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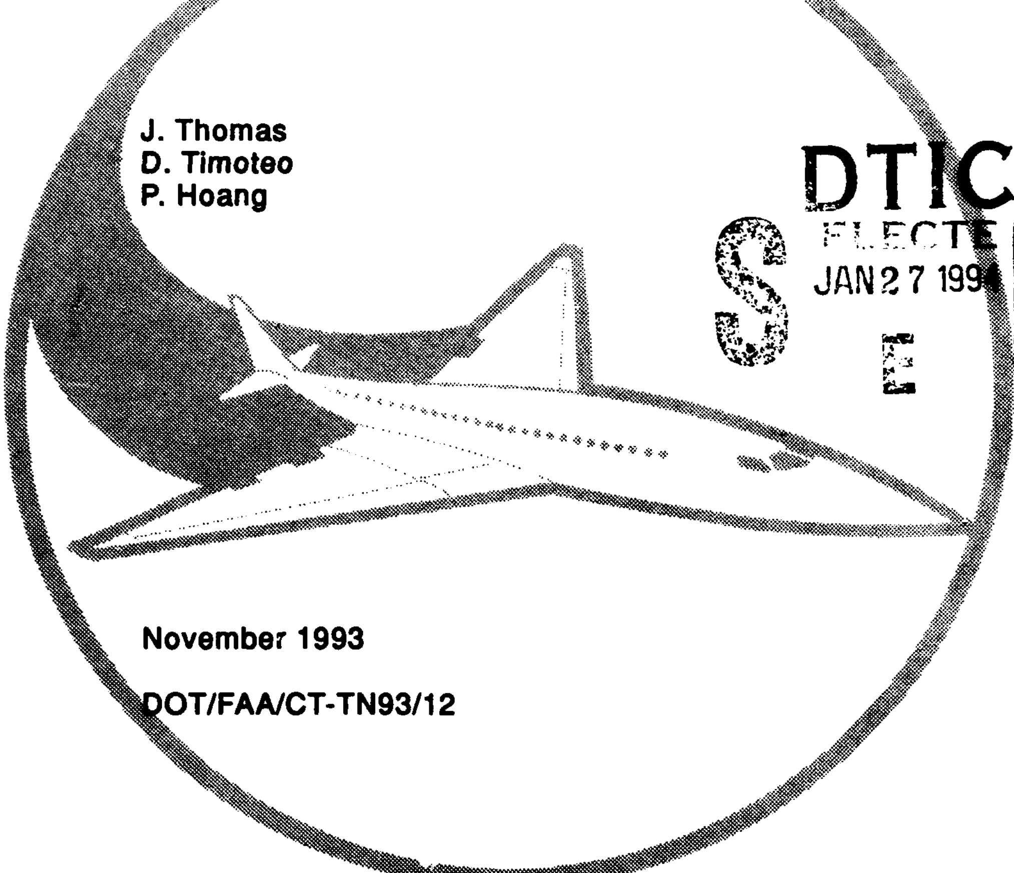
Los Angeles International Airport Instrument Landing System Approach Data Collection and Reduction Phase 1 Final Report

J. Thomas
D. Timoteo
P. Hoang



November 1993

DOT/FAA/CT-TN93/12

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U.S. Department of Transportation
Federal Aviation Administration

Technical Center
Atlantic City International Airport, N.J. 08405

NOTICE

Technical Report Documentation Page

1. Report No.
DOT/FAA/CT-TN93/12

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
Los Angeles International Airport (LAX) Instrument Landing System Approach Data Collection and Reduction Phase 1 Final Report

5. Report Date
November 1993

6. Performing Organization Code
ACD-340

7. Author(s)
J. Thomas, D. Timoteo and P. Hoang

8. Performing Organization Report No.
DOT/FAA/CT-TN93/12

9. Performing Organization Name and Address
Federal Aviation Administration
Technical Center
Atlantic City International Airport, NJ 08405

10. Work Unit No. (TRAIS)

11. Contract or Grant No.

12. Sponsoring Agency Name and Address
Federal Aviation Administration Headquarters
Research and Development Service
800 Independence Ave., S. W.
Washington, DC 20591

13. Type of Report and Period Covered
Technical Note
November 1991 to April 1992

14. Sponsoring Agency Code
ARD-100

15. Supplementary Notes

16. Abstract
Position data on aircraft flying Instrument Landing System (ILS) approaches from 40 nautical miles (nmi) down to runway threshold were collected at Los Angeles International Airport (LAX) between November 26, 1991 and April 25, 1992. The purpose of the data collection was to provide an accurate database of navigational performance of aircraft flying ILS approaches at distances between 10 nmi and 32 nmi. Aircraft position data were collected using the in-place LAX surveillance primary and secondary radars.

The data were reduced and analyzed at the Federal Aviation Administration (FAA) Technical Center by ACD-340 personnel. The discussion in this Final Report concerns the accuracy of the collected position data and possible sources of error in the data collection.

17. Key Words
ILS Approaches
Data Collection
Data Reduction
Aircraft Localizer Behavior

18. Distribution Statement
This document is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	70	

Form DOT F 1700.7 (8-72)

ACKNOWLEDGEMENTS

We would like to thank the many individuals who made significant contributions towards this study. A considerable amount of effort was required to plan, prepare, collect, and reduce the data in this study.

We especially appreciate the assistance provided by the following people at the Los Angeles International Airport (LAX) Automated Radar Terminal System (ARTS) facility. Special thanks to Don Jeffries, the supervisor, for allowing us to use his facility. Dave Albert, Art Davis, Steve Herbst, Ed Hunter, Diane Metty, Cynthia Noble, Al Poggio, Al Qume, and Chet Roher should be commended for their patience and for the quality and depth of their contributions. Their efforts and creative solutions allowed us to successfully interface with facility equipment without impacting Air Traffic Control (ATC) operations.

Members of the Federal Aviation Administration (FAA) technical project team made significant contributions both in system hardware and software development, and on trips to Los Angeles to participate in the data collection. Special thanks to John Wilson for hardware and logistics support, and to Phil Zinno and Karen DiMeo for software development and support.

We appreciate the outstanding effort made by CTA, INCORPORATED employees: Greta Daczkowski for her assistance with on-site equipment set up and test, and monitoring the data collection; Ed Butterly for providing, on short notice, capable software engineering support and a timely and high quality extraction, reduction, and analysis of the collected track data, and technical and editorial assistance for the Final Report.

We would also like to recognize the contributions of Gene Wong and Bill Blake of the Research and Development Service (ARD-100) for providing project guidance and data analysis support.

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EXECUTIVE SUMMARY

Airport capacity, the number and the duration of flight delays, is a critical concern for the Federal Aviation Administration (FAA), airport operators, user groups, and the entire aviation community. The ability of highly active airports to operate at optimal capacity is a high priority issue. Contributing to the capacity problem are the limitations imposed by current airport runway configurations and the associated air traffic separation criteria. To alleviate these constraints, the FAA is investigating the use of triple, quadruple, and closely-spaced dual parallel runway configurations as a means of increasing airport capacity, while maintaining a high level of safety. The implementation of triple and quadruple simultaneous approaches will necessitate the development of approach turn-on procedures for distances greater than 15 nautical miles (nmi) from touchdown.

In 1989, personnel from the FAA Technical Center collected and analyzed position data on aircraft performing simultaneous Instrument Landing System (ILS) approaches at Chicago O'Hare International Airport (ORD), using the existing airport primary and secondary radars. The results of this analysis were used to verify a real-time simulation model of aircraft executing ILS approaches. This model is currently being used in simulations performed at the FAA Technical Center's Target Generator Facility (TGF). The model has been verified out to 12 nmi from runway threshold via the ORD statistics. To date, little qualitative or quantitative data are available to verify the model for distances greater than 12 nmi.

The FAA's Research and Development Service (ARD-100) requested that data be collected to develop an accurate database of the navigational performance of aircraft flying ILS approaches between 10 nmi and 32 nmi from threshold. Airports rarely conduct ILS approaches beginning at distances greater than 15 nmi from touchdown. The CIVET approach course to Los Angeles International Airport (LAX) runways 25L, 25R, 24L, and 24R is an exception. On a normal day at LAX, over 400 aircraft intercept the ILS signal as far as 50 nmi from the runway threshold.

This project was accomplished in phases. This report covers Phase 1 whereby aircraft data were collected using the on-site surveillance primary and secondary radars. Also covered is an explanation of the data extraction and reduction performed at the FAA Technical Center. Summary statistics are also provided. The data collection began in December 1991 and continued until April 1992 when nearly 4500 25L landings had been recorded. Data were collected for runways 24L/R and 25L/R. Radar range and azimuth biases that were calculated in Phase 2 with respect to runway 25L, were removed from the data. The ILS localizer signal bias with respect to the 25L extended runway centerline (ERC), which was calculated in Phase 3, was also removed from the 25L arrivals.

The LAX data analysis effort will continue under Phase 4 where pilot questionnaire data will be used to further reduce the data set from Phase 1. Phase 4 will model total navigation system error (TNSE) for different aircraft types and approach techniques. Phase 1 analysis dealt with a general population of aircraft arriving at LAX.

The Phase 1 study produced summary statistics on lateral aircraft deviations from the ERC. Phases 2 and 3 provided data used to remove some of the ground and airborne equipment error components of the TNSE; the result is an accurate representation of the aircraft flight technical error component. A mapping was made of the position of the actual localizer centerline with respect to the runway centerline, which showed a very small angular deviation (.0723 degrees) from the runway centerline. Summary statistics were then generated based on the localizer centerline to see how well the aircraft followed the localizer signal. Results of the Phase 1 analysis validated the assumption that the existing model used for ILS approaches (that was validated out to 12 nmi by the ORD study) is indeed linear, and can be extended out to 32 nmi from the runway threshold. The summary statistics, in terms of standard deviation of error, are comparable to those of the ORD study, showing slightly better adherence to the localizer centerline. The quality of the data was also better than that from previous studies due to the improved performance characteristics of the airport surveillance radar (ASR)-9 at LAX.

1. INTRODUCTION.

This report describes the methodology employed in Phase 1 of a four phase program to collect and reduce Instrument Landing System (ILS) navigational aircraft track data requested by the Federal Aviation Administration's (FAA) Research and Development Service (ARD-100). The data was collected for aircraft flying ILS approaches to Los Angeles International Airport (LAX) runways 24L\R and 25L\R using the CIVET arrival fix. The data collection report is intended to accomplish the following:

a. Describe the data collection and reduction hardware and software.

b. Specify the data collection and reduction procedures.

c. Describe the deliverables for which the ATC Technology Branch, ACD-340 has responsibility.

d. Discuss general conclusions derived from preliminary ACD-340 data analysis.

1.1 OBJECTIVES.

The objective of this effort was to provide an accurate database of navigational performance of aircraft at distances starting at the runway threshold and going out to 32 nautical miles (nmi) from the runway threshold. These data were provided through primary and secondary radar tracking. Phase 1 created a database consisting of individual aircraft flying ILS approaches. The database was used to develop descriptive statistics for aircraft navigation of ILS localizer as a function of the distance to touchdown.

Phases 2 and 3 were data collection efforts to identify Ground Equipment Error (GEE) and Airborne Equipment Error (AEE) in order to remove these errors from the data collected in Phase 1. Specifically Phase 2 identified the correction factors (range and azimuth biases) applied to Airport Surveillance Radar (ASR)-9 data. Phase 3 identified ILS localizer signal error relative to the ERC; this error was removed from Phase 1 track data to determine the aircraft position relative to the ILS localizer centerline.

In the future, Phase 4 of the track reduction effort will focus on specific aircraft types and types of approaches flown (auto-pilot (A/P), flight director (F/D), or manual). The database will be used to characterize specific aircraft ILS localizer navigational performance and develop an accurate model of this performance for use in real-time Air Traffic Control (ATC) simulations.

1.2 BACKGROUND.

Airport capacity, the number and the duration of flight delays, is a critical concern for the FAA, airport operators, user groups and the entire aviation community. The ability of highly active airports to operate at optimal capacity is a high priority issue. Capacity enhancement programs are underway at airports around the world to reduce air traffic delays and to accommodate increased demands for air services. Included in these programs are efforts to redesign the existing airways structure through projects that provide a more modern air traffic flow management capability. This capability incorporates state-of-the-art automation technology throughout the system.

Contributing to the capacity problem are the limitations imposed by current airport runway configurations and the associated air traffic separation criteria. Limitations related to aircraft executing long, straight-in ILS approaches were the focus of this study. To alleviate constraints, the FAA is investigating the use of triple, quadruple, and closely-spaced dual parallel runway configurations as a means of increasing airport capacity, while maintaining a high level of safety.

The implementation of triple and quadruple simultaneous approaches will necessitate the development of approach turn-on procedures for distances greater than 15 nmi from touchdown. The capability of the pilot and aircraft to navigate the ILS signal at these distances must be assessed and incorporated into real-time ATC simulations in order to evaluate the safety of these operations. Prior to this effort, localizer navigational performance data have only been collected and analyzed for flights within 16 nmi of the runway threshold.

Research has indicated airports infrequently conduct ILS approaches beginning at distances greater than 15 nmi from touchdown. The CIVET approach course to LAX's 25L, 25R, 24L, and 24R was found to be an exception. On a normal day at LAX, over 400 aircraft intercept the ILS signal up to 50 nmi from the runway threshold. Based on this, the CIVET approach to LAX was chosen for this data collection effort.

2. RELATED DOCUMENTATION AND PROJECTS.

2.1 CHICAGO O'HARE INTERNATIONAL AIRPORT (ORD) SIMULTANEOUS ILS APPROACH DATA COLLECTION.

The DUAL Sensor Receiver and Processor (DUALSRAP) system was developed and employed first at ORD by J. Thomas, et al [1]. The DUALSRAP system collected data from a SRAP connected to an ASR-7 radar and an ATC Beacon Interrogator (ATCBI)-4. This system was used to characterize the ILS navigational performance of a typical mix of commercial aircraft executing simultaneous approaches. The reduced track data were analyzed to determine the degree of containment within several hypothetical Normal Operating Zones (NOZ) smaller than those presently allowed.

2.2 VISUAL APPROACH DATA COLLECTION AT SAN FRANCISCO INTERNATIONAL AIRPORT (SFO).

Data on aircraft executing simultaneous visual approaches to parallel runways were collected at SFO between November 1990 and March 1991 [2]. The purpose of the data collection was to analyze the navigational characteristics of aircraft flying the "fly visual" segment of the approach. Aircraft position data were collected from a SRAP connected to an ASR-7 radar and an ATCBI-4.

2.3 VISUAL APPROACH DATA COLLECTION AT LAMBERT ST. LOUIS FIELD (STL).

The DUALSRAP system was set up at STL to collect a database of simultaneous ILS approaches, converging approaches, and Localizer Directional Aid (LDA) approaches [3]. These data were collected and reduced by ACD-340 personnel. The data were collected to provide an accurate database of the navigational characteristics of aircraft flying the "fly visual" segment of the approach.

2.4 AUTOMATED RADAR TERMINAL SYSTEM (ARTS)IIIA/TRANSPORTABLE RADAR ANALYSIS COMPUTER SYSTEM (TRACS) INTERFACE SYSTEM (ATRAIN).

The development of ATRAIN [4] enabled the collection of surveillance data from the 32-bit parallel output of the ARTS IIIA facility Surveillance and Communications Interface Processor (SCIP). This allowed system analysts to evaluate the performance of a terminal radar system without the need for an off-line Input/Output Processor (IOP).

2.5 SIMULATION OF TRIPLE AND QUADRUPLE SIMULTANEOUS ILS APPROACHES.

The Multiple Parallel ILS Approach Program Office has initiated efforts to evaluate the operational capability of triple and quadruple simultaneous ILS approaches to parallel runways spaced as close as 4000 feet (ft). The program has used high fidelity real-time ATC simulations to investigate the controller's ability to safely handle traffic in this environment. The simulations require accurate modeling of aircraft navigational performance to make reliable decisions concerning the safety of the operation.

3. PROJECT IMPLEMENTATION.

The data collected for this study were radar tracks of aircraft flying ILS approaches to runways 24L/24R and 25L/25R at LAX. Only 25L tracks were reduced and analyzed for this report. These tracks were provided by the ASR-9 and ATCBI-5 reporting system through the SCIP interface. Modified ATRAIN software was used to collect the data at the SCIP interface.

In order to extract the maximum information from the track data, additional data were collected. This secondary data consisted of parrot data, hourly weather reports, interfacility data, audio recordings of ATC voice communications, and pilot questionnaires used to identify the type of approach flown by the pilot (A/P, F/D, or manual), the approach fix for each aircraft, and pilot comments.

The CIVET Two profile descent, airport diagram, and ILS plates for each approach category (CAT) are shown in figures 1 through 8.

4. DATA COLLECTION.

4.1 DATA COLLECTION SYSTEM HARDWARE DESCRIPTION.

The data collection system (see figure 9) was installed at the LAX Terminal Radar Approach Control (TRACON). It consisted of the following hardware:

a. ATRAIN support hardware:

1. AT&T Personal Computer (PC).
2. Two tee ATRAIN connectors and cables for passive listening.
3. Local Area Network (LAN) card.
4. One ATRAIN (SCIP to AT&T) interface card.
5. WWVB Time Code Receiver, Antenna, and interface card.
6. AT&T Paradyne modem.

b. Network Server:

1. Zenith Z-248 computer system running Novell Netware 2.15 in non-dedicated mode.
2. Interfacility Data System Microprocessor (IDSM) interface software and board.
3. LAN card.
4. Network cabling.

c. Tape Backup and remote access

1. Compaq SLT PC.
2. LAN card.
3. Hayes Optima 9600 Modem.
4. Dual Mountain Filesafe Series 7300 300 Megabyte (Mb) Tape Backups.

