4	-2	12
771	122	124	2.9	2.6	2.7		856	-5	0.7	1.7	-1.7	2.3	-0.8	-2.1	-2	12
797	126	133	0.2	0.7	0.4	25317	1833	15	0.1	1.0	-1.0	2.5	-4.1	-4.4	-6	8
800	116	122	0.5	0.5	0.5		1730	7	0.1	2.9	-3.2	3.8	4.2	-1.2	-6	8
815	127	122	0.7	0.1	0.4		1927	9	-0.1	3.6	2.3	2.2	-4.0	-1.5	5	9
818	134	129	0.6	2.0	1.3		2393	-3	0.3	1.4	-2.7	6.1	-5.4	-0.6	5	9
838	116	105	0.0	0.2	0.1		865	-5	0.0	3.0	-1.8	1.4	-2.3	1.2	11	9
853	107	104	0.2	1.0	0.6		1694	11	-0.2	2.6	-0.7	2.8	2.5	-2.6	3	8
882	113	111	0.3	0.3	0.3		1969	9	-0.1	2.6	-1.7	3.5	-1.1	-2.7	1	7
925	107	102	0.6	0.4	0.5	21431	939	0	0.2	2.9	0.1	3.2	5.1	0.5	5	9
971	116	117	0.5	0.4	0.5	25167	2479	10	-0.1	1.6	1.3	8.0	0.2	-4.7	-1	6
996	109	110	4.0	2.2	3.1		888	0	1.0	2.8	-3.0	0.3	7.6	-2.6	-1	6

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 (ft/sec)

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 PITCH RATE $\dot{\theta}_p$

The aircraft pitch rate is calculated from image data. It is reported just prior to the touchdown of the first main wheel. Positive values of this variable indicate that the aircraft nose is pitching down. This rate is determined with respect to the runway surface.

The symbol used for this quantity is $\dot{\theta}_p$ and is reported in degrees per second (deg/sec).

AIRCRAFT ROLL RATE $\dot{\theta}_r$

The aircraft roll rate is calculated from image data. It is reported just prior to the touchdown of the first main wheel. Positive values of this variable indicate that the aircraft is rolling to port. This rate is determined with respect to the runway.

The symbol used for this quantity is $\dot{\theta}_r$ and is reported in degrees per second (deg/sec).

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 (ft).

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 (ft).

AIRCRAFT INSTANTANEOUS GLIDESLOPE ANGLE β_{V_V}

This angle is determined just prior to first main wheel touchdown. The value of average sink speed (V_{V_A}) and closure speed (Vc) are used to define the instantaneous glideslope as follows:

$$\beta_{V_V} = \arctan\left(\frac{V_{V_A}}{Vc}\right)$$

NOTE: A consistent set of units must be used in this equation.

The symbol for this quantity is β_{V_V} and is reported in degrees.

LANDING WEIGHT W

The landing weight reported in the survey is an estimate provided by the aircraft operators.

The symbol for this quantity is W and the value of this quantity is reported in pounds.

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

APPENDIX D—ACCURACY CHECK OF VIDEO LANDING PARAMETER MEASUREMENT SYSTEM FOR COMMERCIAL AIRCRAFT

BACKGROUND

A video landing parameter system, the Naval Aircraft Approach and Landing Data Acquisition System (NAALDAS), developed by the Naval Air Warfare Center, Aircraft Division, has been modified to collect landing parameter data on commercial transports. This was done through an interagency agreement between the FAA William J. Hughes Technical Center and the Naval Air Warfare Center, Aircraft Division.

An extensive series of tests and analysis were performed during the qualification of the NAALDAS video landing parameter system. These were aimed at verifying that the measurement system properly processed data for landings of carrier aircraft. These landings are performed in a limited touchdown area, with smaller aircraft, and at much higher sink rates than commercial transports.

Because of the much larger size of transport category aircraft in comparison with carrier aircraft, an analysis was performed to adjust the camera lens size and camera coverage area for commercial surveys. The intent was to maintain the same image dimension to camera pixel ratio used in the Navy test of this system.