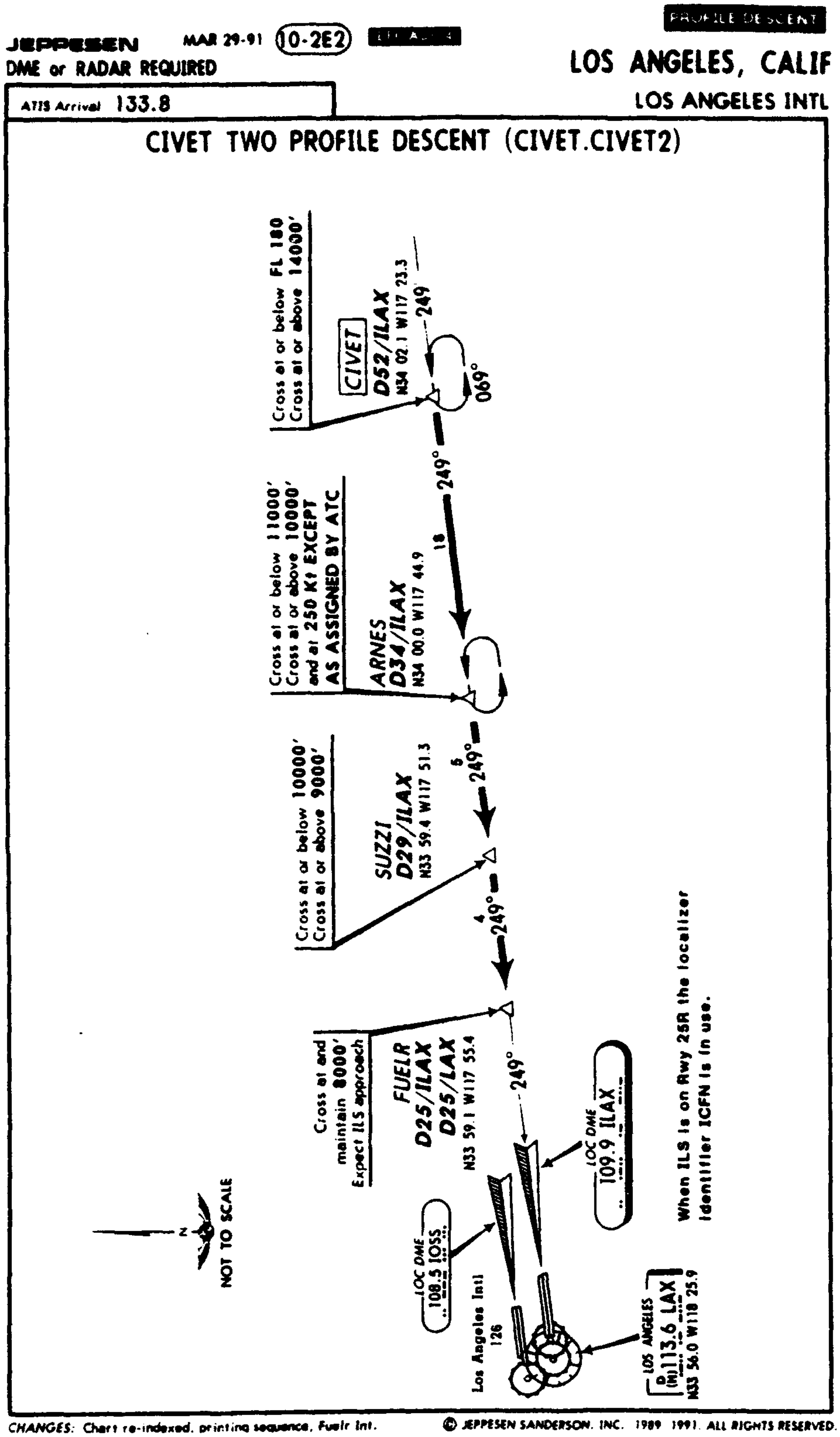

FIGURE 1. CIVET TWO PROFILE DESCENT

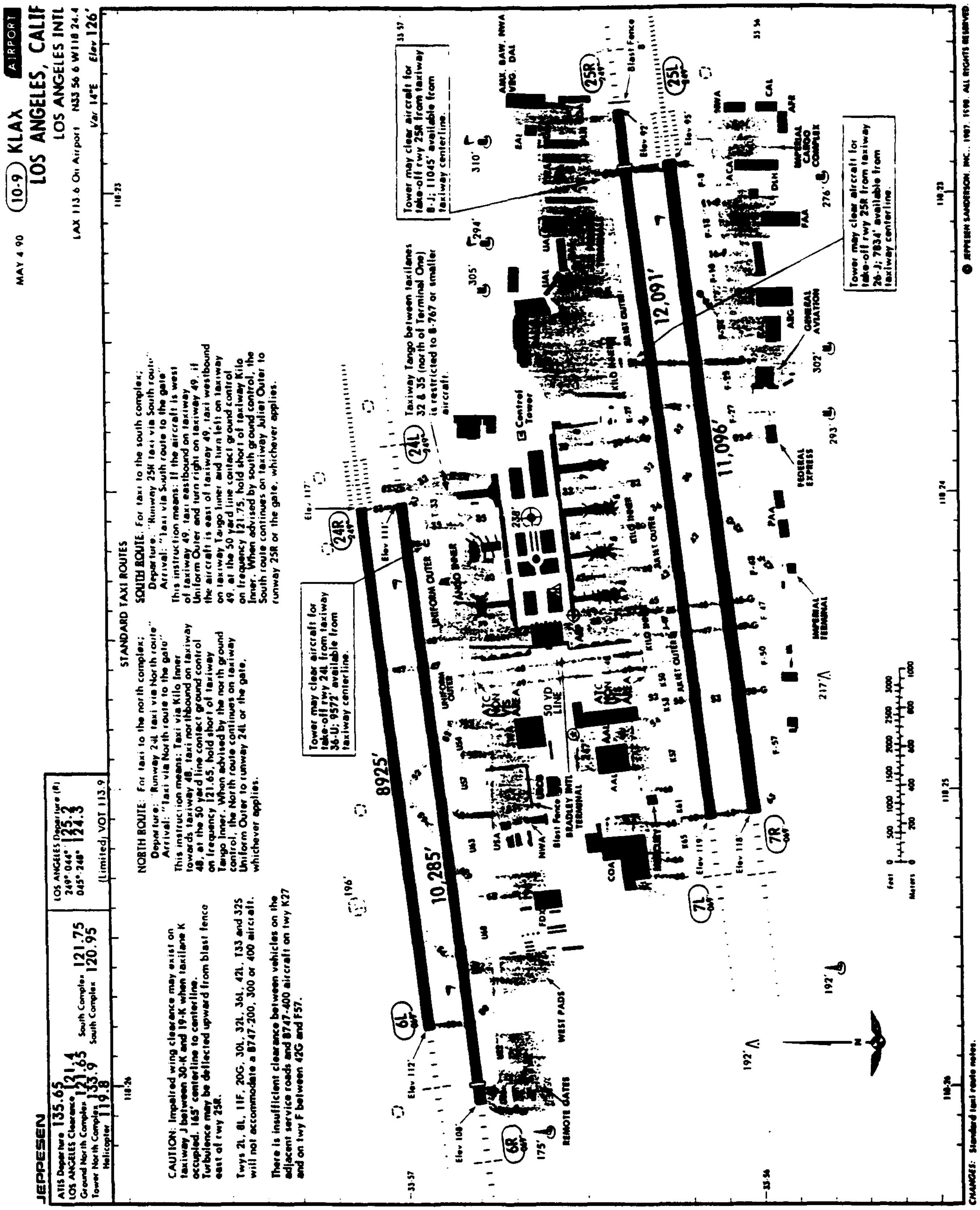

FIGURE 2. AIRPORT OVERVIEW MAP

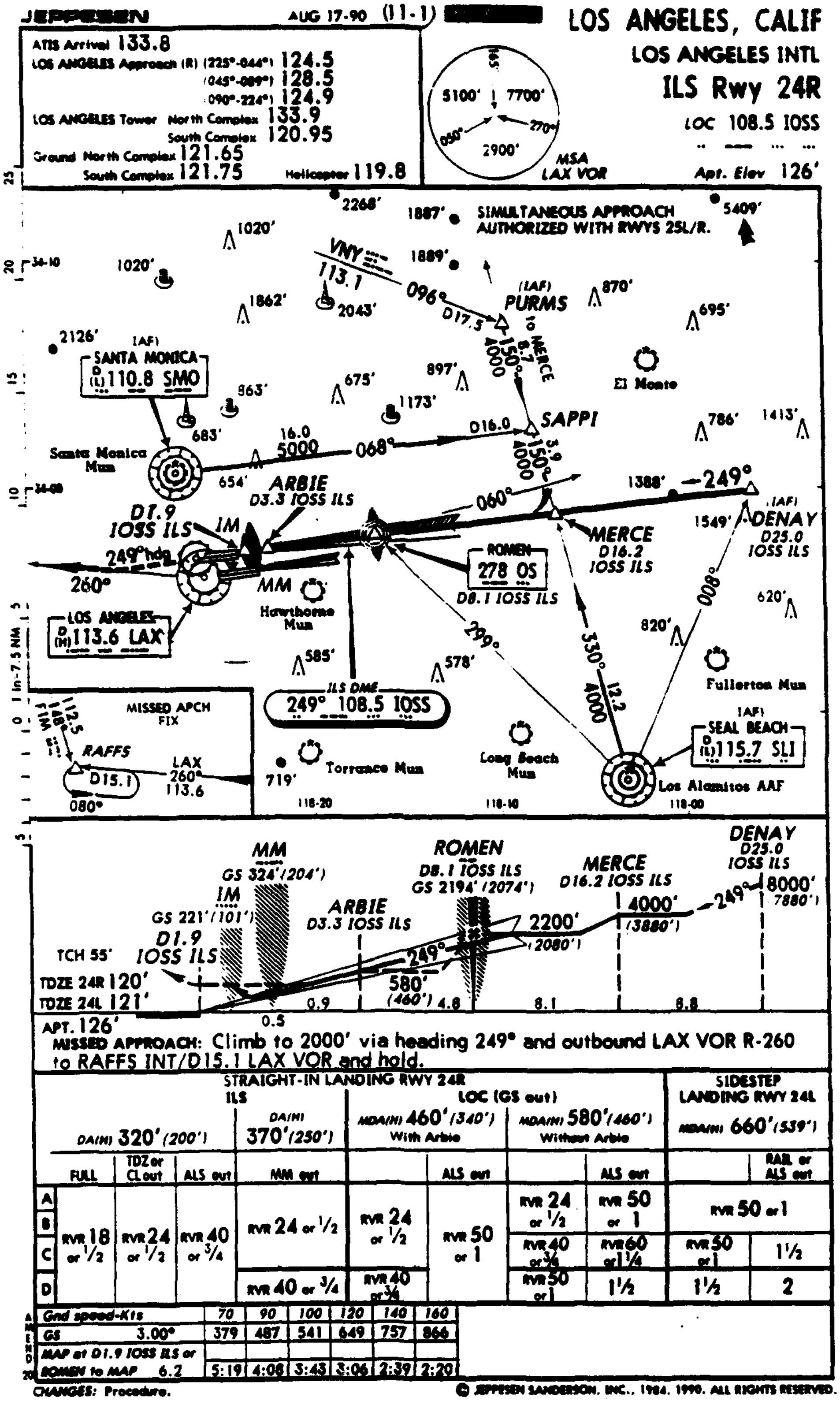

FIGURE 3. ILS APPROACH RUNWAY 24R

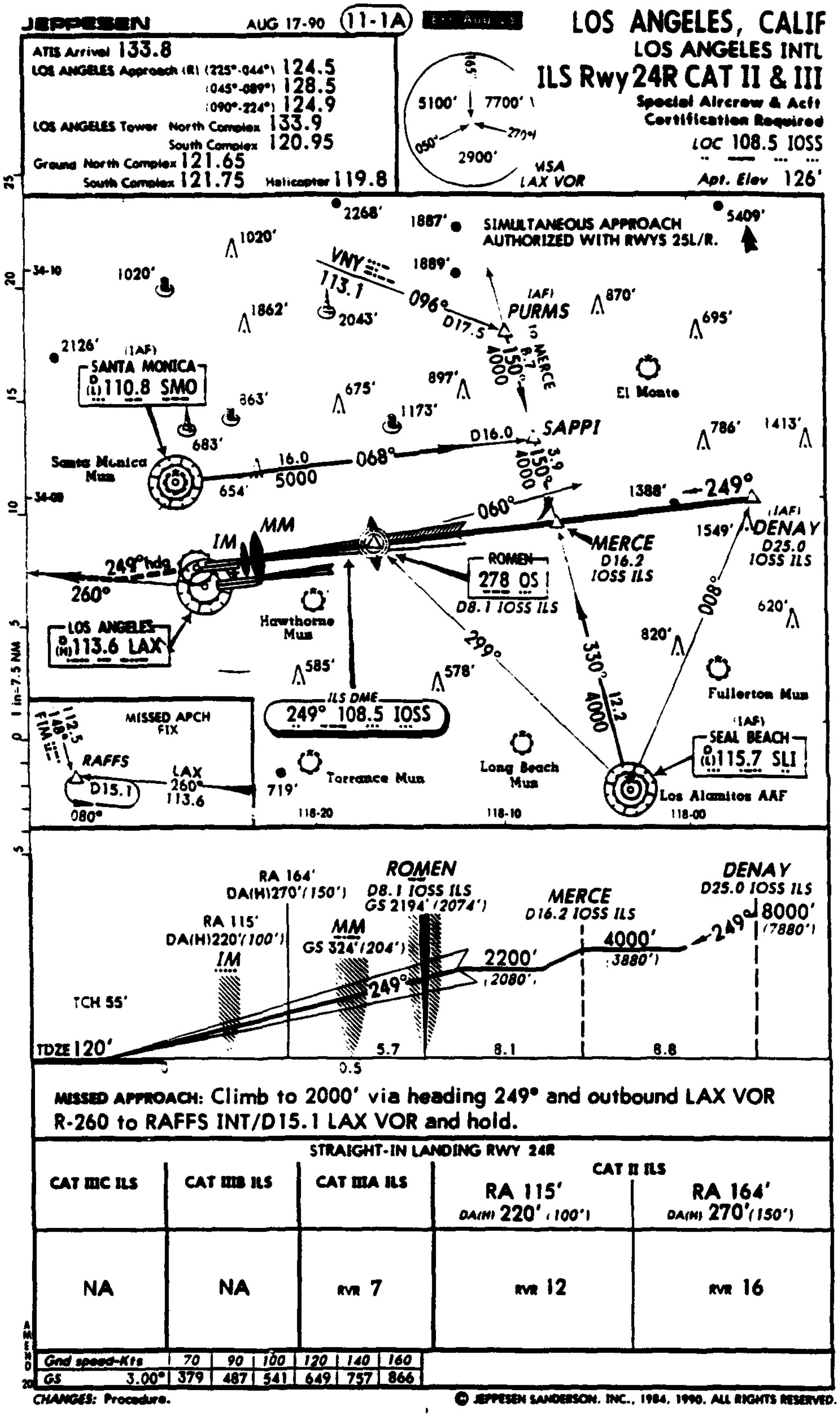

FIGURE 4. ILS APPROACH RUNWAY 24R, CAT II & III

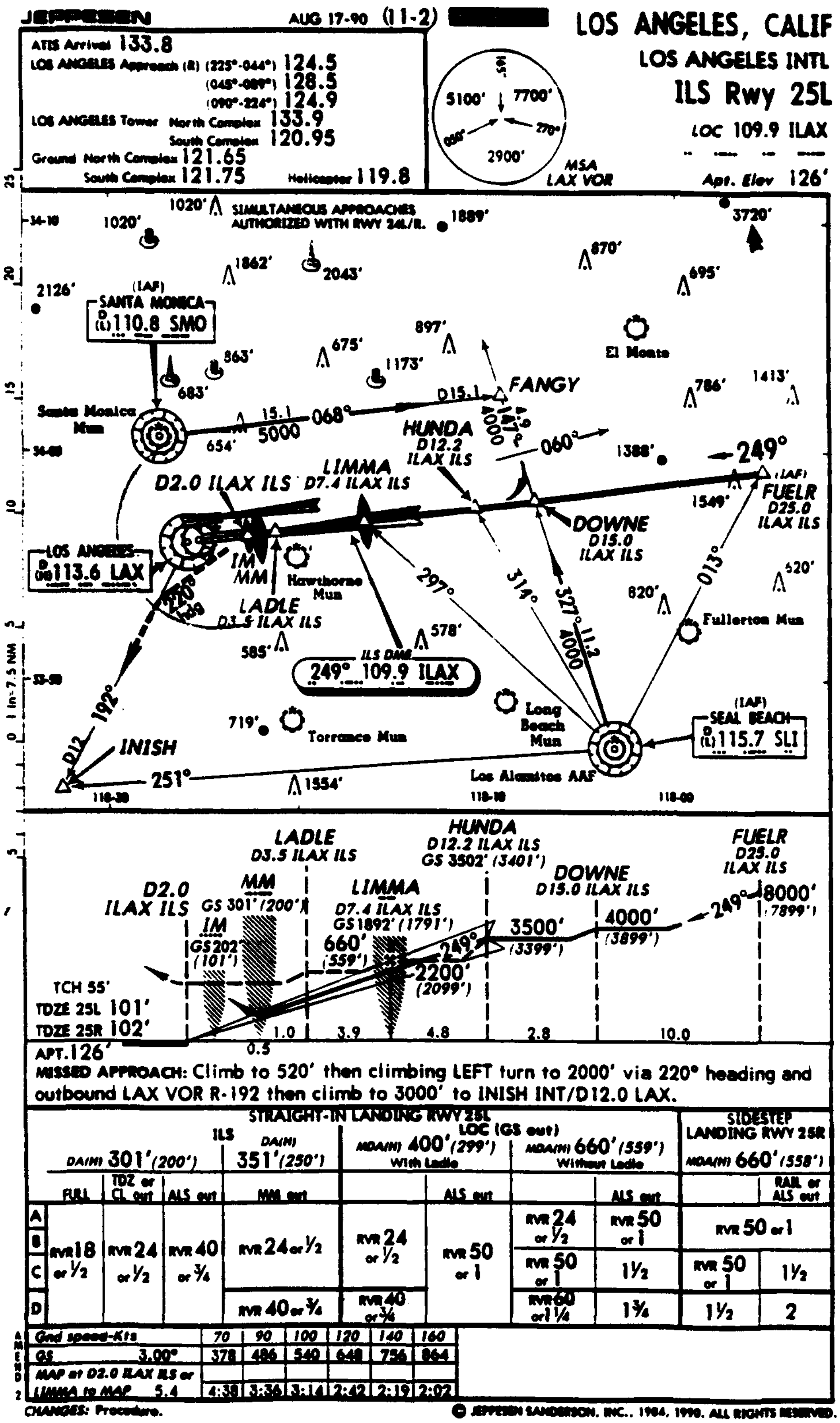

FIGURE 5. ILS APPROACH RUNWAY 25L

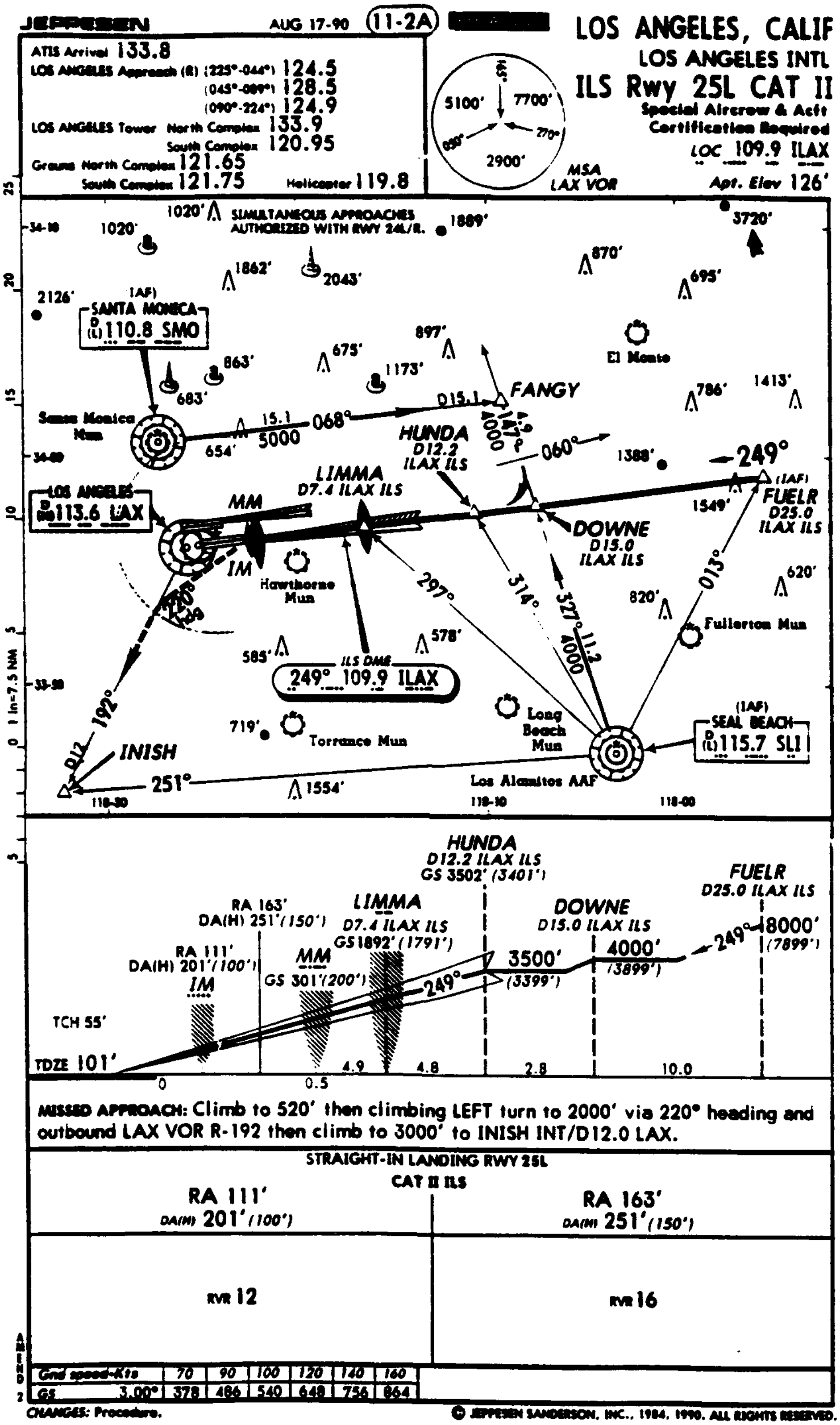

FIGURE 6. ILS APPROACH RUNWAY 25L, CAT II

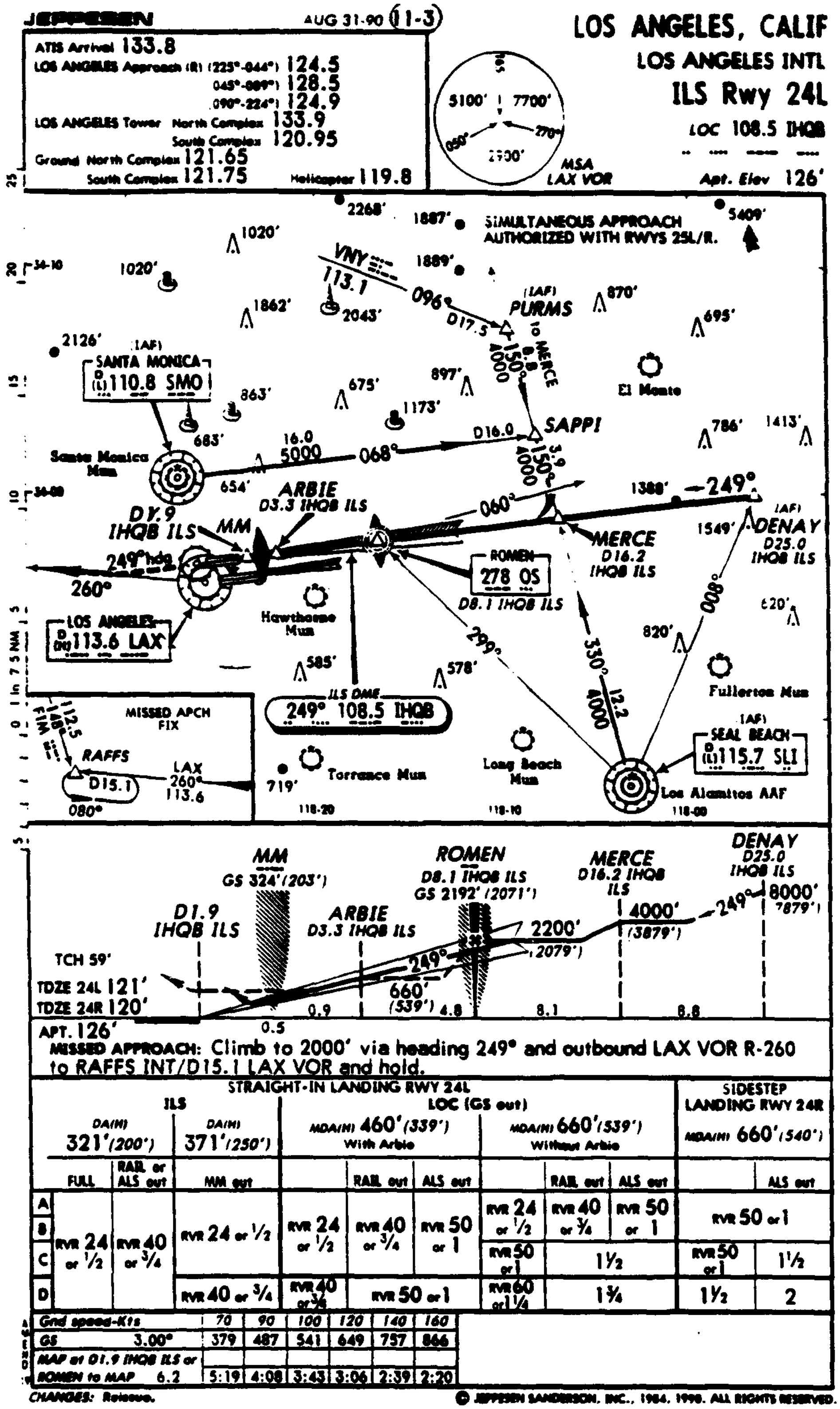

FIGURE 7. ILS APPROACH RUNWAY 24L

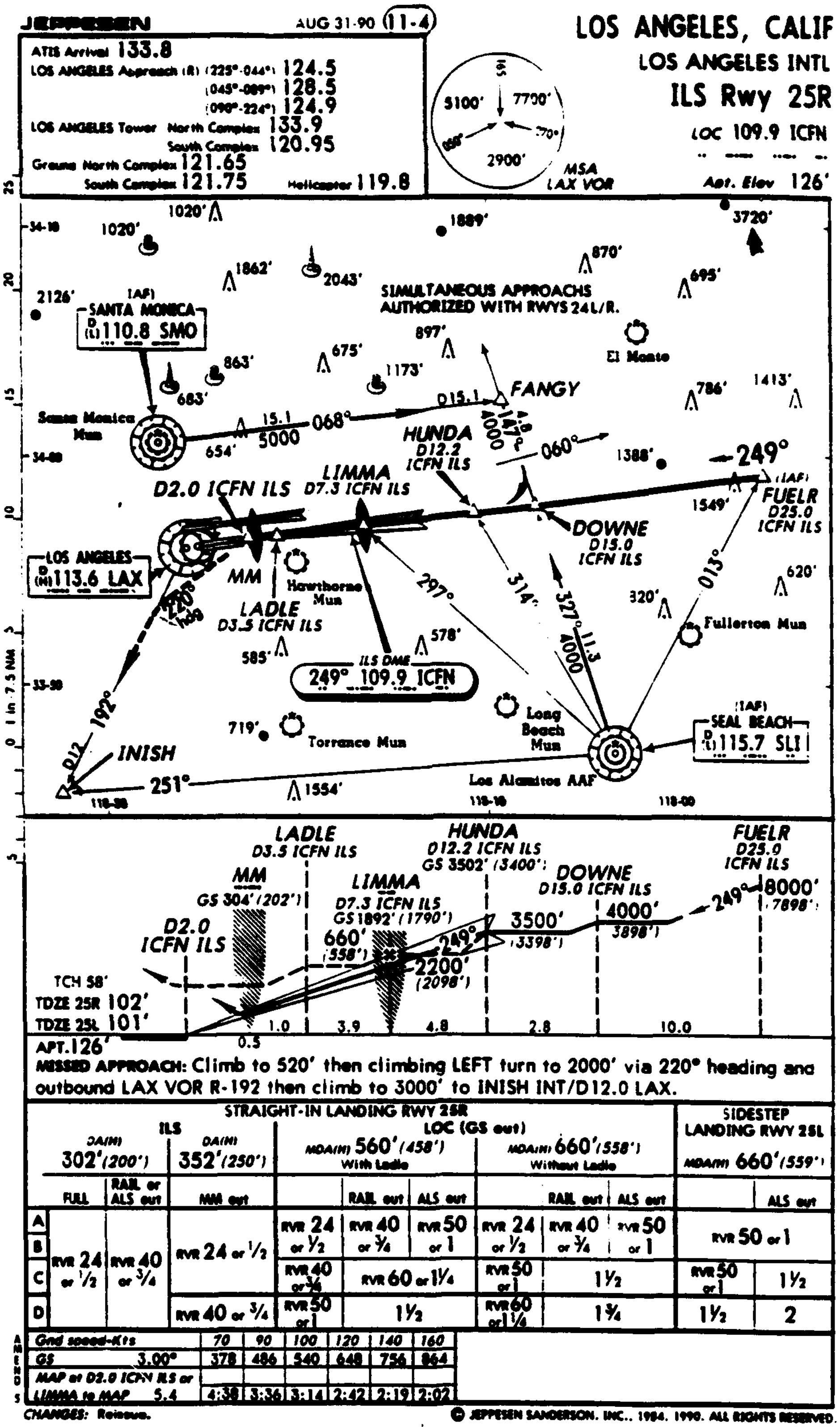

FIGURE 8. ILS APPROACH RUNWAY 25R

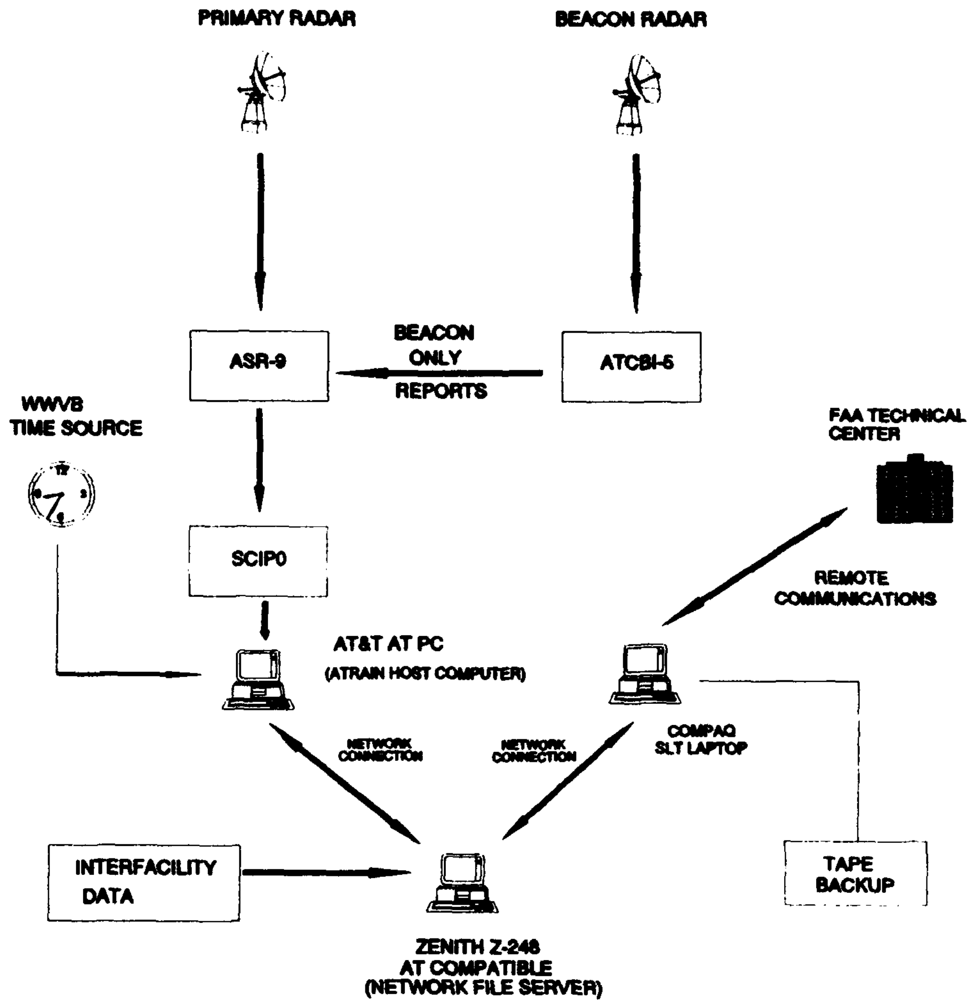

FIGURE 9. LAX DATA COLLECTION SYSTEM

d. American Power Conversion 1200VX Uninterruptible Power Supply (UPS) unit.

4.1.1 SCIP/ASR-9/ATCBI-5.

The SCIP's were located in the TRACON. They accepted digital output via modem or microwave link from the LAX north and south ASR-9's. They then passed this data to the ARTS IIIA processor. The ASR-9's provided detection of range and azimuth of aircraft targets. Two ATCBI-5's provided detection and reporting of range, azimuth, altitude, and identity of transponder equipped aircraft. The ASR-9's received data from the ATCBI-5's in order to perform radar/beacon target correlation before passing target data to the SCIP's.

Both the LAX north and south radars were used to collect data. The track data described in this report were collected from the south radar because its proximity to runway 25L provided greater accuracy for targets close to runway threshold.

4.1.2 ATRAIN System.

4.1.2.1 ATRAIN Usage at LAX.

The ATRAIN was a PC-based system that allowed users to collect or display surveillance data from the 32-bit (30 data and 2 parity bits) parallel output of an ARTS IIIA facility SCIP. The collected data were time tagged, using the WWVB time source, and stored by the ATRAIN system to disk in the X-base format used by FoxPro Database Management software.

The ATRAIN system incorporated azimuth filtering of the radar and beacon only/radar reinforced messages based on sector. User input dialogue boxes enabled the user to specify start and stop sectors by Azimuth Change Pulse (ACP) values. These parameters were set to restrict data collection to sectors actually used by the aircraft during approach and landing at the LAX 24L/R and 25L/R runways.

4.1.2.2 ATRAIN System Description.

The ATRAIN system consisted of the following equipment:

a. Custom tee device to tap into SCIP data.

b. Signal repeater assembly to drive signals from the tee to the PC.

c. Custom Industry Standard Architecture (ISA)-bus parallel interface card (ATRAIN interface card).

d. ATRAIN PC-resident software.

e. WWVB Time Code Receiver interface card (added to original ATRAIN system for LAX data collection).

The ATRAIN system collected surveillance data from the output of one SCIP (north or south). The ATRAIN operated in a listen-only mode, utilizing the SCIP-generated handshake signal Input Data Request (IDR). The system accepted the high-speed data transfers from the SCIP (up to 330,000 parallel transfers per second).

The tee style cabling device provided the ATRAIN system with access to the SCIP-to-IOP surveillance data. The tee served two primary functions:

a. Provided a tap into the SCIP surveillance data flow.

b. Provided the first level of fault isolation from the operational system.

System design ensured any failure within the ATRAIN system did not adversely affect the ARTS operational system. The signal repeater assembly provided much of this isolation and allowed the Host PC to be located up to 75 ft away from the SCIP.

The ATRAIN parallel interface board accepted the high speed data transfers from the signal repeater assembly, buffered the data until the computer was ready to accept it, and then passed the data to the computer at a slower rate. The computers used for data collection were ISA PC systems with a number of add-on cards. An AT&T PC ran the custom software that collected, time-stamped, and stored SCIP data. In addition to ATRAIN, add-on cards included a high speed serial port, a Mountain Tape Interface, a WWVB interface card and a LAN card. The data collection was monitored from the Technical Center via two dial-up telephone lines.

The ATRAIN software used time-code transmitted by radio station WWVB to time-stamp the SCIP data. The WWVB interface card accessed this time in IRIG-B format from a Time Code Receiver.

4.1.3 Network File Server Computer Equipment.

The Zenith Z-248 AT Compatible functioned as a non-dedicated network file server. The Zenith had a 600 Mb drive where SCIP and interfacility data were saved after each day's data collection. The Zenith also included software that permitted on-site plotting of collected data. Add-on cards included a memory board containing 6.0 Mb of Random Access Memory (RAM), an ARCNET Active Hub, and an Emulex Persyst coprocessor board.

In addition to acting as a network server, the Zenith Z-248 collected LAX interfacility data via the Landrum and Brown ARTS IDentification Data Acquisition System (ID-DAS). The ID-DAS interface consisted of a Persyst multiport serial coprocessor board and the ID-DAS software. The Persyst board is a distributed serial data communications processor capable of running independently of the Host PC.

The LAX interfacility data were collected via passive tee's attached to the coaxial cables between the interfacility data modems and the ARTS Peripheral Adaptor Module (PAM). This interfacility data provided communications between LAX and Los Angeles Air Route Traffic Control Center (ARTCC) containing flight information (flight plans, initiate controller handoff requests, etc.) on flights coming into or going out of LAX and its satellite airports. The information extracted for this data collection consisted of each LAX arrival's beacon code, aircraft ID, aircraft type, approach fix, and altitude at the CIVET fix.

4.1.4 Remote Access & Tape Backup System.

A Compaq SLT Laptop computer was used to allow remote access to the data collection system from the FAA Technical Center in New Jersey. The system also performed tape backup via the Mountain Tape Drive software and hardware. A Mountain Series 7300 300 Mb dual tape drive system was used. Tape backup was performed automatically using commercial, off-the-shelf (COTS) software supplied by Mountain, Inc.

4.1.5 Voice Logging Recorder (VLR).

A four channel audio recorder was used to record ATC communications between pilots and LAX air traffic controllers. The VLR-466 also monitored ATC communications at Ontario International Airport (ONT). ONT was an airport along the CIVET approach.

4.2 DATA COLLECTION SYSTEM SOFTWARE.

4.2.1 ATRAIN Software.

The ATRAIN software collected surveillance data from the SCIP. The software provided a tabular and graphical representation of the data, converted the data into FoxPro database format, and stored the formatted data onto the hard disk.

The ATRAIN system software was modified to allow greater flexibility for remote operation. The options that defined the system configuration for a given session included:

a. Range filtering of collected targets with respect to radar collection (50 nmi for LAX).

b. Specification of Start and Stop ACP count (110 and 855 for LAX).

c. Termination of data collection at a preset time each day (2200 hours, LAX time).

In addition, the software was modified to collect beacon returns from three stationary targets called "parrots." Parrots are radar transponders, installed at surveyed locations, used to calibrate radars. The software created three data files, one for each parrot. The parrots used beacon codes 1224, 1225, and 1275.

4.2.2 WWVB Time Processing.

The National Bureau of Standards WWVB broadcast station located in Fort Collins, Colorado was used as the reference time source for the data collection. WWVB time was received and processed by a commercially available unit with an accurate internal clock. The internal clock provided a stable reference at the site when radio reception was poor. The WWVB time was used to time stamp each record written to disk.

4.2.3 Interfacility Data Collection Software.

A Fortran program written by the Landrum & Brown Company called the ID-DAS collected and stored interfacility data. The program's input parameters had to be set up each time data collection was started [5]. The ID-DAS provided the ability to execute the collection software via a batch command. The batch command specified a re-directed input file with the parameters needed to initialize and configure the software. The parameters provided for filtering of the interfacility data during collection. The options were set as:

a. Processing mode = All Operations.

b. Include all aircraft ID's for LAX.

c. All ARTS interfacility messages, pertinent to the data collection, were copied to a buffer file.

d. Start and Stop times were specified for LAX (data collection began at 0530 and stopped at 2355 hours Pacific time).

4.2.4 Weather Data Collection Software.

The LAX and ONT National Weather Service meteorological reports were collected once a day from the Meteorological Database computer located at the Minneapolis International Airport (see figure 10). Surface Observation Reports (SA) were normally available on an hourly basis, with Special Reports (SP) given more frequently when warranted by rapidly changing weather conditions. PC Weather was a telecommunications program which accessed the Kavouras Inc. meteorological database [6]. The software was set up to call up and logon to the Kavouras database, request the 30 previous reports, save the reports to disk, and logoff the system.

Although both ONT and LAX data were collected, only LAX information was incorporated into the Master Database. ONT weather is available on disk, to review if needed.

4.2.5 Tape Archive of Data.

A daily tape backup was made of collected data. When a day's data collection was completed, all ATRAIN and interfacility files were copied to the network disk. At 4 a.m., TAPEBCK.BAT was executed. This batch file backed up the day's collected data files from the network disk to primary and secondary backup tapes. As the back up tapes neared capacity, on-site personnel replaced the tapes with fresh ones.

4.2.6 Data Collection Support Software Summary.

Various COTS software packages were used to support the LAX data collection effort. The support software was supplied by Mountain Computer, Inc., Novell Incorporated, and Dynamic Microprocessor Associates, Inc.

4.2.6.1 Autorun.

Autorun was a program supplied with the Mountain Filesafe Tape Backup software [7]. The program executed appointments based on the PC time and date. Autorun was used to start the SCIP and interfacility data collection and initiate the tape backup of the data daily.

4.2.6.2 Novell NetWare.

NetWare software was used to set up the LAN for the AT&T, COMPAQ, and the Zenith Z-248 computers at LAX.

4.2.6.3 PCAnywhere.

PCAnywhere was a communications software package [8] that provided remote access for the monitoring and operation of the project computers and the transfer of files via modem between the FAA Technical Center and the LAX installation.

4.3 DATA COLLECTION PROCEDURES.

After the data collection procedures were established, it was not necessary to have FAA Technical Center/CTA personnel on-site. Data collection was monitored and operated by personnel at the FAA Technical Center. TRACON personnel provided support when required.

4.3.1 SCIP Data Collection Procedures.

The SCIP data collection process was initiated by a batch file (LAX_RUN.BAT). The batch file was started on the AT&T PC each day at 0530 hours (Pacific time) by Autorun. The batch file initiated the following procedures:

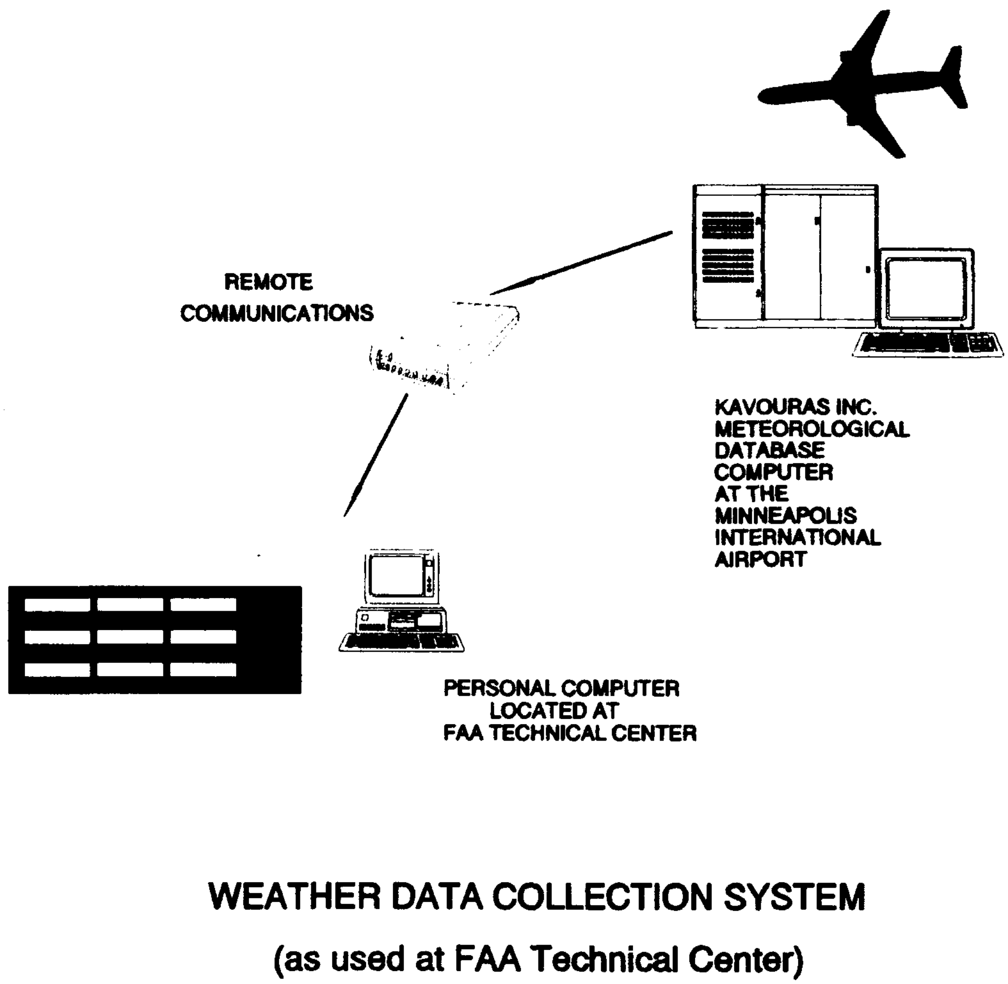

FIGURE 10. WEATHER DATA COLLECTION SYSTEM

a. Reset the Disk Operating System (DOS) time to WWVB time.

b. Started the ATRAIN data collection program. This program ran from the time it was started until 2200 hours (Pacific time).

c. After ATRAIN terminated, the collected data was copied to the network disk.