In addition to the analysis, a series of static drop tests were performed to confirm that the system provided the proper level of accuracy. These tests also document the effect of increased range to the target on the system capability to measure sink rate.

TEST DESCRIPTION

This test was designed to demonstrate that the NAALDAS acquisition and analysis system, using the established calibration procedures and techniques, can accurately measure vertical position from image data at distances typical of those in commercial aircraft landing surveys.

The primary difficulty in verifying the accuracy of NAALDAS is in providing known test input. The video system records the last 0.5 to 1.0 second of aircraft motion prior to touchdown. The data rates and onboard instrumentation of target aircraft are not accurate enough to establish sink rates for this test. In addition the cost of operating transport aircraft for this testing is prohibitive. To overcome these difficulties, a static test procedure was developed.

The NAALDAS system measures the vertical height of an image feature as well as the separation of features a known distance apart to calculate image range and location. For most aircraft, the two main landing gear wheels (or center of a multiwheeled truck) are used for these calculations.

A target the same size as a DC-9 main landing gear wheel was manufactured. The target is positioned at a known height and a video image is recorded. Then the target is moved to the next specified position, and again the image is recorded. A series of these video images is combined to create a video sequence which has a prescribed sink rate. This sequence is used to test the accuracy of the complete system.

This procedure was repeated at the same distance from the camera for both the port and starboard wheels. This was necessary to permit the system to establish the scale factor used in determining the vertical height. The distance between the port and starboard wheels is used in determining the range of the target from the camera. The value of horizontal speed of an aircraft is derived from the change of this range information in successive video images.

An additional part of the test procedure is the camera calibration. Video images of calibration targets, at known locations in the camera field of view, are recorded. The calibration targets and camera positions are established using a surveyor's Total Station. The Total Station is an electronic version of a theodolite which uses an infrared beam and mirror reflector targets to measure distances and angular positions. This information is used to create a transformation matrix relating image pixel locations to real world positions. Once the transformation matrix is created, the pixel data is processed into a format compatible with the analysis system's software. This camera calibration procedure was performed prior to performing the static drop test.

Since the NAALDAS system makes measurements on actual images, the size of the image impacts the accuracy of the measurement. In planning system installations, the distance of the aircraft's expected touchdown point from the camera is considered. The camera lens is selected to meet the conflicting requirements of image size and camera coverage area. However, since all the previous testing was done for the limited area of a carrier deck, the maximum range for using the system had not been established. To address this issue, the drop test was repeated at increasing range from the camera, to attempt to determine the effect of target range on the system's resolution capability. Drop tests were repeated at 400, 600, 800, and 1000 ft from the camera. The land-based testing of this system in the naval configuration was performed at 400 ft from the expected touchdown point.

For this testing, the camera configuration and lens system used to collect data at Washington National Airport were used. The main gear track of a DC-9 aircraft, 16 foot 4 inches, was used in this testing. A sketch showing the camera configuration used at Washington National is included as figure D-1.

The maximum coverage area is assigned to the first camera designated C1 in figure D-1. It covers a total distance of 800 ft along the runway center line. However, this coverage area extends to the end of the runway and none of the aircraft from the National Airport survey landed within the first 500 feet from the end of the runway. The pilots attempt to land at the 1000-ft mark, which concentrates the landings within 300 feet of camera two or at a maximum of 750 feet from camera three. The preference in the analysis station is to use the largest image possible, and cameras are not switched to the next camera unless it is obvious that touchdown will not occur in the operating camera's range.