If problems occurred during data collection necessitating a reboot of the PC, LAX_RUN.BAT was restarted manually by either on-site personnel, or remotely by FAA Technical Center/CTA personnel.

4.3.2 Interfacility Data Collection Procedures.

The Landrum and Brown ARTS ID-DAS was invoked by a batch file (IDDAS.BAT). This batch file was invoked at midnight, but data recording did not begin until 0530. The batch file initiated the following procedures:

a. Set up ID-DAS configuration and started execution of the interfacility data collection program. This program ran from when it was started until 2355 hours (Pacific time).

b. Saved the day's data to hard disk and to the network disk. The interfacility data saved on the network drive was backed up to tape at the same time as the SCIP data files.

4.3.3 Weather Data Collection Procedures.

LAX surface weather reports were collected daily by ACD-340. This data was obtained through an existing contract with the Kavouras Meteorological Network.

4.3.4 Data Collection Monitoring Procedures.

During data collection, the site was monitored daily. Although the software and hardware used in this configuration were reliable, occasionally an unusual event locked-up one of the systems.

Event log files were use to check the status of the various systems. ATRAIN data collection status could be reviewed by checking the file, RUN_LAX.LOG, on the hard disk of the AT&T or on the network disk. The status of interfacility data collection was contained in IDDAS.LOG, on the network disk. Tape backup status was recorded in TAPEBCK.LOG, on the network disk.

4.3.5 Pilot Questionnaire Collection Procedures.

Flight crew data were collected via pre-addressed, postage paid, postcards. Questionnaire data consisted of date, airline and flight number, aircraft type, approach type (A/P, F/D or raw data), distance pilot started navigating the localizer, distance runway was visible, and any additional comments from the flight crew. Of the 428 questionnaires collected, 283 were for dates that flight track data were extracted and reduced. Corresponding track data were found for 210 out of 283 responses.

5. DATA PROCESSING.

The raw LAX data were processed at the FAA Technical Center to reduce it to a form suitable for analysis. The track extraction and reduction processes are outlined in figure 11. Almost 7200 CIVET arrivals were extracted from the interfacility and SCIP data files. Nearly 4500 of these landed on runway 25L.

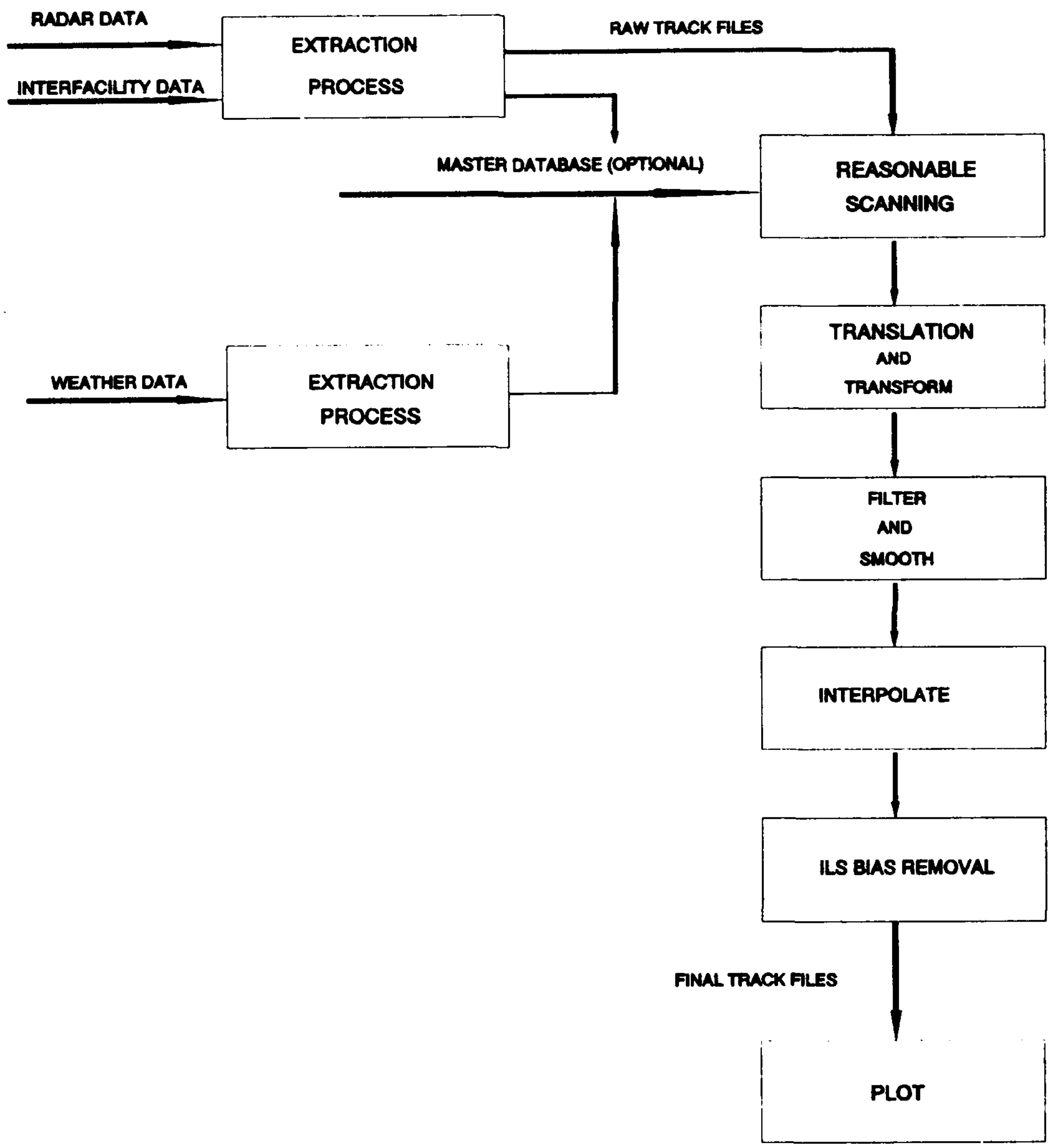

FIGURE 11. DATA EXTRACTION AND REDUCTION PROCESS

For this report, track extraction and reduction were performed only on the 25L tracks.

5.1 DATA EXTRACTION AND REDUCTION.

5.1.1 Parrot Statistics.

Parrot statistics were calculated using the raw SCIP data to assist in the calculation of the radar range and azimuth biases for a session. This process used a series of programs that extracted and analyzed the parrot data to produce a statistical report. The Parrot transponder data, collected continuously during each session, were received from three fixed beacon radar parrots. The report had values, based on the total number of Parrot returns, for the mean and standard deviation of both radar range and azimuth, and the skewness and kurtosis of the azimuth. In previous studies (references 1, 2, 3) these reports (figure 12) were used to determine if there had been any change in the radar range and azimuth mean values over time. Any changes of these mean values entailed adjustment of the range and azimuth bias values. In this study, however, biases were determined via comparison with an independent precision radar. More information on this is contained in section 6.2 of this report.

5.1.2 Track Extraction.

Subsequent to data collection, but prior to data analysis, track data were extracted from the raw SCIP and interfacility files and merged into a database. The extraction consisted of the following:

a. Interfacility data were converted to X-base database format.

b. SCIP and interfacility data were cross referenced to obtain the aircraft ID and the aircraft type for each track. Only data for those tracks having the CIVET arrival fix in their flight plan were extracted from the SCIP data. SCIP data were sorted into individual track files, according to beacon code and time.

c. Aircraft tracks with a sufficient number of scans were identified, and the runway being approached was determined for each track.

d. One record for each track was appended to the master database.

The raw track files were placed into a session subdirectory, where a session was normally one day of the collection period.

5.1.3 Track Reduction.

The reduction process used the "raw" or unfiltered track files created by the extraction process and performed the following operations on them:

a. Individual track file data were checked for reasonableness; multiple scans were deleted, altitudes were added or corrected as needed, time gaps in data were identified, and pre- and post-gap data were checked to see if they were from the same track.

b. Data were converted from slant-range, azimuth, and altitude to cartesian coordinates (x, y, z). Range and azimuth biases were removed from the track data.

c. Since the parallel runways at LAX were closely spaced, runway assignment was checked and verified. If necessary, a runway assignment was changed.

```
11:11:47                                                                   08/11/92

      Radar Statistics using N:\LAX\UNPACK\A3300005.DBF

       >>> PARROT STATISTICS FOR BC = 1275 <<<

   Total number of samples is 16450
   Mean value of RANGE is 14.542 nmi (88270 ft)
   Mean value of ACP count is 3262.23 (286.72 deg)
   Standard Deviation of RANGE is 0.007 nmi (45.2 ft)
   Standard Deviation of ACP is 1.768 (0.155 deg/2.71 mr)
     or 239.4 ft @ 14.562 nmi
   The Skewness of ACP is 2.130
   The Kurtosis of ACP is 17.697
   Range of Range's is from 14.531 to 14.547
   Range of ACP's  is from 3251 to 3284
     or 285.73 to 288.53 deg
   Correlated Beacon reports unused in thes computations: 597

ACP                                                                          CNT
3251                                                                           1
3252                                                                           0
3253                                                                           1
3254                                                                           4
3255                                                                           1
3256                                                                           4
3257                                                                           3
3258                                                                          27
3259 *****                                                                   303
3260 ********************************                                       1631
3261 ***********************************************************            3933
3262 *****************************************************************      4192
3263 ************************************************                       3046
3264 **************************************                                 1944
3265 *********************                                                   940
3266 *****                                                                   277
3267 *                                                                        55
3268                                                                          19
3269                                                                          11
3270                                                                           3
3271                                                                           9
3272                                                                           4
3273                                                                           7
3274                                                                           6
3275                                                                           4
3276                                                                           1
3277                                                                           3
3278                                                                           6
3279                                                                           4
3280                                                                           2
3281                                                                           3
3282                                                                           2
3283                                                                           2
3284                                                                           2
     |----------------------------------|-----------------------------------|
     0
```

FIGURE 12. RADAR STATISTICS FOR PARROT TRANSPONDER

d. Data were filtered and smoothed to eliminate remaining radar outliers and dampen random radar noise using algorithms developed at M.I.T./Lincoln Laboratory [9] and modified by ACD-340 for previous data collecting.

e. Interpolated data points were calculated at 0.15 nmi increments along the ERC.

f. ILS localizer bias (displacement of ILS localizer centerline from the ERC) was removed from the track data.

g. The stability point on the ILS localizer for each track was determined by an algorithm which flagged all data points outside a predetermined fan (see section 6.2.2). The point before the flagged point nearest the threshold was used as the localizer stability point with one caveat: a fan was chosen with width small enough to minimize the inclusion of localizer turn-on data in the stable tracks. Due to the conservative nature of this fan, cases where the automatic process produced a stability point within 20 nmi of runway threshold were examined manually. This "second look" determined if the aircraft could have been considered stable beyond the original stability point and, if so, the most likely cause of the stability fan transgression.

The final reduced track files consisted of reports at 0.15 nmi increments along the ILS localizer centerline. Each track file record contained: Time - the time of day in hours, minutes, and seconds; X - distance from runway threshold along the ERC; Y - distance from ILS localizer centerline; and Z - distance (altitude) above mean sea level (msl). All distances were in nmi. The conversion factor was 6076 ft/nmi. File records were arranged in reverse time order. This meant that the first record in the file represented the touchdown point or the distance closest to touchdown. Each successive record was an additional 0.15 nmi from touchdown in the X direction.

5.1.4 Plotting.

All track files for each session were plotted as a group on a two-dimensional (x,y) scale, where x is the distance to touchdown, and y is the deviation about the ILS localizer centerline. The plots were identified by session number, runway designation, and number of track files plotted (see figure 13). A grid in both axes was superimposed on the plot so that distances can be more easily judged. The x scale was from touchdown to 40 nmi out. The y scale was from -0.5 to +0.5 nmi.

5.1.5 Master Database.

The master database consists of information about each track, and the weather at the time of data collection. It was created during the extraction process. The master database does not contain any radar data. This database was used to identify tracks for conditions that need to be analyzed. For a more detailed description of the master database fields, see appendix C.

5.1.6 Weather Data Integration.

Weather data collected from Kavouras were in ASCII text. LAX weather data files were converted to dBASE formatted files and merged into the master database. For a more detailed description of the weather data files, see appendix A.

Data from ONT TRACON were stored as separate files on a floppy and on the network disk at the FAA Technical Center.

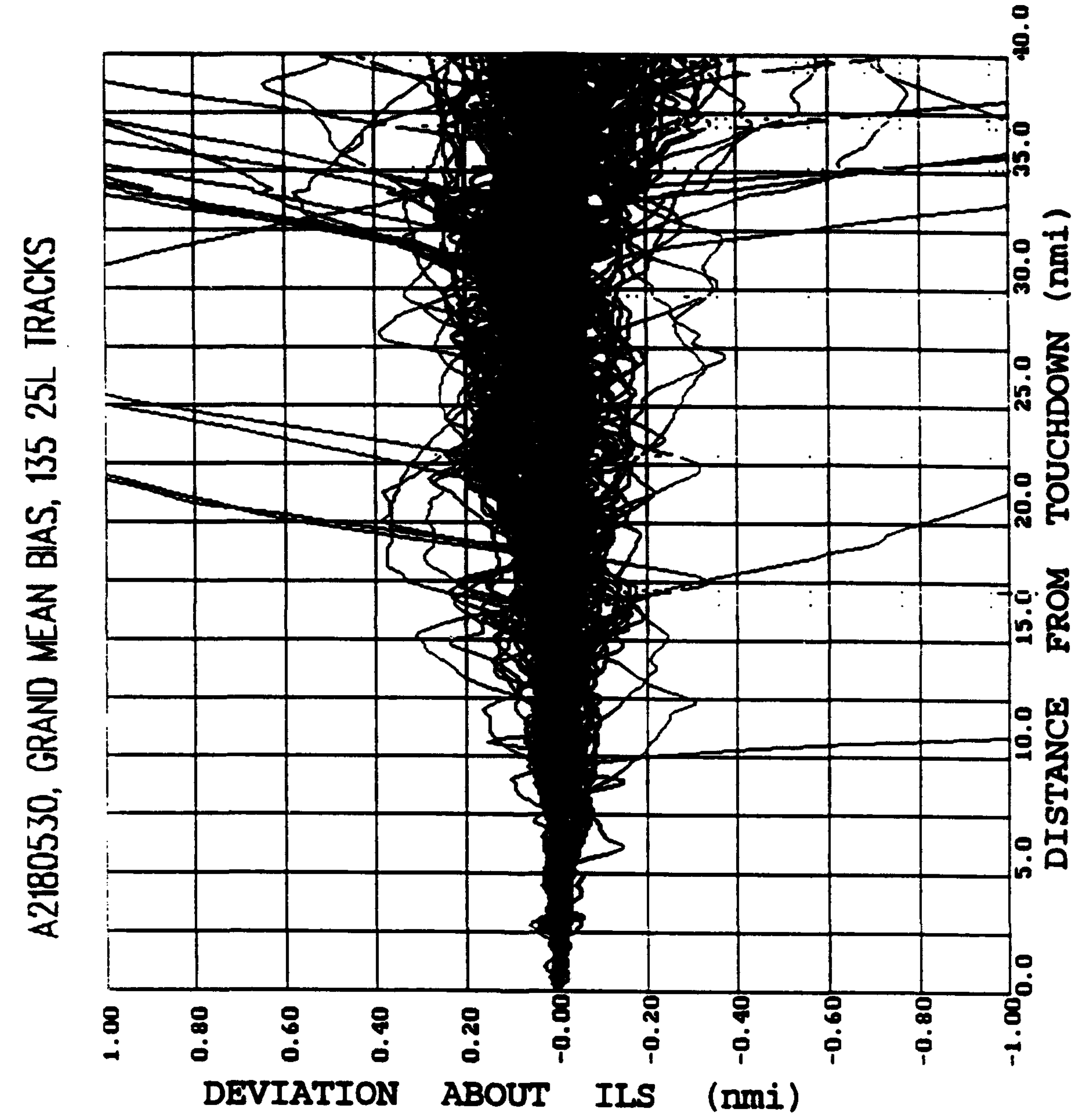

FIGURE 13. EXAMPLE SESSION TRACKS PLOT

5.2 DELIVERABLES.

The final track data files and the master database were compressed using PKZIP and stored on floppy disks. The data delivered will be used to extend and validate existing simulation models used at the FAA Technical Center. These models are used to
perform real-time, controller-in-the-loop, Multiple Parallel Runway Simulations.

The sessions will be checked against the returned pilot questionnaires to obtain a list of the corresponding tracks.

5.2.1 Sessions Extracted and Reduced.

Selection of sessions were based on the amount of flight track, pilot questionnaire, weather data, and the ability of these data to support Phase 4 research. The main consideration was to assure a sufficient amount of data to characterize FTE by aircraft type, approach technique, and weather conditions in the Phase 4 analysis. FTE and aircraft type were contained in the track files of combined radar and interfacility data. It was assumed that there would be a sufficient mix of aircraft types in the 2500 to 3000 tracks originally planned to be extracted and reduced. Approach technique (A/P, F/D or raw data) were contained in the pilot questionnaire responses. Ceiling and visibility data were available from the collected weather data. The sessions extracted and reduced were based in part on the number of individual flights that had data from all three sources. An additional criterion was the number of flights in each approach category under different weather conditions.

To meet these requirements, the first set of sessions extracted and reduced were 2/25, and 3/20 to 4/4/92. A large number (187) of questionnaire responses were returned for this period. Radar data collected by a Vitro (RIR-778X) mobile tracking radar were compared with the south ASR-9 radar data to determine the ASR-9's range and azimuth biases for 2/25, 3/30, 3/31, 4/2, and 4/3/92. After analysis of the first set of reduced track data, it was determined that there was a critical shortage of flight tracks collected under Instrument Meteorological Conditions (IMC), a critical shortage of raw data approaches, and a less critical shortage of F/D approaches. Based on the these criteria and the availability of questionnaire and track data, an additional 15 days (1/17, 1/25, 1/27, 2/8, 2/18, 2/20, 2/26, 2/28, 3/9 - 3/11, and 4/7 - 4/10) were extracted and reduced.

There were a total of 7199 tracks in the master database. 4481 tracks were 25L landings and 4109 of these tracks (92 percent) had a stability point of 20 nmi or greater. A list of extracted sessions is in table 1. The number of reduced tracks easily exceeded the 2500 to 3000 tracks originally planned for the Phase 1 part of the project.

6. DISCUSSION.

6.1 TRACK REDUCTION RESPONSIBILITIES.

The ATC Technology Branch, ACD-340, was tasked to collect and reduce track4 data for aircraft conducting approaches to LAX runways 24L/R and 25L/R. These data will be used by ARD-100 to support development for national standards of dual, triple, and quadruple approaches to parallel runways. It will also be used to develop analytical models to be used in ATC simulations. ACD-340 performed an analysis to determine the quality of the collected data incuding the possible sources of error. ACD-340 also computed ILS containment statistics. Further analysis with respect to Phase 4 of the LAX data analysis effort will be done by ARD-100 in conjunction with ACD-340.

TABLE 1. SESSIONS EXTRACTED AND REDUCED

DATE	SESSION	TRACKS UNPACKED AND REDUCED: (25L landings only)
1/17/92	A1170532	100
1/25/92	A1250532	103
1/27/92	A1270532	149
2/1/92	A2011845	1
2/8/92	A2080530	136
2/9/92	A2090530	9
2/18/92	A2180530	135
2/20/92	A2200530	201
2/25/92	A2250531	155
2/26/92	A2260531	164
2/28/92	A2280531	176
3/9/92	A3090726	167
3/10/92	A3100530	146
3/11/92	A3110530	190
3/20/92	A3200922	55
3/21/92	A3210530	158
3/22/92	A3220600	99
3/23/92	A3230540	168
3/24/92	A3240613	144
3/25/92	A3250530	18
3/26/92	A3261221	130
3/28/92	A3280530	24
3/28/92	A3281000	108
3/29/92	A3291003	158
3/30/92	A3300649	177
3/31/92	A3310603	174
4/1/92	A4013500	88
4/2/92	A4020754	126
4/3/92	A4030220	168
4/4/92	A4040600	161
4/7/92	A4070600	118
4/8/92	A4080600	192
4/9/92	A4090802	171
4/10/92	A4100600	198
Total:		4481

6.2 DATA FIDELITY.

The track reduction process, as described in section 5.1.3 of this report, produced a file of position information (time, x, y, z) for each recorded track, where time was time of day, x was the distance from touchdown along the ERC, y was the perpendicular distance from the ILS localizer centerline, and z was the altitude above msl. These data were filtered, smoothed (appendix A) and interpolated to give a value for the crosstrack deviation at each 0.15 nmi increment along the ILS localizer centerline. In addition, since the data

were collected via ASR-9, range and azimuth biases were determined, and subsequently removed. The data were then translated from range, azimuth, and altitude with the origin at the radar antenna to x, y, and z with the origin at the runway threshold. Details of the procedures used to remove the radar biases can be found in section 5.1.3.

The final result was a collection of sessions. A session consisted of the reduced data files for all the tracks collected in a day. All tracks for a session were plotted on a single graph. A sample plot can be found in section 5.1.3. Statistical analysis was performed on all sessions to produce mean and standard deviation values of the measured deviation from localizer centerline at increments of 0.15 nmi away from runway threshold (see appendix D, table 1). The numbers of aircraft inside and outside a 500 ft envelope about the localizer centerline were calculated at 0.15 nmi increments (see appendix D, table 2).

6.2.1 Track Extraction Problems.

In previous data collections (FAA Technical Center, ORD, SFO and STL), it was found that tracks were difficult to smooth with fidelity near their terminus. Ground clutter produced erroneous radar replies and lowered the occurrence of primary/beacon radar reinforcement. When coupled with the relatively low scan rate (4.7 seconds), one or more questionable or missing surveillance reports near touchdown could significantly skew the track at its terminus, causing the aircraft to appear to miss the runway at landing. Due to the higher quality of the ASR-9 radar data, there were only a small number of tracks exhibiting this problem at touchdown. These problem tracks were found by plotting an entire session and picking out questionable track plots by hand. Questionable reports generally occurred within 2 nmi of touchdown. The track data were manually examined; reports having more than a reasonable amount of deviation at touchdown (approximately 5 sigma) were removed, leaving a gap in the data. This data gap was "filled" during the smoothing process.

During the extraction process, there were three days (4/7-9) where the aircraft were arriving 40 to 50 minutes after the interfacility data arrival time. Since the existing extraction software (TRACKS) only checked the SCIP data -20 to +20 minutes from a given aircraft's interfacility arrival time, no track files were initially extracted for these days. The TRACKS software was temporarily modified to examine a -20 to +60 minute window for the SCIP data. This change enabled the extraction of track data for the three days.

6.2.2 ILS Stability Point Calculation.

In order to perform meaningful statistical analysis of track data, the aircraft needed to be stabilized on the localizer. A simple algorithm is used to create an ILS stability detection fan, originating at the runway threshold and extending out to 40 nmi (see figure 14). The fan is the area bounded by the following equation:

Y_FAN = ±(MAX_Y_VAL / MAX_X_VAL) * X_VAL ± OFFSET

where: MAX_Y_VAL = 0.30 nmi, maximum deviation from centerline.

MAX_X_VAL = 40.0 nmi, distance from runway threshold along the ILS localizer centerline.

OFFSET = 0.1 nmi.

All points outside the fan were flagged. The point before the flagged point, nearest the threshold, was used as the localizer stability point. For a given track, data analysis was based on the track data that was equal to or less

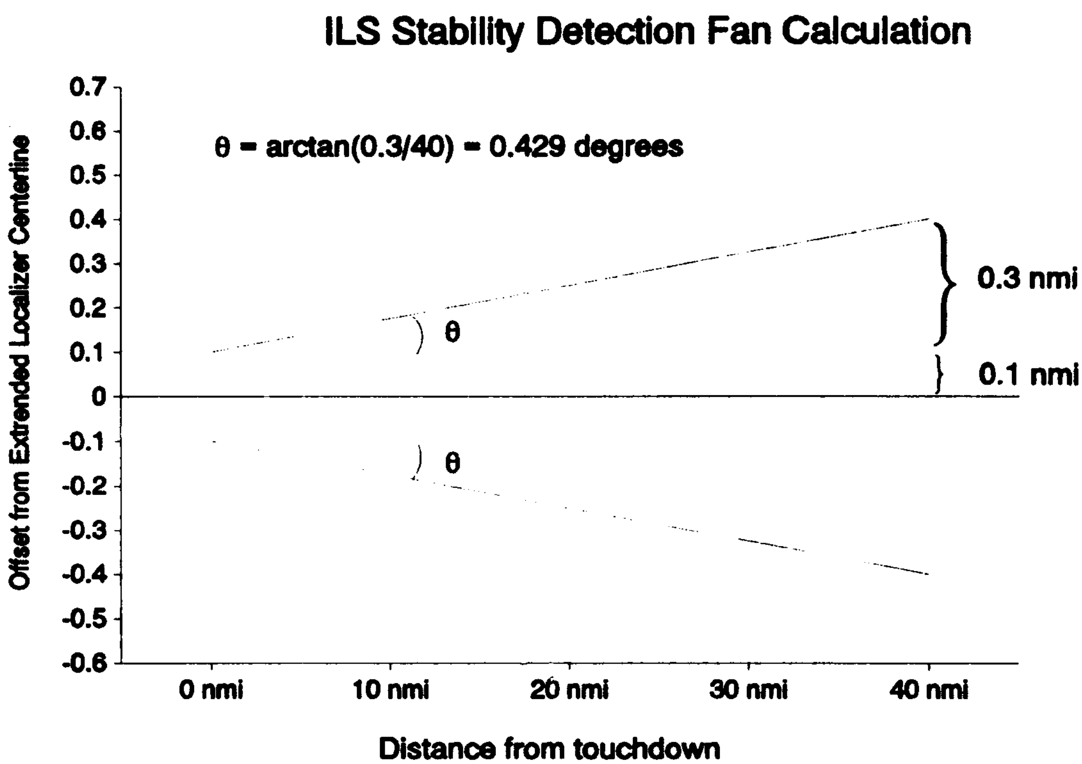

FIGURE 14. ILS STABILITY DETECTION FAN

than the stability point for that track file. Track data beyond the stability was not used in calculating containment statistics.

Occasionally during plotting, a track would display a large spike (deviation from centerline) further out from touchdown. These spikes appeared to be approach sequencing vectors or delay turns. These spikes may affect the calculation of the ILS stability point for the track. An aircraft could be stabilized on the localizer further out, but the spike would cause the aircraft to pass outside the stability fan (see section 6.2.2). Tracks that displayed this occurrence within 20 nmi of runway threshold were examined manually and the stability point was modified, if appropriate. However there was not sufficient resources to examine all tracks not stable by 32 nmi. It is recommended that these tracks be examined on a case by case basis, or that the stability fan be increased to be as wide as the localizer fan.

6.2.3 Radar Range and Azimuth Bias Removal.

In previous data collections, the radar's range and azimuth biases were determined empirically from reduced track data. For the LAX data collection effort, radar data collected by a VITRO (RIR-778X) mobile radar tracking system was compared with south ASR-9 radar data to better determine the ASR-9's range and azimuth biases. VITRO data was collected on 2/25, 3/30, 3/31, 4/2, and 4/3 for the south radar. The individual range and azimuth biases calculated for a given day were used to reduce the track data collected for that day. The remainder of the sessions was reduced using the mean values of these calculated biases. The mean calculated values of the range and azimuth biases were -279 ft or -0.04592 nmi and 0.1879 degrees, respectively. The total azimuth bias included the magnetic declination at LAX for a total azimuth bias of 14.1879 degrees.

6.2.4 ILS Localizer Bias Removal.

The location of the center of the ILS localizer was calculated with respect to the ERC. These data were obtained using a specially equipped test B-737 aircraft supplied by National Aeronautics and Space Administration (NASA) at Langley, VA. This aircraft had the capability to record ILS data inflight and to time-synchronize ILS data collection with VITRO data collection. The aircraft flew numerous CIVET approaches to runway 25L along the localizer centerline while being tracked by the VITRO radar. After comparison with VITRO data, the NASA data indicated the ILS localizer centerline was slightly to the left of the ERC. The data obtained from the NASA aircraft was used for the ILS localizer location. The data (appendix D, table 3) show the displacement of the localizer centerline from the ERC in 0.15 nmi increments from 1.95 nmi to 32.10 nmi from the runway 25L threshold. The values of the localizer displacement varied from approximately -31 ft (0.00505 nmi) to -267 ft (-0.04394 nmi). In an additional reduction step, this bias was removed from the track data in order to determine crosstrack deviation relative to the ILS localizer centerline.

6.2.5 Data Analysis.

Analysis of the reduced track data was limited to containment statistics similar to those provided in the ORD report. The breakout characteristics and ILS localizer centerline containment statistics were determined for all the tracks. Extensive statistical analysis was beyond the scope of this effort, thus, was not performed on individual sessions.

A breakout of the sample's airframes is shown in the pie chart in figure 15. Of the 4481 aircraft landing on runway 25L; 4266 were large air carriers, 171 were general aviation, and 44 were military.

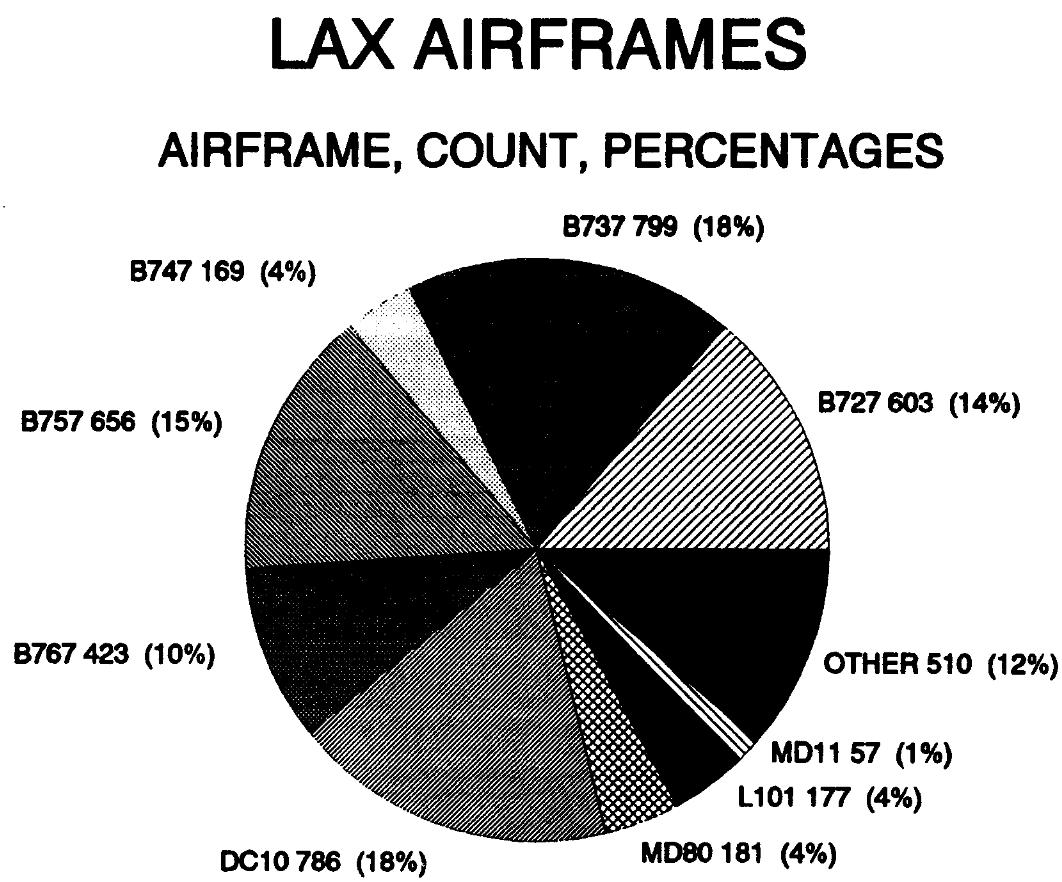

FIGURE 15. BREAKOUT OF SAMPLE AIRFRAMES

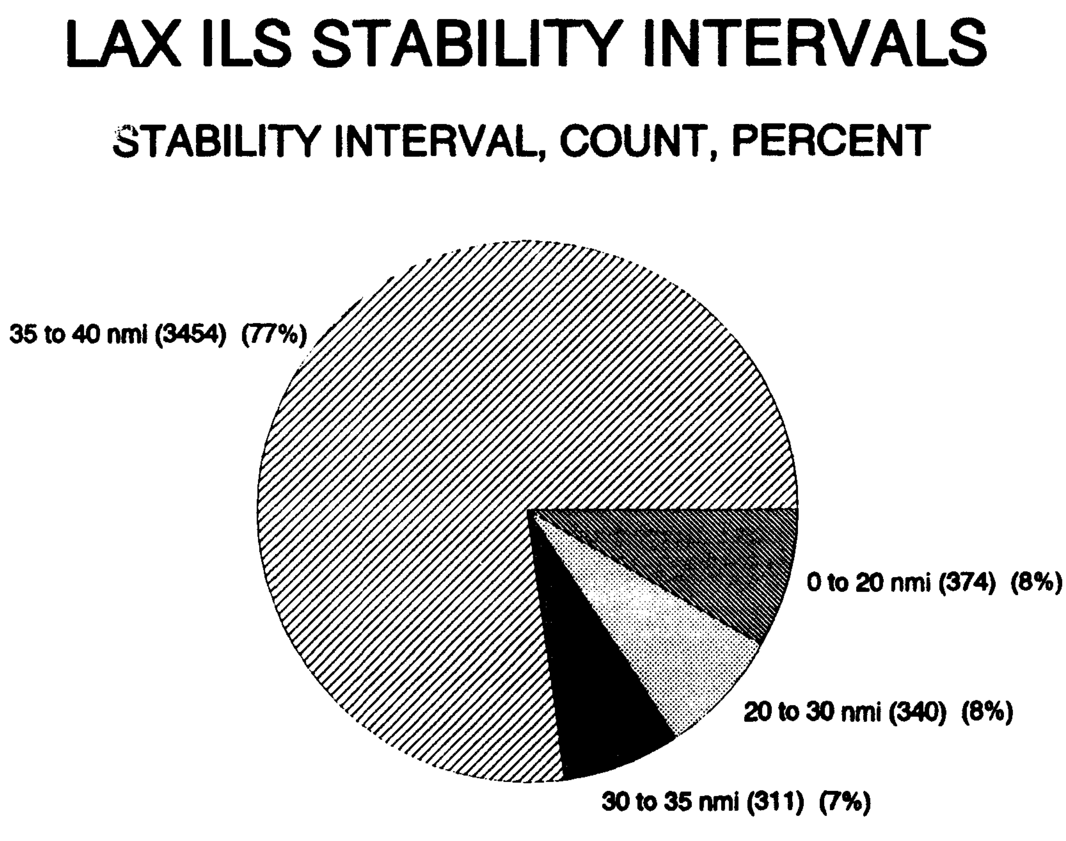

FIGURE 16. BREAKOUT OF STABILITY INTERVALS

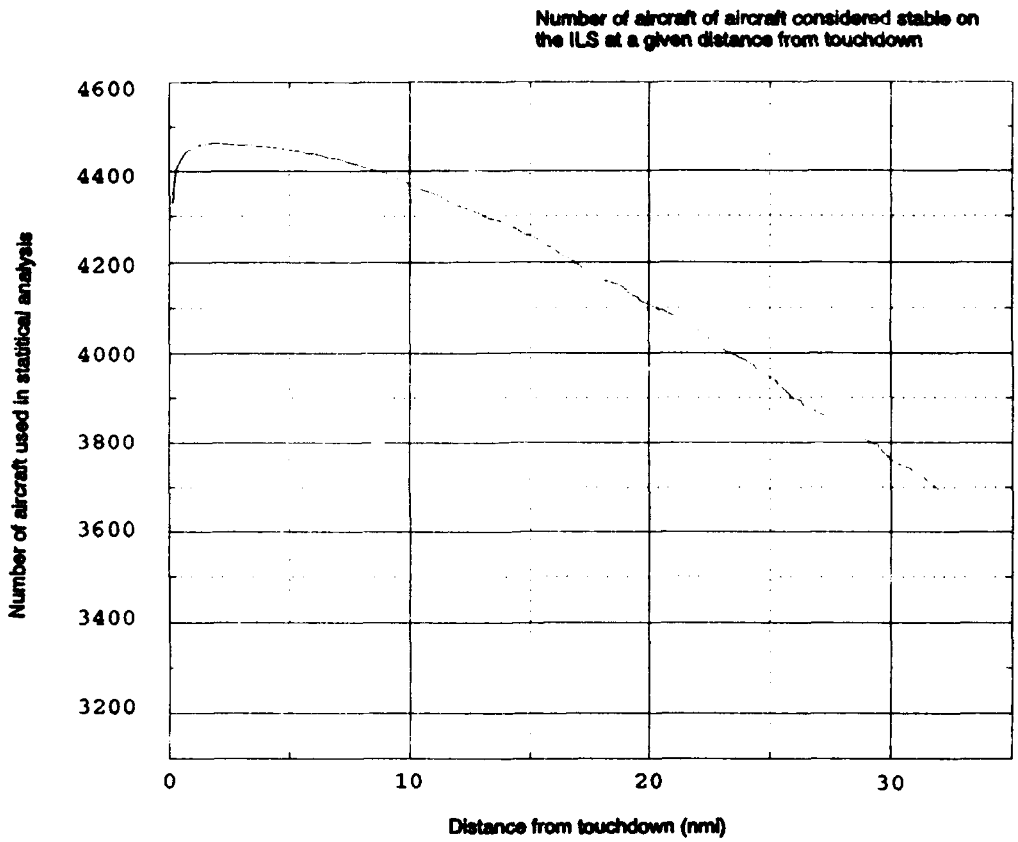

FIGURE 17. NUMBER OF TRACKS CONSIDERED STABLE

A breakout of the numbers of aircraft considered stable at varying distances from the runway threshold is shown in figure 16. In other words, how many aircraft first became stable in the following 4 intervals representing miles from runway threshold: (0,20], (20,30], (30,35], and (35,40]. A plot of the number of aircraft considered stable versus distance from threshold is shown in figure 17. Nearly 85 percent (3777 tracks) of the aircraft had stabilized on the localizer at 35 nmi from threshold. 92 percent (4109 tracks) of the aircraft were considered stable at 20 nmi from threshold. These numbers exceed the original Phase 1 goal of 2500 reduced, stable tracks.

Two different types of data analyses were performed on the collected track data. The first determined the number of tracks inside and outside a 500 ft envelope on either side of the ILS localizer centerline. The data (appendix D, table 3) show the number of aircraft inside a 500 ft envelope and numbers of aircraft on either side of the envelope in 50 ft increments out to 900 ft on either side of the localizer centerline. A plot of the number of aircraft inside the envelope versus the total number outside is shown in figure 18.

A second set of statistics shows the number of aircraft, mean, and standard deviation for tracks; to left of centerline, right of centerline, and for the entire data set (appendix D, table 3). A plot of the standard deviation for all the tracks versus distance from threshold is in figure 19. A plot of the mean crosstrack deviation for the tracks versus distance from threshold is in figure 20. Removal of the ILS bias from track data had minimal effect on standard deviation values. Removal of the ILS bias had a greater effect on the mean crosstrack deviation.

6.3 DISCUSSION.

The overall quality of the LAX data is better than previous data collections performed by ACD-340 (FAA Technical Center, ORD, SFO, and STL). There are several reasons for this: the close alignment of the south ASR-9 radar and the 25L/R runways, the high quality of the radar data, and determination of the radar range and azimuth biases not based solely on parrot data (previous data collections), but by direct comparison with VITRO precision radar data.

The data described in this report will serve as a baseline for further data analysis of subgroups of tracks based on pilot questionnaire data, airframe, weather conditions and approach technique. Additional days of data remain to be extracted and reduced, if needed.

6.3.1 Recommendations.

The work reported produced a data base of ILS arrival tracks, each with an extremely long final leg. An attempt was made to get the highest accuracy possible from a two milli-radian radar by performing independent measurements of test aircraft position via a precision approach radar to identify and remove ASR biases. The track data with ASR bias removed was initially compared to the ERC to identify deviations normal to this line. When this was done, symmetric deviations about the ERC were observed. An additional step was undertaken which identified the difference between the ERC and localizer centerline. This difference was then removed from the track data, effectively making the subsequently calculated deviations relative to the localizer centerline. These latter deviations were significantly biased to one side of the localizer centerline (towards the adjacent approach).