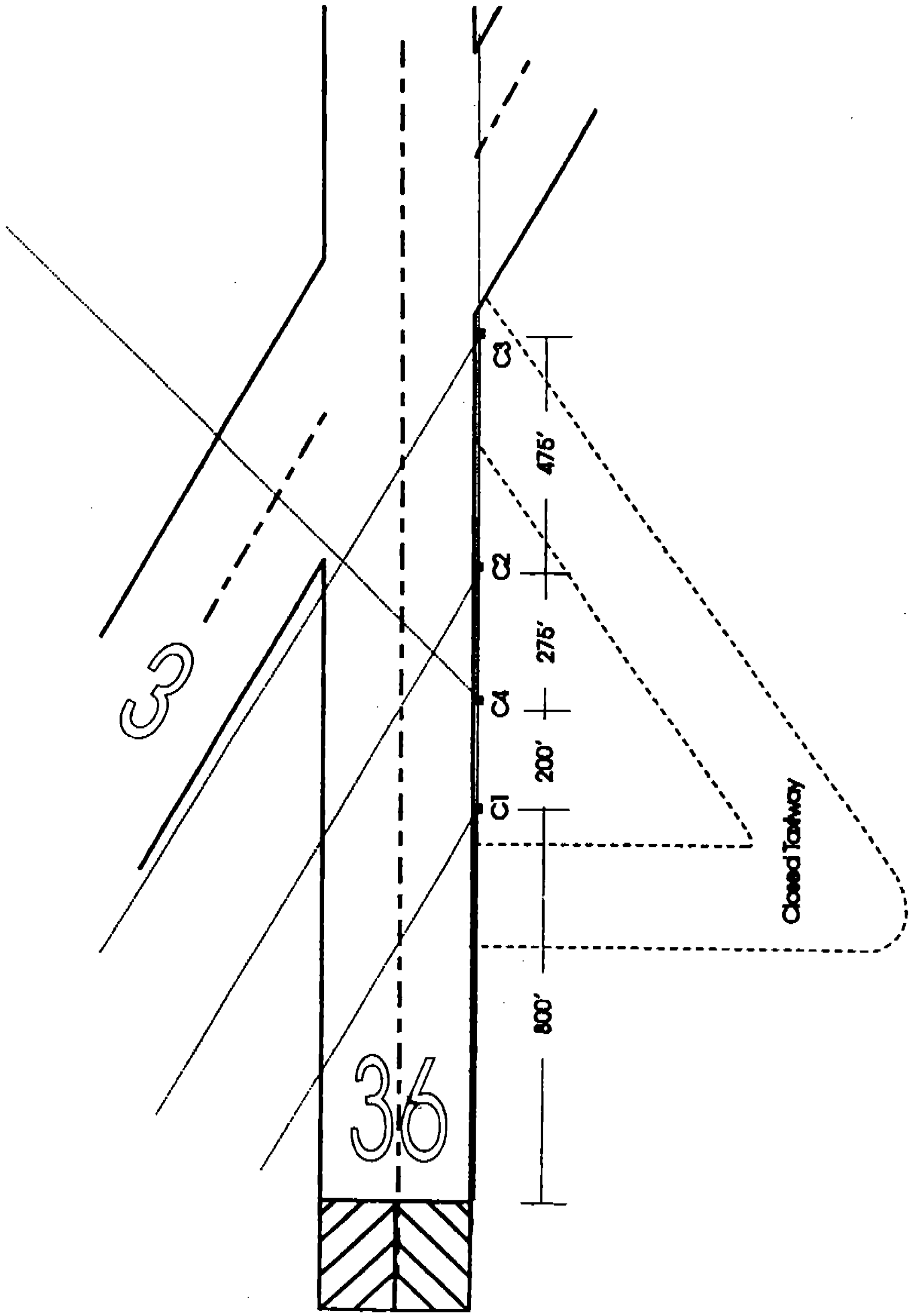

FIGURE D-1. FAA LANDING SURVEY CAMERA CONFIGURATION
WASHINGTON NATIONAL AIRPORT

The input value for this test was established by moving the target 2 inches vertically between video frames. With a camera frame rate of 30 frames per second, this corresponds to an apparent sink rate of 5 ft/sec. The target was moved to 15 different positions for each test. This is a minimum value used in the analysis software and replicates the last half second of flight prior to aircraft touchdown. In practice, 30 to 35 frames are used in the analysis of most landings.