As of this writing, there is no acceptable explanation for this approach track bias. It is recommended that further research be carried out in an attempt to explain this phenomenon. One suggestion, from The MITRE Corporation, is that the ILS stability fan was conservative to the point of excluding data on one side of the centerline when the localizer centerline/ERC bias was removed. This is worth exploring since it appears that the current stability fan is

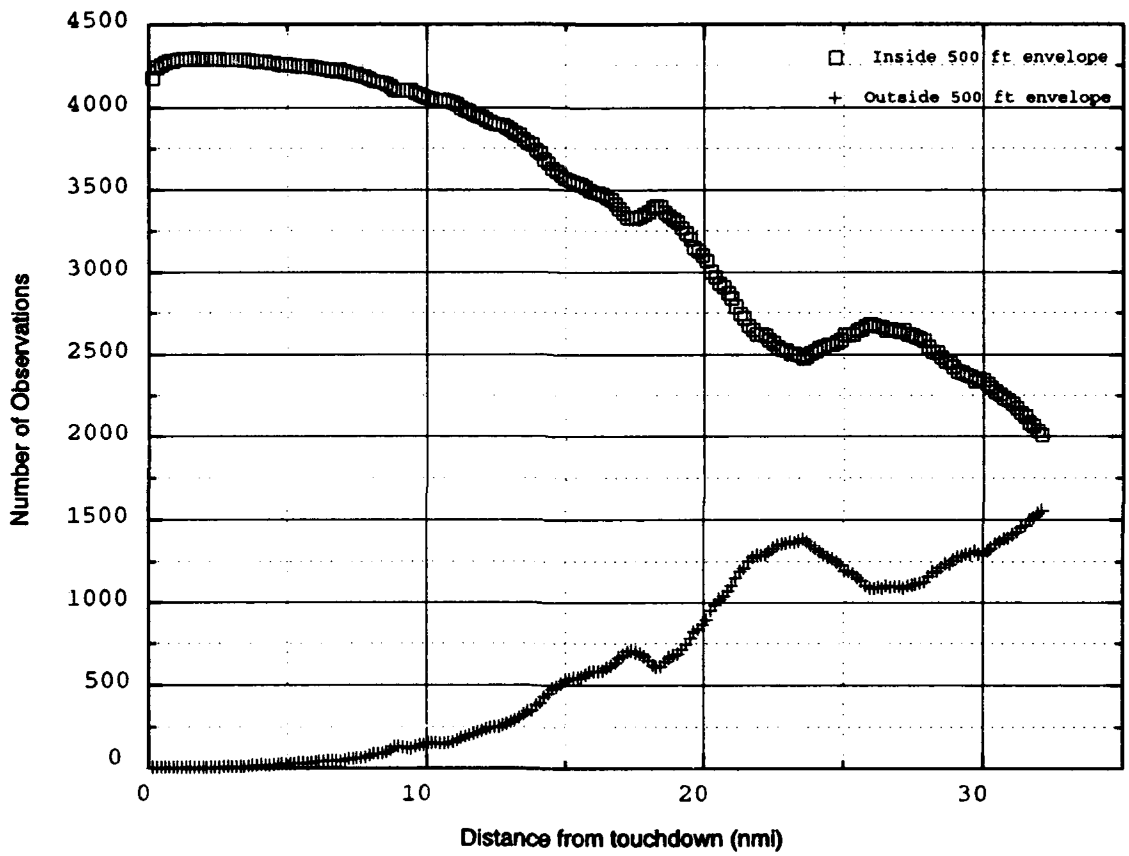

FIGURE 18. NUMBERS OF AIRCRAFT INSIDE/OUTSIDE CONTAINMENT ZONE

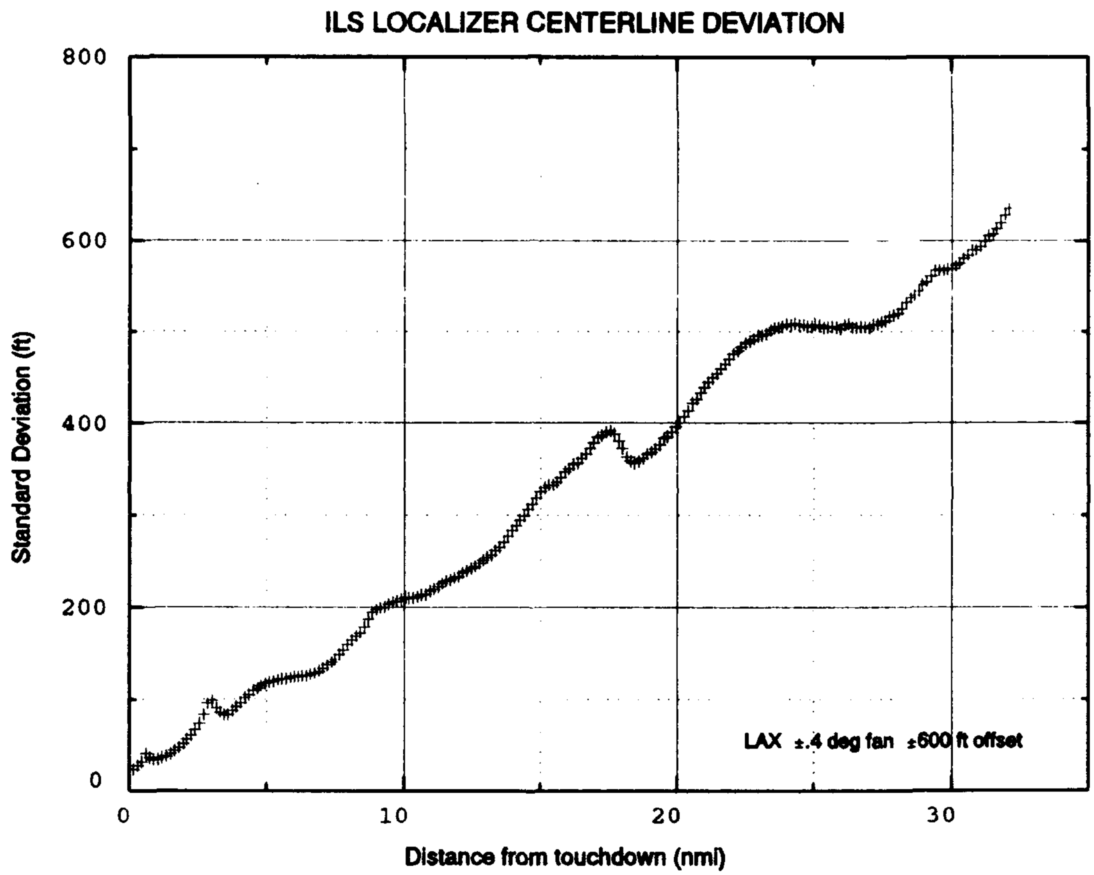

FIGURE 19. MEASURED DEVIATION FROM LOCALIZER CENTERLINE

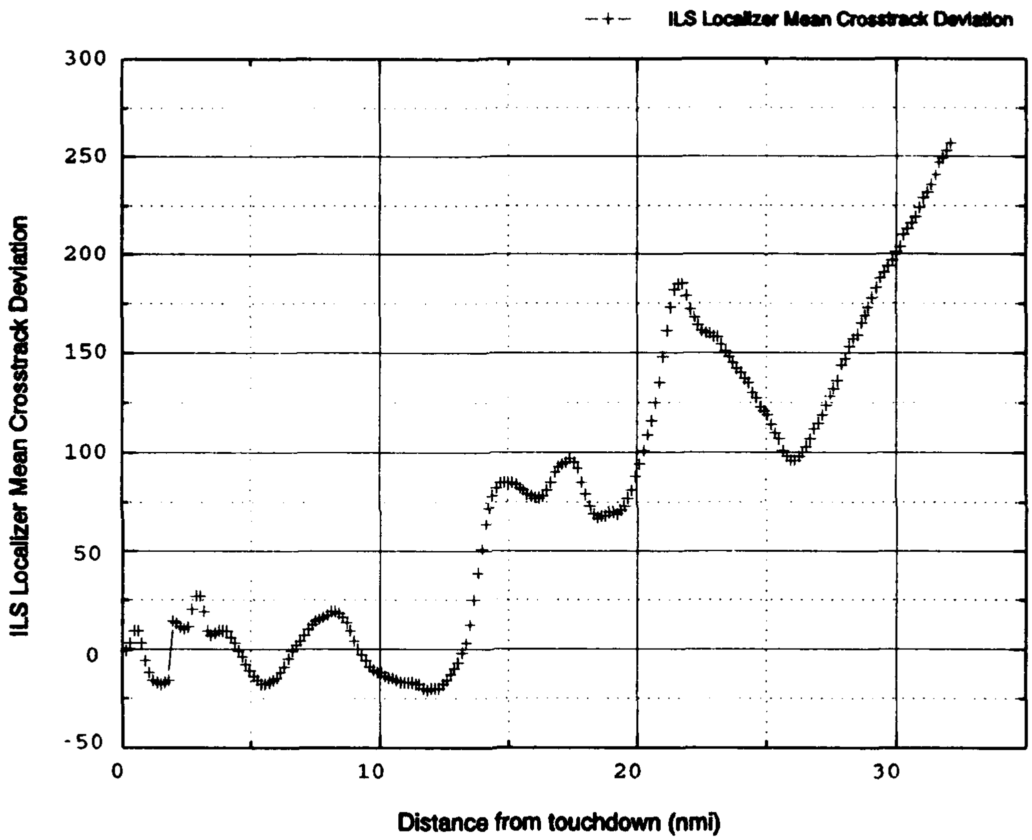

FIGURE 20. ILS MEAN CROSSTRACK DEVIATION

indeed too conservative and should be expanded even without the symmetry concern. The fan was made conservative to guard against inclusion of turn-on data. Although it did omit turn-on data, there exists the possibility that it also omitted data which could be considered stable. This data would be from tracks executing greater than average flight maneuvering after having captured the localizer. The number of tracks that would fall into this category and the magnitude of their deviation from the localizer centerline suggests that their inclusion would not significantly affect the computed sample standard deviation. However, this supposition should be confirmed.

Figure 21 shows the stability fan superimposed on a typical session's tracks. It also depicts another fan which is modeled more closely to the actual ILS localizer fan width (approximately 2.15 degrees on each side of the localizer centerline). It is suggested that this second fan width be used to recompute stability to examine the MITRE supposition and also increase the number of stable tracks beyond 20 nmi.

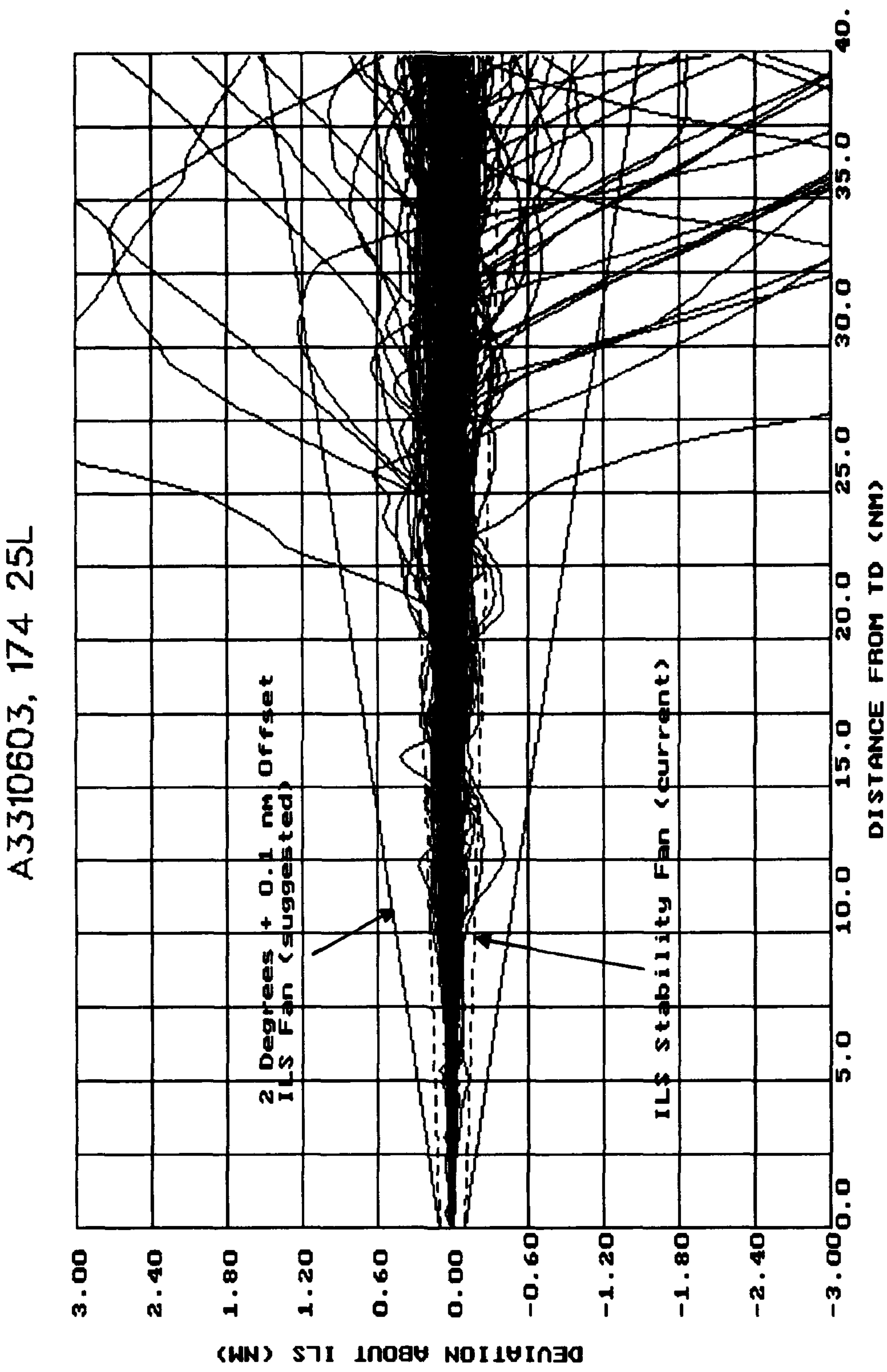

FIGURE 21. EXAMPLE SESSION WITH ILS STABILITY FAN.

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ACRONYMS

ACP	Azimuth Change Pulse
AEE	Airborne Equipment Error
A/P	Auto-Pilot
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
ATCBI	Air Traffic Control Beacon Interrogator
ATIS	Air Traffic Information System
ATRAIN	Automated Radar Terminal System/Transportable Radar Analysis Computer System
COTS	commercial, off-the-shelf
DOS	Disk Operating System
DUALSRAP	DUAL Sensor Receiver and Processor
ERC	extended runway centerline
FAA	Federal Aviation Administration
F/D	Flight Director
ft	feet
GEE	Ground Equipment Error
ID-DAS	IDentification Data Acquisition System
IDR	Input Data Request
IDSM	Interfacility Data System Microprocessor
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IOP	Input/Output Processor
ISA	Industry Standard Architecture
LDA	Localizer Directional Aid
LAN	Local Area Network
LAX	Los Angeles International Airport
Mb	Megabyte
msl	mean sea level
NASA	National Aeronautics and Space Administration
nmi	nautical mile
NOZ	Normal Operating Zone
ONT	Ontario International Airport
ORD	Chicago O'Hare International Airport
PAM	Peripheral Adaptor Module
PC	Personal Computer
RAM	Random Access Memory
SA	Surface Observation Report (Weather)
SCIP	Surveillance and Communications Interface Processor
SFO	San Francisco International Airport
SP	Special Report (Weather)
SRAP	Sensor Receiver and Processor
STL	Lambert St. Louis Field
TRACON	Terminal Radar Approach Control
TRACS	Transportable Radar Analysis Computer System
UPS	Uninterruptible Power Supply
VLR	Voice Logging Recorder

APPENDIX A

DATA FILES

Two types of data files are described in this appendix. Raw data files consist of data collected in the field, both at Los Angeles International Airport (LAX) and at the Federal Aviation Administration (FAA) Technical Center. Reduced data files consist of data converted to a format compatible with the analysis environment.

A.1 RAW DATA FILES.

Raw Surveillance and Communications Interface Processor (SCIP) and interfacility data were collected on-site at LAX. Raw weather data were collected at the FAA Technical Center. The following is a description of the raw data files created at the time of field collection.

A.1.1 SCIP.

The raw SCIP data were recorded onto disk in the database format. The data files were save with the filename Smddhhmm.DBF:

where: S = the letter "S"
m = the month (1 thru 9, A for October, B for November, and C for December)
dd = day of month-2 digits (01 to 31)
hh = hour of start of test (00 to 23)
mm = minute of start of test (00 to 59)

From the raw SCIP file the following data were extracted:

a. Time in hours, minutes, seconds referenced to Pacific standard time (PST).

b. Slant range in nautical miles (nmi) from radar.

c. Azimuth Change Pulse (ACP) (0 thru 4096).

d. Beacon code (0000 thru 7777).

e. Altitude in hundreds of feet (uncorrected).

f. Message type (B for beacon only, C for radar reinforced beacon).

A.1.2 Interfacility.

The interfacility data was recorded onto disk using the filename format Imddhhmm.AOL (for more information on "mddhhmm", see A.1.1). The interfacility data file contained the following data:

a. ARR (arrival).
b. Time in hours and minutes with respect to LAX.
c. Beacon code (0000 thru 7777).
d. ACID (e.g., UAL923).
e. ACTYPE (e.g., B737).
f. Approach fix (e.g., CIV).
g. Altitude at fix in hundreds of feet (e.g., 100 for 10,000 feet).

A.1.3 Weather.

The raw weather data were collected on an FAA Technical Center computer by logging on the Kavouris Inc. weather database and requesting the day's weather reports for LAX and Ontario International Airport (ONT). The data were recorded onto a disk file whose name had the format WXmmddyy.TXT:

where: WX = the letters "WX"
m = the month - 2 digits (01 thru 12)
dd = day of month - 2 digits (01 to 31)
yy = year - 2 digits (00 to 99)

The weather file consisted of weather reports, each report containing the following data:

a. Date in month/day/year.
b. Time in hours and minutes (Zulu).
c. Location (LAX).
d. Report type (SA or SP or RS).
e. Lowest ceiling type (E or M or W).
f. Lowest ceiling height in hundreds of feet.
g. Lowest sky descriptor (OVC or CLR or BKN or ...).
h. Next lowest ceiling type (E or M or W).
i. Next lowest ceiling height in hundreds of feet.
j. Next lowest sky descriptor (OVC or CLR or BKN or ...).
k. Visibility in nmi.
l. Weather (rain or fog or snow or ...).
m. Sea level pressure in millibars.
n. Temperature in degrees fahrenheit.
o. Dewpoint in degrees fahrenheit.
p. Wind direction in tens of degrees referenced to true north.
q. Wind speed in knots.
r. Wind gust in knots.
s. Altimeter setting in inches of mercury.
t. Remarks.

Note: for more information on this data refer to the Aviation Weather Services Manual, AC 00-45B, published jointly by FAA and NOAH.

A.2 DATA REDUCTION FILES.

Raw SCIP, interfacility, DASI, and weather data files were unpacked and reduced at the FAA Technical Center. The following is a description of the Data Reduction files created from the raw data files.

A.2.1 Data Reduction Track Files.

The track files created during the reduction process consisted of all the position reports for a single aircraft's approach. The type and format of the information contained in each track file type is listed below:

FILENAME ==> MEANING

_acid.rwy ==> raw track file (SCIP 0) (output of TRACKS)
DATA: HR, MN, SEC, CH, RANGE, AZMTH, BC, ALT, TYPE

@acid.rwy ==> corrected track file (SCIP 0) (output of GAP)
DATA: HR, MN, SEC, CH, RANGE, AZMTH, BC, ALT, TYPE

$acid.rwy ==> GAP documentation file (SCIP 0)
DATA: list of missing scans and altitudes, and multiple scans

&acid.rwy ==> translated to runway and corrected track file (SCIP 0) (output of PTTRANS)
DATA: HR, MN, SEC, X, Y, Z

'acid.rwy ==> smoothed, translated, and corrected track file (SCIP 0) (output of SM)
DATA: HR, MN, SEC, X, Y, Z

(acid.rwy ==> interpolated, smoothed, translated, and corrected track file (SCIP 0) (output of SP)
DATA: HR, MN, SEC, X, Y, Z

{acid.rwy ==> ILS localizer bias removed, interpolated, smoothed, translated, and corrected track file (SCIP 0) (output of RM_BIAS)
DATA: HR, MN, SEC, X, Y, Z

where: acid ==> aircraft ID (AAL1115, UAL100, ...)
rwy ==> runway designator (25L, 25R, ...)

A.2.2 Data Reduction Interfacility Files.

The interfacility data files created during the reduction process consisted of the data extracted from the raw interfacility data files, however, this file data was converted to a database format.

Imddhhmm.DBF ==> Interfacility data in a X-base database format
DATA: (see A.1.2)

A.2.3 Data Reduction Weather Files.

The weather data files created during the reduction process consisted of the data present in the raw weather data files. The reduced data files were converted to a database format and merged with the master database (see appendix C).

WXmmddyy.FIX ==> preprocessed and corrected weather data file
DATA: (see A.1.3)

WXmmddyy.DAT ==> weather data for one day
DATA: (see A.1.3)

LAXmmm.DAT ==> weather data for one month (mmm = Jan, Feb, etc.)
DATA: (see A.1.3)

APPENDIX B

DATA REDUCTION

The data collected at the site were brought back to the Federal Aviation Administration (FAA) Technical Center where it were reduced to a form to be used in the final analysis. Extraction was the process whereby data, recorded in a foreign format for purposes of space and efficiency, were converted to a format compatible with the analysis environment. Reduction was the process of coordinate conversion, filtering, smoothing, and interpolation of the extracted radar data. Each of the raw data files identified in appendix A had to be extracted. The extraction and reduction procedures are described here.

B.1 SURVEILLANCE AND COMMUNICATIONS INTERFACE PROCESSOR (SCIP) AND INTERFACILITY DATA.

The radar data collected via the SCIP required considerably more processing than any other type of data collected to prepare it for analysis. Extraction and reduction of the radar data involved:

a. Conversion to engineering units and sorted according to beacon code.

b. Deletion from further processing if any of the following were detected: large gap(s) in the track, track was of short duration, or no Mode C altitude, and altitude can't be had from other sources.

c. Conversion to (time, x,y,z), then translation and rotation to the runway threshold being approached.

d. Filtering and smoothing of radar data to eliminate radar outliers and to obtain a more accurate estimate of aircraft position.

e. Calculation of interpolation data points at 0.15 nautical mile (nmi) increments along the extended runway centerline (ERC).

f. Removal of Instrument Landing System (ILS) localizer bias data (displacement of ILS localizer centerline from the ERC) from the interpolated track data to attain estimates of crosstrack deviation at specific points along the ILS approach.

The following software programs performed these processes on the raw SCIP data with the following results:

B.1.1 TRACKS.FXP.

Language: Foxpro programming language.

Input:

a. Smddhhmm.DBF (raw SCIP data file).
b. Imddhhmm.AOL (raw Interfacility data file).

Process:

a. Produced interfacility database file Imddhhmm.DBF from Imddhhmm.AOL.

b. Indexed Smddhhmm.DBF by session and beacon code.

c. Identified tracks with sufficient number of scans.

d. Determined runway being approached for each track.

e. Cross referenced SCIP data with interfacility database file Imddhhmm.DBF to obtain aircraft ID (ACID) and aircraft type (ACTYPE) for each beacon code.

Output:

a. Created directory "Smddhhmm" and placed ASCII aircraft track files _acid.RWY for SCIPO into this directory (see A.2).

b. Appended one record for each identified track to the master database (see appendix C).

B.1.2 GAP.C.

Language: Turbo C 2.0.

Input:

a. All _acid.rwy files (raw track files).
b. MASTER.DBF master database (optional, depends on version of GAP.C).

Process:

a. Deleted illegal multiple scans.

b. Added missed altitudes.

c. Corrected altitude based on airport altimeter.

d. Identified large time gaps and determined if the pre-gap and post-gap data were from the same track.

e. Produced documentation explaining results.

Output:

a. @acid.rwy (SCIPO) corrected track files (A.2.1).
b. $acid.rwy (SCIPO) documentation files (A.2.1).

B.1.3 PTTRANS.C.

Language: Turbo C 2.0.

Input: All @acid.rwy files (corrected track files).

Process:

a. Converted data from (rng,az,alt) to (x,y,z).

b. Translated data to runway threshold identified in the filename extension.

Output: &acid.rwy (SCIPO) translated and corrected track files (A.2.1).

B.1.4 SM.C.

Language: Turbo C 2.0.

Input: All &acid.rwy files (translated and corrected track files).

Process: Filtered and smoothed using Lincoln Lab's radar smoothing algorithms.

Output: 'acid.rwy (SCIPO) filtered, smoothed, translated, and corrected track files (A.2.1).

B.1.5 SP.C.

Language: Turbo C 2.0.

Input: All 'acid.rwy files (filtered, smoothed, translated, and corrected track files).

Process: Inserted an interpolated data point (time,x,y,z) at each 0.15 nmi X increment.

Output: (acid.rwy (SCIPO) interpolated, filtered, smoothed, translated, and corrected track files (A.2.1).

B.1.6 RM_BIAS.C.

Language: Turbo C 2.0.

Input: All (acid.rwy files (interpolated, filtered, smoothed, translated, and corrected track files).

Process: Removed ILS localizer bias at each 0.15 nmi X increment.

Output: {acid.rwy (SCIPO) ILS localizer bias removed, interpolated, filtered, smoothed, translated, and corrected track files (A.2.1).

B.2 WEATHER DATA.

The weather data for Los Angeles International Airport (LAX) required some preprocessing before it could be extracted by the weather data extraction program, LAXWX.BAS. The weather data preprocessing and extraction procedures are described here.

Preprocessing a weather data file consisted of:

a. Removed correction weather reports and blank lines between weather reports.

b. Added, if necessary, a ")" to the end of the weather data file as an End of File marker (EOF).

c. Checked that the first line of each weather report had at least one "/" in it. STLWX.BAS needed at least one "/" in the first line of a weather report to process that report properly.

Extraction of the preprocessed weather data files created one database compatible file for each day and one database compatible file for each month of weather data files.

The following software programs performed these processes on the weather data with the following results:

B.2.1 CORRECT.BAS.

Language: Turbo BASIC 1.0.

Input: WXmmddyy.TXT (raw weather data file).

Process:

a. Kept last correction weather report in data file; all previous correction reports and the original report were removed from the weather data file.

b. Removed blank lines between weather reports in a file.

c. Added, if needed, a ")" to the weather data file as an EOF marker.

Output: WXmmddyy.FIX (corrected weather data files).

B.2.2 SLASH.BAS.

Language: Turbo BASIC 1.0.

Input: WXmmddyy.FIX (corrected weather data file).

Process: Counted the number of "/" in first line of each weather report.

Output: WXmmyy.BAD (listing by time for each ".FIX" file of weather reports with less than five "/" in their first line).

B.2.3 STLWX.BAS.

Language: Turbo BASIC 1.0.

Input: WXmmddyy.FIX (corrected weather data file).

Process: Extracted a weather data file to produce a database-compatible record for each weather report and reordered records by time and date in ascending order in the output files.

Output:

a. WXmmddyy.DAT (Extracted weather data file).

b. STLmmm.TOT (combined WXmmddyy.DAT files for one month, where mmm = JAN, FEB, MAR, etc).

B.2.4 STRU.DBF.

Language: Foxpro programming language.

Input: STLmmm.TOT (combined WXmmddyy.DAT files).

Process: STRU.DBF was a database structure with fields for the data contained in a weather report; it was copied to WX_mmm.DBF. The data in the STLmmm.TOT file were then added to WX_mmm.DBF using the Foxpro APPEND command.

Output: WX_mmm.DBF (weather data for 1 month in database format).

Certain weather database fields were next merged with the master database (see appendix C).

B.3 ILS LOCALIZER STABILITY POINT.

All track files were processed by an algorithm that flagged all points outside a predetermined fan. The point before the flagged point nearest the runway threshold was considered the ILS localizer stability point.

The following sub-sections explain the processing used to calculate and store the stability points.

B.3.1 STB_XY2.C.

Language: Turbo C 2.0.

Input: All {acid.rwy files (ILS localizer bias removed, interpolated, filtered, smoothed, translated, and corrected track files).

Process: Determined the value of the ILS localizer stability point for each track for one session.

Output:

a. ST_XY.DOC - list of stability points for all the tracks in one session.

b. ST_XY.BAD - list of tracks whose stability points were less than 20 nmi.

B.3.2 STABLE_X.DBF.

STABLE_X.DBF was a database structure with fields for the data contained in each STB_XY.DOC file. The data in each STB_XY.DOC file (one file for each session) were then added to STABLE_X.DBF using the Foxpro APPEND command.

B.4 PARROT TRANSPONDER DATA.

Parrot data statistics were extracted from the raw SCIP data, to assist in the calculation of the radar range and azimuth biases, using the program described below:

B.4.1 TC_PAROT.FXP.

Language: Foxpro programming language.

Input: Smddhhmm.DBF database format).

Process: Collected, extracted, analyzed, and produced a statistical report on the quantity and quality of the Parrot transponder data.

Output: A report containing values for the mean and standard deviation of both range and azimuth, and the ACP skewness and kurtosis of the azimuth.

APPENDIX C

MASTER DATABASE

Prior to data analysis, all unpacked data were merged into a database that identified each approach collected. This database was referred to as the master database. Data used to construct the master database consisted of information about each track and the weather at the time of the track's collection. The master database did not contain the tracks' radar position data however. The radar position data for each track was, instead, stored in the individual track files (refer to section A.2.1).

The master database contained one record for each approach. The record had a field for each track characteristic. Since the format of the master database was developed for an earlier data collection effort, there were some fields in the database not used for the Los Angeles International Airport (LAX) data collection effort.

C.1 MASTER DATABASE FIELDS.

For purposes of clarity all the master database record fields are shown on a single page in figure C.1.

Field	Field Name	Type	Length	Description
1	SESSION	Chr	8	test name (eg. S2131453) (see A.1.1)
2	CH	Num	1	channel # (0 or 1) of SCIP
3	AC_ID	Chr	7	aircraft ID (eg. UAL9253)
4	USER_TYPE	Chr	1	user type (Military or Commercial or ...)
5	AC_TYPE	Chr	5	aircraft type (eg. B727)
6	BEACON	Chr	4	beacon code (0000 thru 7777)
7	DATE	Date	8	month/day/year of collection
8	START_TIME	Chr	11	time of day of first scan for the track
9	STOP_TIME	Chr	11	time of day of last scan for the track
10	START_ALT	Num	6	altitude of first scan for the track
11	STOP_ALT	Num	6	altitude of last scan for the track
12	TARGET_CT	Num	4	number of scans for the track
13	RUNWAY	Chr	3	runway being approached
14	MIN_X	Num	8	minimum distance from threshold
15	T_AT_4_NMI	Chr	11	time of day at 4 nmi from threshold
16	MAX_Y_TNTZ	Num	6	maximum lateral deviation from ILS towards NTZ
17	XMAXY_TNTZ	Num	8	distance from threshold at MAX_Y_TNTZ
18	MAX_Y_ANTZ	Num	6	maximum lateral deviation from ILS away from NTZ
19	XMAXY_ANTZ	Num	8	distance from threshold at MAX_Y_ANTZ
20	MAX_Z	Num	6	maximum altitude for the track
21	MIN_Z	Num	6	minimum altitude for the track
22	MEAN_Y	Num	6	average ILS deviation from stabilization to TD
23	MEAN_XDOT	Num	8	average velocity of A/C during ILS approach
24	STD_DEV_Y	Num	6	standard deviation of ILS lateral deviation
25	IN_NTZ	Log	1	.TRUE. if A/C in NTZ after stabilization
26	NTZ_DIS	Num	6	width of NOZ in feet
27	X_AT_VIO	Num	8	distance from threshold at first NTZ violation
28	TEMP	Num	3	temperature in degrees fahrenheit during track
29	DEWPT	Num	3	dewpoint in degrees fahrenheit during track
30	CEIL_TYPE	Chr	1	ceiling type (M or E or W)
31	CEILING	Num	5	ceiling height in feet
32	VISIBILITY	Num	5	visibility in nmi
33	WEATHER	Chr	4	(Fog and/or Rain and/or Snow and/or ...)
34	WIND_SPEED	Num	2	wind speed in knots
35	WIND_DIR	Num	3	wind direction in degrees from true north
36	LLWAS_SPD	Num	2	low level windshear alert system speed in knots
37	LLWAS_DIR	Num	3	low level windshear alert system direction deg
38	LLWAS_GUST	Num	2	low level windshear alert system gusts in knots
39	CFA_SPD	Num	2	low level windshear alert system center field ws
40	CFA_DIR	Num	3	low level windshear alert system center field wd
41	RVR	Num	4	runway visual range in feet
42	BRMTR	Num	5	barometric pressure in inches of mercury
43	STBL_X	Num	5	X at which A/C is stabilized on localizer
44	PAIR_LDR	Chr	7	leading adjacent localizer AC_ID (if it exists)
45	PAIR_TRL	Chr	7	trailing adjacent localizer AC_ID (if it exists)
46	GAP_START	Chr	11	raw track file start time (as determined by GAP)
47	GAP_STOP	Chr	11	raw track file stop time (as determined by GAP)
48	GAP_STRT_R	Num	6	raw track file initial range
49	GAP_STOP_R	Num	6	raw track file final range
50	GAP_NUM	Num	3	number of scans in raw track file
51	GAP_MS_SCN	Num	3	number of missing scans in raw track file
52	GAP_DOUBLE	Num	3	number of double scans in raw track file
53	GAP_ALT	Num	3	number of missing or unreasonable altitudes

total of 282 bytes/record.

FIGURE C.1 --- MASTER DATABASE RECORD STRUCTURE

C.2 MASTER DATABASE GENERATION.

The master database (_MASTER.DBF) was generated in a multi-step process. Only the following fields were used in the LAX data collection.

Field	Description
1	test or session name (eg. S2131453)
2	SCIP channel # (0 or 1)
3	aircraft ID (eg. UAL9253),
4	user type (Military, Commercial,...)
5	aircraft type (eg. B727)
6	beacon code (0000 thru 7777)
7	month/day/year of collection
8	time of day of first scan for the track
9	time of day of last scan for the track
10	altitude of first scan for the track
11	altitude of last scan for the track
12	number of scans for the track
13	runway being approached
28	temperature in degrees fahrenheit during track
29	dewpoint in degrees fahrenheit during track
30	ceiling type (M or E or W)
31	ceiling height in feet
32	visibility in nautical miles
33	weather (Fog and/or Rain and/or Snow,...)
34	wind speed in knots
35	wind direction in degrees from true north
42	barometric pressure in inches of mercury
43	distance X at which A/C is stabilized on localizer

The processes that generated the master database are identified and described in the following:

C.2.1 TRACKS.FXP.

TRACKS.FXP was the same process identified and partially described in section B.1.1. In addition to the identification and unpacking of the individual track files, it also appended one record to the master database for each track. TRACKS.FOX filled in data fields 1 through 13; (1) session, (2) channel, (3) ACID, (4) user-type, (5) A/C-type, (6) beacon code, (7) date, (8) start time, (9) stop time, (10) start altitude, (11) stop altitude, (12) target count, and (13) runway for each aircraft track.

C.2.2 WX_APP.FXP.

This process appended the appropriate data from WX_mmm.DBF to fields; (28) temperature, (29) dewpoint, (30) ceil_type, (31) ceiling, (32) visibility, (33) weather, (34) wind speed, (35) wind direction, and (42) barometer pressure by time and date to records in the master database.

Input: WX_mmm.DBF (weather database files, see B.2.4).

Process: Merged fields from weather database with the appropriate fields in the master database.

Output: Master database with modified weather fields cited above.

C.2.3 STBLX_MRG.FXP.

This process appended field (43) STBL_X to the master database. STBL_X was the distance from the end of the runway on the X axis at which the approaching aircraft is considered stabilized on the localizer. This value was used to run analysis software.

Input: STABLE_X.DBF database (see B.3.2).

Process: Merged STABLE_X field from STABLE_X.DBF database via session and aircraft ID with STBL_X field in the master database.

Output: Master database with modified STBL_X field.

APPENDIX D
LOS ANGELES INTERNATIONAL AIRPORT STATISTICS

Table 1 (1 of 5)

MEASURED DEVIATION FROM LOCALIZER CENTERLINE

TIME PERIOD: 1/17/92 TO 4/10/92 — 4466 AIRCRAFT

RANGE (NMI)	AWAY FROM OTHER APPROACH NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION	TOWARD OTHER APPROACH NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION	TOTAL OBSERVATIONS NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION
39.90	1564	-628	504	1657	581	461	3221	-6	774
39.75	1545	-628	493	1680	574	457	3225	-2	766
39.60	1555	-621	493	1677	576	454	3232	-0	762
39.45	1558	-614	488	1680	577	454	3238	4	759
39.30	1567	-609	490	1679	579	451	3246	5	758
39.15	1565	-606	487	1690	582	457	3255	11	758
39.00	1562	-607	488	1702	580	458	3264	12	758
38.85	1572	-603	489	1701	582	458	3273	13	758
38.70	1569	-603	487	1711	581	458	3280	15	757
38.55	1564	-602	484	1723	579	460	3287	18	755
38.40	1580	-597	487	1715	581	455	3295	17	754
38.25	1590	-590	485	1714	584	455	3304	19	752
38.10	1592	-586	482	1718	582	452	3310	21	747
37.95	1599	-585	486	1723	579	451	3322	19	747
37.80	1613	-577	481	1714	577	443	3327	17	739
37.65	1614	-577	479	1719	570	437	3333	14	734
37.50	1627	-572	476	1719	574	442	3346	17	734
37.35	1630	-567	468	1721	572	441	3351	18	728
37.20	1629	-565	463	1729	571	442	3358	20	726
37.05	1629	-564	460	1735	567	442	3364	20	723
36.90	1631	-563	459	1742	564	443	3373	19	721
36.75	1649	-557	462	1736	565	445	3385	18	721
36.60	1654	-554	460	1741	561	443	3395	18	717
36.45	1653	-547	450	1744	555	436	3397	18	707
36.30	1667	-539	448	1739	556	435	3406	20	703
36.15	1671	-535	445	1743	554	432	3414	21	699
36.00	1670	-533	441	1750	550	425	3420	21	693
35.85	1666	-529	435	1755	544	415	3421	22	684
35.70	1663	-525	432	1763	539	413	3426	22	679
35.55	1661	-524	432	1774	535	417	3435	23	678
35.40	1677	-516	432	1765	532	414	3442	21	674
35.25	1688	-509	428	1761	529	412	3449	21	667
35.10	1685	-510	427	1772	521	409	3457	19	664
34.95	1688	-505	420	1775	521	411	3463	21	660
34.80	1685	-510	424	1785	514	405	3470	17	658
34.65	1687	-509	423	1792	514	407	3479	18	658
34.50	1700	-507	426	1793	516	411	3493	18	661
34.35	1710	-506	427	1796	518	414	3506	18	662
34.20	1709	-501	420	1802	514	412	3511	20	656
34.05	1727	-507	438	1797	508	402	3524	11	659
33.90	1741	-505	440	1792	509	397	3533	9	658
33.75	1757	-506	444	1795	514	402	3552	10	663
33.60	1788	-498	445	1771	517	395	3559	7	659
33.45	1782	-501	441	1791	515	401	3573	9	660
33.30	1782	-504	438	1799	509	397	3581	5	657
33.15	1795	-505	438	1802	509	399	3597	3	658
33.00	1821	-496	427	1783	510	397	3604	2	650
32.85	1826	-493	415	1793	512	405	3619	5	648
32.70	1854	-491	418	1777	511	400	3631	-1	647
32.55	1856	-496	416	1792	506	400	3648	-4	646
32.40	1853	-498	409	1811	501	402	3664	-4	644
32.25	1871	-493	401	1807	502	400	3678	-4	639
32.10	1217	-420	375	2473	591	442	3690	257	635

Table 1 (2 of 5)

MEASURED DEVIATION FROM LOCALIZER CENTERLINE

TIME PERIOD: 1/17/92 TO 4/10/92 4466 AIRCRAFT

RANGE (NMI)	AWAY FROM OTHER APPROACH NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION	TOWARD OTHER APPROACH NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION	TOTAL OBSERVATIONS NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION
31.95	1229	-413	367	2467	585	436	3696	253	627
31.80	1223	-410	360	2478	574	433	3701	249	619
31.65	1243	-398	354	2465	572	432	3708	247	613
31.50	1263	-390	354	2450	566	428	3713	241	607
31.35	1268	-391	353	2454	560	427	3722	236	605
31.20	1265	-390	347	2461	551	424	3726	232	599
31.05	1273	-384	340	2457	546	422	3730	229	593
30.90	1291	-380	342	2444	543	419	3735	224	589
30.75	1289	-384	348	2454	536	417	3743	219	589
30.60	1282	-384	343	2463	529	414	3745	216	584
30.45	1291	-380	343	2458	524	411	3749	213	580
30.30	1288	-379	339	2463	517	409	3751	210	575
30.15	1302	-379	345	2455	513	405	3757	204	573
30.00	1303	-377	340	2459	507	405	3762	201	569
29.85	1327	-372	342	2443	507	404	3770	197	569
29.70	1342	-369	341	2434	504	404	3776	194	567
29.55	1373	-363	344	2413	506	406	3786	191	568
29.40	1403	-357	342	2392	508	406	3795	188	567
29.25	1410	-355	338	2389	501	401	3799	183	561
29.10	1417	-353	332	2384	494	396	3801	178	554
28.95	1446	-349	331	2361	492	392	3807	173	551
28.80	1459	-344	322	2352	487	389	3811	169	544
28.65	1476	-339	319	2341	483	388	3817	165	540
28.50	1486	-338	321	2337	476	385	3823	159	537
28.35	1511	-330	314	2316	475	384	3827	157	532
28.20	1498	-331	306	2330	464	380	3828	153	525
28.05	1529	-327	303	2302	461	375	3831	147	520
27.90	1557	-321	298	2281	462	377	3838	144	518
27.75	1584	-322	301	2259	458	373	3843	136	516
27.60	1610	-319	295	2237	456	370	3847	132	512
27.45	1636	-317	296	2217	456	369	3853	128	511
27.30	1627	-320	296	2231	447	366	3858	124	508
27.15	1643	-321	298	2221	445	364	3864	119	507
27.00	1642	-325	294	2224	440	360	3866	115	504
26.85	1660	-328	292	2213	441	360	3873	112	505
26.70	1685	-329	292	2193	442	359	3878	107	506
26.55	1694	-331	290	2186	439	358	3880	103	505
26.40	1720	-329	291	2164	441	357	3884	100	505
26.25	1747	-329	296	2148	445	360	3895	98	509
26.10	1749	-330	295	2149	443	356	3898	96	507
25.95	1742	-330	293	2157	439	352	3899	96	503
25.80	1727	-333	295	2181	439	354	3908	98	505
25.65	1706	-335	296	2210	438	355	3916	101	506
25.50	1679	-334	293	2245	437	357	3924	107	505
25.35	1682	-330	296	2248	439	354	3930	110	504
25.20	1674	-331	298	2267	443	355	3941	114	507
25.05	1656	-334	293	2291	445	354	3947	119	507
24.90	1641	-338	292	2309	447	349	3950	121	506
24.75	1649	-337	294	2304	452	343	3953	123	506
24.60	1641	-337	295	2318	455	342	3959	127	507
24.45	1645	-335	297	2320	460	339	3965	130	507
24.30	1631	-336	293	2343	463	342	3974	135	509
24.15	1617	-339	291	2361	463	338	3978	137	507