The static test was repeated at four positions along the runway center line at distances of 400, 600, 800, and 1000 feet from the camera.

This was a very labor intensive test procedure. Since the target wheel had to be accurately positioned for each frame, a ridged guide pole and mounting fixture was needed. The position was set and measured for each video frame.

TEST RESULTS

Four Hundred-Foot Test Results

Figure D-2 is a plot of the vertical heights measured at 400 feet from the camera. These vertical height measurements are converted into sink rates by running the vertical positions through a linear regression routine. The resulting value of sink speed was 5.03 ft/sec. The standard error of estimate for this measurement is 0.04 ft/sec. The 98% confidence interval on this result is 5.15 to 4.92 ft/sec. This result is considerably better than the assumed capability of measuring sink speed of 0.5 ft/sec.

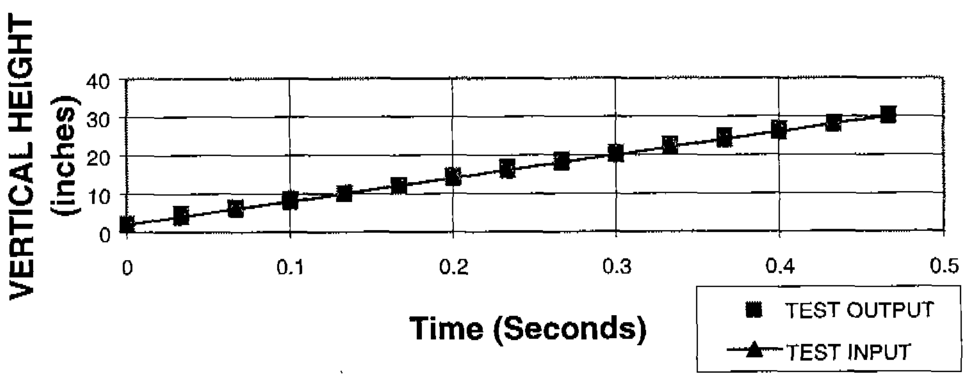

FIGURE D-2. NAALDAS COMMERCIAL EVALUATION 400-FT. DROP TEST

Six Hundred-Foot Test Results

Figure D-3 is a plot of the vertical heights measured at 600 feet from the camera. Processing the NAALDAS determined vertical heights through a linear regression routine. The results of this procedure provided a vertical sink speed of 5.22 ft/sec. The associated standard error of estimate is 0.07 ft/sec. The 98% confidence boundaries are 5.446 and 5.01. Again well within the accuracy for the system, even at a significantly greater range from the camera. Also, if the same data is processed assuming a second order curve fit, then the curve is differentiated and evaluated at T = 0 which is the traditional technique used in Navy surveys; the resulting sink speed value is 5.01 ft/sec.

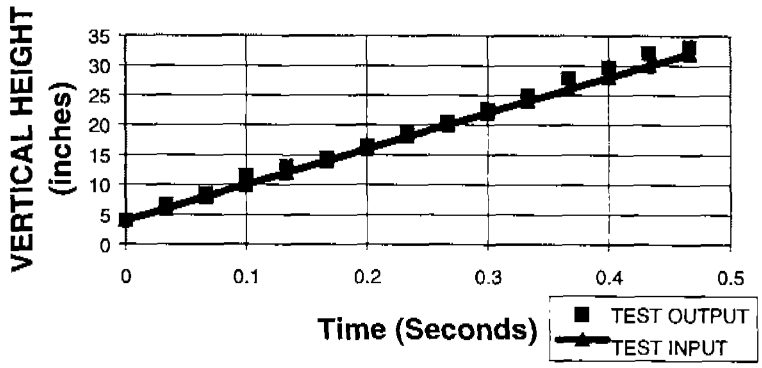

FIGURE D-3. NAALDAS COMMERCIAL EVALUATION 600-FT. DROP TEST

Eight Hundred-Foot Test Results

The results of the 800-foot drop test are presented in figure D-4. At this range, the system determined a sink rate of 5.69 ft/sec. The associated standard error of estimate is 0.303 ft/sec. The 98% confidence boundaries are 6.16 and 5.23. This result does not improve if a second order fit is used. The camera and lens combination did not provide sufficient resolution at this distance to meet an accuracy of 0.5 ft/sec. Note that for this setup, the camera configuration at Washington National Airport*, only camera 1 would be recording images at this distance and that data would only by processed at that distance if the aircraft touched down at the runway threshold. None of the surveyed aircraft touched down within 500 foot of the end of the runway.

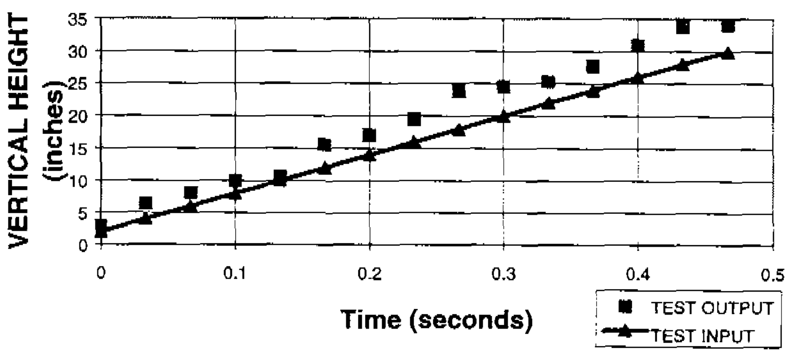

FIGURE D-4. NAALDAS COMMERCIAL EVALUATION 800-FT. DROP TEST

One Thousand Foot Test Results

*We had smaller images to work with at Washington National Airport than at John F. Kennedy International Airport (JFK), and if our system accuracy proved to be satisfactory at Washington National Airport, it would also be satisfactory at JFK.

One Thousand-Foot Test Results

While the data at this distance was being processed, it became obvious that the resolution capability of the system had been exceeded. In light of this observation and the analysis results for the 800-foot test, no attempt was made to evaluate this data set.

CONCLUSIONS

Within the coverage area assigned to a single camera, the modified NAALDAS system can provide accurate measurements of aircraft vertical position and the corresponding sink rates within acceptable levels of accuracy. That this system, which was originally specified to measure sink rate within 0.1 ft/sec at 300 ft from the target, can perform with a resolution within 0.05 ft/sec at 400 foot from the target is remarkable.

The results of these tests confirm the necessity to use multiple cameras to cover the expected touchdown area during landing parameter surveys. These tests show that an optimum camera configuration limits the range of the NAALDAS camera to approximately 700 ft. This is the distance where the camera coverages at Washington National overlap.

The assumptions used to size and configure the camera and lens system for commercial surveys are effective and accurate.

During an actual survey, the aircraft is moving toward the camera, reducing the range with each measurement. This improves the systems actual performance when compared to this static test where all the measurements were made at a specified distance from the camera. If a closure speed of 130 knots is used, the aircraft moves forward approximately 7 ft per video image. This would result in the aircraft being 175 feet closer to the camera at the end of a typical (25-frame) image sequence.

While it would have been preferable to conduct a more extensive series of tests to completely document the capability of this system, the rather limited testing did resolve the crucial issues associated with this technique. Testing with additional camera lens combinations, a range of test sink speeds, and an increased range of target distances could more completely characterize this system.

Given the precision needed to make these measurements, resolving a 2-inch change at 600 ft. from the target, it is apparent that this system does push the state of the art. These findings raise doubts about the accuracy of the film system used by NASA in the 1960's to collect sink speed data at over 1000 ft from the target.

In light of the above test, landing survey results will be reviewed and any landings recorded outside the effective range of a camera will be deleted from the analysis and not included in any survey statistical summaries.