Table 1 (3 of 5)

MEASURED DEVIATION FROM LOCALIZER CENTERLINE

TIME PERIOD: 1/17/92 TO 4/10/92 | 4466 AIRCRAFT

RANGE	AWAY FROM OTHER APPROACH			TOWARD OTHER APPROACH			TOTAL OBSERVATIONS		
(NMI)	NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION	NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION	NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION
24.00	1615	-339	288	2370	467	339	3985	140	508
23.85	1625	-334	283	2362	470	337	3987	142	506
23.70	1650	-328	280	2340	478	333	3990	145	505
23.55	1653	-325	278	2343	481	333	3996	148	504
23.40	1645	-322	274	2355	481	331	4000	151	501
23.25	1646	-314	270	2355	482	329	4001	154	497
23.10	1601	-317	269	2406	474	334	4007	158	496
22.95	1585	-317	274	2428	469	334	4013	158	495
22.80	1556	-317	270	2461	462	334	4017	160	491
22.65	1567	-313	271	2458	462	334	4025	160	489
22.50	1570	-309	269	2461	460	334	4031	161	487
22.35	1543	-307	266	2494	455	335	4037	164	483
22.20	1513	-304	263	2529	451	332	4042	168	478
22.05	1485	-303	269	2565	447	329	4050	172	475
21.90	1455	-298	268	2601	445	326	4056	179	470
21.75	1432	-290	261	2629	444	326	4061	185	464
21.60	1406	-289	261	2660	436	324	4066	185	459
21.45	1415	-284	257	2656	430	322	4071	182	454
21.30	1440	-282	256	2636	422	318	4076	173	449
21.15	1474	-283	255	2606	412	313	4080	161	444
21.00	1512	-284	254	2572	402	306	4084	148	439
20.85	1549	-284	255	2537	391	298	4086	135	433
20.70	1576	-283	254	2514	380	292	4090	125	426
20.55	1593	-283	254	2502	370	288	4095	116	421
20.40	1627	-276	249	2469	363	282	4096	109	413
20.25	1667	-272	248	2434	357	278	4101	101	407
20.10	1698	-267	244	2405	349	272	4103	94	400
19.95	1719	-265	242	2389	342	270	4108	88	396
19.80	1726	-266	240	2384	333	264	4110	81	390
19.65	1755	-262	237	2359	329	260	4114	77	385
19.50	1770	-261	239	2354	324	259	4124	73	383
19.35	1779	-255	235	2347	318	254	4126	71	376
19.20	1765	-254	232	2366	310	253	4131	69	371
19.05	1758	-251	229	2380	307	253	4138	70	368
18.90	1763	-249	227	2383	306	252	4146	70	366
18.75	1765	-248	223	2385	302	248	4150	68	361
18.60	1752	-247	220	2401	297	248	4153	68	358
18.45	1746	-246	219	2409	294	248	4155	67	356
18.30	1742	-246	221	2416	295	251	4158	69	358
18.15	1710	-251	219	2449	299	256	4159	73	362
18.00	1723	-250	219	2442	311	268	4165	79	372
17.85	1726	-248	218	2442	321	281	4168	85	380
17.70	1703	-250	216	2470	327	293	4173	92	388
17.55	1710	-247	215	2467	332	298	4177	95	391
17.40	1696	-247	215	2485	331	298	4181	97	390
17.25	1689	-247	216	2495	327	292	4184	95	386
17.10	1686	-247	220	2506	323	288	4192	94	384
16.95	1672	-247	219	2524	318	282	4196	93	378
16.80	1655	-248	221	2547	309	273	4202	90	372
16.65	1648	-249	225	2559	300	264	4207	85	366
16.50	1632	-250	226	2580	291	259	4212	81	361
16.35	1601	-253	229	2613	281	253	4214	78	356
16.20	1587	-255	235	2634	276	247	4221	77	354

Table 1 (4 of 5)

MEASURED DEVIATION FROM LOCALIZER CENTERLINE

TIME PERIOD: 1/17/92 TO 4/10/92 4466 AIRCRAFT

RANGE (NMI)	AWAY FROM OTHER APPROACH NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION	TOWARD OTHER APPROACH NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION	TOTAL OBSERVATIONS NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION
16.05	1560	-255	238	2667	272	243	4227	77	350
15.90	1544	-254	242	2689	268	238	4233	78	347
15.75	1507	-252	239	2728	262	233	4235	79	340
15.60	1486	-249	237	2752	259	229	4238	81	335
15.45	1469	-248	240	2775	256	225	4244	82	332
15.30	1421	-253	240	2830	254	225	4251	84	332
15.15	1386	-256	242	2868	249	221	4254	85	329
15.00	1351	-257	245	2907	244	217	4258	85	325
14.85	1332	-253	243	2927	239	211	4259	85	318
14.70	1311	-250	240	2950	233	205	4261	85	311
14.55	1307	-247	239	2961	228	203	4268	82	306
14.40	1293	-245	236	2979	218	198	4272	78	299
14.25	1347	-234	232	2929	212	196	4276	72	294
14.10	1408	-224	226	2871	205	194	4279	64	288
13.95	1518	-214	223	2766	197	192	4284	51	283
13.80	1648	-201	212	2640	188	195	4288	39	277
13.65	1858	-184	199	2431	185	198	4289	25	270
13.50	2085	-173	190	2207	186	201	4292	12	265
13.35	2220	-168	180	2074	186	203	4294	3	261
13.20	2301	-164	173	1996	184	206	4297	-2	256
13.05	2381	-161	169	1920	183	205	4301	-7	253
12.90	2431	-159	165	1875	184	208	4306	-10	251
12.75	2497	-156	162	1811	184	206	4308	-13	247
12.60	2546	-153	161	1765	183	204	4311	-16	244
12.45	2583	-152	159	1732	183	203	4315	-18	242
12.30	2601	-152	156	1716	181	200	4317	-20	239
12.15	2615	-151	152	1707	180	201	4322	-20	237
12.00	2604	-150	148	1719	176	199	4323	-20	233
11.85	2609	-150	147	1717	175	195	4326	-21	231
11.70	2620	-148	147	1712	175	194	4332	-20	230
11.55	2623	-145	142	1713	175	196	4336	-18	228
11.40	2635	-143	139	1704	176	193	4339	-18	225
11.25	2628	-142	134	1716	175	191	4344	-17	222
11.10	2638	-141	132	1710	174	187	4348	-17	219
10.95	2636	-140	132	1715	172	183	4351	-17	217
10.80	2657	-139	129	1696	174	179	4353	-17	214
10.65	2643	-139	127	1714	173	178	4357	-16	213
10.50	2649	-137	124	1710	174	177	4359	-15	211
10.35	2631	-138	124	1731	171	172	4362	-15	209
10.20	2592	-139	123	1773	168	172	4365	-14	209
10.05	2576	-138	121	1795	168	176	4371	-12	210
9.90	2556	-138	122	1818	165	172	4374	-12	208
9.75	2509	-139	123	1868	161	166	4377	-11	206
9.60	2472	-139	124	1911	159	162	4383	-9	205
9.45	2412	-139	123	1973	156	158	4385	-6	203
9.30	2337	-140	122	2051	153	153	4388	-3	200
9.15	2298	-138	125	2095	151	149	4393	-0	199
9.00	2186	-138	128	2209	144	145	4395	4	197
8.85	2089	-136	131	2311	140	141	4400	9	194
8.70	1970	-133	130	2431	132	134	4401	13	187
8.55	1842	-132	129	2560	122	127	4402	16	179
8.40	1767	-127	125	2636	116	123	4403	18	172
8.25	1715	-124	127	2691	110	121	4406	19	168

Table 1 (5 of 5)

MEASURED DEVIATION FROM LOCALIZER CENTERLINE

TIME PERIOD: 1/17/92 TO 4/10/92 4466 AIRCRAFT

RANGE (NMI)	AWAY FROM OTHER APPROACH NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION	TOWARD OTHER APPROACH NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION	TOTAL OBSERVATIONS NO. OF OBSERVATIONS	MEAN (FT)	STANDARD DEVIATION
8.10	1658	-123	130	2751	104	118	4409	19	164
7.95	1631	-119	130	2781	98	113	4412	17	159
7.80	1629	-114	126	2786	92	110	4415	16	153
7.65	1671	-105	120	2746	89	110	4417	15	148
7.50	1745	-97	116	2675	86	109	4420	14	143
7.35	1819	-91	112	2604	84	109	4423	12	140
7.20	1897	-87	109	2529	82	108	4426	10	137
7.05	2016	-82	104	2412	81	107	4428	7	133
6.90	2213	-75	97	2217	83	109	4430	4	130
6.75	2423	-70	90	2007	89	111	4430	2	128
6.60	2590	-69	85	1842	94	113	4432	-1	127
6.45	2707	-70	83	1727	97	112	4434	-5	125
6.30	2768	-73	82	1669	97	111	4437	-9	125
6.15	2853	-74	79	1585	100	112	4438	-12	124
6.00	2876	-77	77	1564	100	112	4440	-15	124
5.85	2925	-78	73	1516	102	113	4441	-16	123
5.70	2903	-80	70	1538	101	111	4441	-17	122
5.55	2875	-82	71	1568	99	109	4443	-18	122
5.40	2845	-82	70	1601	97	108	4446	-18	121
5.25	2821	-81	69	1625	95	104	4446	-16	119
5.10	2770	-79	67	1678	94	103	4448	-14	118
4.95	2739	-76	67	1710	93	100	4449	-11	116
4.80	2665	-74	64	1786	92	99	4451	-8	114
4.65	2548	-72	63	1904	87	96	4452	-4	111
4.50	2414	-71	62	2039	83	92	4453	-1	109
4.35	2262	-69	62	2191	78	85	4453	3	104
4.20	2117	-67	63	2338	73	80	4455	6	101
4.05	1982	-64	62	2473	67	75	4455	9	95
3.90	1919	-61	61	2537	62	73	4456	9	91
3.75	1888	-57	62	2569	57	69	4457	9	87
3.60	1960	-53	57	2497	55	68	4457	8	83
3.45	2107	-50	54	2352	57	69	4459	7	82
3.30	2141	-51	55	2320	63	71	4461	9	85
3.15	1947	-50	53	2513	72	76	4460	19	90
3.00	1885	-51	49	2575	84	84	4460	27	98
2.85	1884	-49	45	2576	83	83	4460	27	95
2.70	1881	-46	44	2580	69	70	4461	20	83
2.55	1981	-45	41	2480	57	60	4461	11	73
2.40	1929	-43	40	2533	49	52	4462	10	66
2.25	1846	-38	37	2616	46	47	4462	11	60
2.10	1762	-34	34	2701	43	45	4463	13	56
1.95	1649	-31	31	2814	40	42	4463	14	51
1.80	3073	-38	30	1390	30	43	4463	-16	47
1.65	3119	-36	28	1344	28	40	4463	-17	43
1.50	3204	-34	27	1258	26	36	4462	-18	40
1.35	3225	-33	26	1235	24	31	4460	-17	37
1.20	3151	-32	25	1309	23	27	4460	-16	36
1.05	2962	-29	24	1492	22	24	4454	-12	34
0.90	2560	-26	23	1888	23	24	4448	-6	34
0.75	2056	-23	27	2390	26	27	4446	3	36
0.60	1712	-21	37	2725	29	28	4437	9	40
0.45	1686	-19	17	2737	25	25	4423	9	31
0.30	1950	-18	16	2456	20	21	4406	3	27
0.15	2213	-17	15	2117	16	18	4330	-1	23

Table 2 (1 of 5)

OBSERVED DEVIATIONS FROM LOCALIZER CENTERLINE

TIME PERIOD: 1/17/92 TO 4/10/92 — 4254 AIRCRAFT

RANGE (NMI)	NO. OF OBSERVATIONS	NO. OF AIRCRAFT AWAY FROM OTHER APPROACH -900	-800	-700	-650	-600	-550	-500		NO. OF AIRCRAFT TOWARD OTHER APPROACH 500	550	600	650	700	800	900
39.90	3100	410	73	80	36	55	42	40	1613	50	55	62	56	98	99	331
39.75	3126	406	63	98	28	61	40	53	1606	56	66	51	69	94	117	318
39.60	3133	394	93	70	45	43	45	47	1615	63	59	67	60	107	100	325
39.45	3139	387	85	75	44	47	40	50	1626	69	54	53	63	118	97	331
39.30	3146	388	74	76	45	45	38	54	1649	59	57	57	62	111	102	329
39.15	3155	378	83	67	39	43	53	61	1644	66	58	65	56	113	85	344
39.00	3162	380	68	72	42	48	39	61	1676	68	50	72	49	101	89	347
38.85	3171	367	80	79	38	42	48	53	1687	71	67	57	50	94	86	352
38.70	3177	362	78	86	41	44	41	53	1691	79	55	49	63	93	90	352
38.55	3184	370	66	73	57	42	36	53	1701	81	56	51	60	95	90	353
38.40	3192	377	52	75	53	45	42	60	1710	72	56	57	58	98	93	344
38.25	3201	369	67	73	43	43	42	65	1716	73	62	61	50	110	79	348
38.10	3206	359	73	70	39	45	50	58	1731	72	61	55	55	115	74	349
37.95	3218	367	65	75	38	44	37	66	1735	75	75	59	42	108	78	354
37.80	3223	371	63	68	43	42	46	63	1752	65	68	69	39	110	74	350
37.65	3228	358	64	80	50	48	45	50	1767	59	69	69	44	102	72	351
37.50	3239	351	72	79	45	46	51	55	1763	66	64	70	50	105	73	349
37.35	3244	349	69	82	46	43	42	63	1775	66	68	63	53	115	78	332
37.20	3249	351	57	82	38	56	50	64	1774	70	77	68	56	98	69	339
37.05	3255	340	71	76	44	49	51	56	1792	70	70	68	59	106	69	334
36.90	3263	340	75	75	43	44	46	68	1793	65	77	57	67	116	62	335
36.75	3275	332	79	76	45	41	49	69	1796	76	74	56	60	121	60	341
36.60	3285	332	56	87	47	54	53	60	1809	75	61	66	72	105	72	336
36.45	3287	318	62	85	47	54	56	52	1830	81	57	71	68	107	67	332
36.30	3296	313	66	75	42	52	64	59	1848	70	71	71	65	96	71	333
36.15	3304	310	62	78	38	51	55	75	1861	71	84	56	65	102	75	321
36.00	3309	301	66	82	44	46	48	64	1884	75	65	73	65	105	76	315
35.85	3310	298	64	85	55	37	45	64	1890	77	65	74	68	101	72	315
35.70	3315	288	66	96	40	50	49	66	1890	73	65	75	70	107	69	311
35.55	3324	288	68	87	38	61	48	63	1907	65	76	69	70	94	91	299
35.40	3331	288	63	86	45	45	51	76	1917	67	74	77	67	104	78	293
35.25	3338	275	70	79	47	53	45	85	1941	70	68	65	70	106	76	288
35.10	3346	278	65	71	48	49	54	81	1962	77	63	67	68	102	75	286
34.95	3352	273	61	80	51	40	61	73	1985	71	73	74	59	91	79	281
34.80	3359	272	72	70	49	52	55	70	1994	83	80	72	46	93	69	282
34.65	3367	278	62	72	53	47	51	63	2019	84	77	77	49	91	62	282
34.50	3380	282	52	76	50	55	54	59	2026	79	75	81	47	103	51	290
34.35	3394	275	56	85	44	58	51	68	2025	82	69	78	57	107	55	284
34.20	3399	271	64	75	54	52	47	56	2050	76	74	80	54	103	51	292
34.05	3412	292	44	73	62	48	44	68	2054	76	79	76	58	98	50	290
33.90	3421	291	46	68	55	56	49	62	2068	76	76	78	53	89	74	280
33.75	3439	289	55	64	42	53	66	69	2067	74	85	59	72	92	63	289
33.60	3446	295	53	57	48	56	47	69	2086	81	76	65	65	92	78	278
33.45	3459	298	52	54	51	45	59	68	2099	80	76	65	51	99	71	291
33.30	3466	288	54	61	49	39	76	62	2108	86	82	60	42	95	59	305
33.15	3481	288	45	71	44	56	70	72	2112	79	88	52	43	86	73	302
33.00	3488	280	46	79	44	60	61	80	2118	68	94	61	40	86	79	292
32.85	3503	266	60	83	44	59	67	73	2126	85	74	49	51	88	71	307
32.70	3513	270	64	85	48	55	68	85	2129	81	67	46	45	93	80	297
32.55	3530	270	59	101	55	46	69	90	2133	81	58	49	49	81	93	296
32.40	3546	268	63	92	56	70	66	78	2137	84	64	53	39	92	90	294
32.25	3559	280	50	88	64	61	69	79	2151	72	71	51	47	102	84	290
32.10	3570	143	54	46	19	37	30	37	2011	105	93	93	89	144	144	525

Table 2 (2 of 5)

OBSERVED DEVIATIONS FROM LOCALIZER CENTERLINE

TIME PERIOD: 1/17/92 TO 4/10/92 — 4254 AIRCRAFT

RANGE (NMI)	NO. OF OBSERVATIONS	NO. OF AIRCRAFT AWAY FROM OTHER APPROACH -900	-800	-700	-650	-600	-550	-500		NO. OF AIRCRAFT TOWARD OTHER APPROACH 500	550	600	650	700	800	900
31.95	3575	138	49	49	28	31	32	33	2036	101	99	86	86	164	130	513
31.80	3580	136	49	44	24	35	28	35	2066	106	92	83	85	177	123	497
31.65	3586	132	44	47	33	29	19	42	2084	93	101	96	90	164	113	499
31.50	3591	136	36	52	28	39	22	29	2122	98	95	83	84	165	115	487
31.35	3599	130	40	49	26	38	37	25	2144	104	89	81	88	155	107	486
31.20	3603	120	46	46	28	41	24	36	2175	96	104	71	82	154	104	476
31.05	3607	117	45	45	25	37	33	42	2197	93	95	83	69	144	115	467
30.90	3612	117	40	49	26	30	40	36	2221	96	79	90	66	153	110	459
30.75	3619	118	43	52	17	29	36	37	2233	101	78	82	67	158	111	457
30.60	3622	125	35	41	26	30	36	41	2254	88	77	84	71	148	115	451
30.45	3626	124	36	42	21	33	30	42	2270	93	94	61	77	148	109	446
30.30	3628	121	42	33	22	30	39	33	2298	94	78	70	89	140	101	438
30.15	3632	122	33	36	36	29	38	31	2318	81	70	86	82	135	109	426
30.00	3637	118	35	46	32	25	26	27	2346	82	72	81	92	132	102	421
29.85	3644	119	32	50	30	26	28	32	2348	89	80	77	92	127	99	415
29.70	3651	122	34	42	18	38	26	44	2337	103	87	85	84	121	91	419
29.55	3660	120	42	30	18	40	31	43	2366	80	90	93	86	116	87	418
29.40	3669	120	35	37	25	31	38	38	2373	88	89	105	74	106	92	418
29.25	3673	116	33	40	28	34	35	35	2388	97	85	103	67	107	104	401
29.10	3675	110	35	43	32	34	36	42	2396	90	87	101	70	107	96	396
28.95	3680	104	35	46	36	37	29	42	2421	98	78	99	66	111	90	388
28.80	3684	103	36	44	32	40	37	32	2452	90	82	100	65	104	83	384
28.65	3690	97	38	56	23	33	36	49	2455	93	102	77	72	99	85	375
28.50	3696	96	43	43	35	34	32	49	2481	92	91	79	64	104	91	362
28.35	3700	93	40	44	32	43	29	47	2512	92	81	77	62	97	95	356
28.20	3701	90	36	47	31	39	34	56	2514	103	83	71	59	95	95	348
28.05	3702	87	35	53	27	36	40	49	2544	91	80	71	57	101	107	324
27.90	3708	86	32	53	35	33	37	43	2584	78	75	64	62	113	92	321
27.75	3715	92	29	50	42	28	34	43	2598	83	79	64	68	109	77	319
27.60	3719	91	31	53	34	34	34	41	2605	91	80	59	70	109	78	309
27.45	3725	99	24	51	33	28	38	50	2617	82	84	65	67	100	80	307
27.30	3729	98	28	47	27	35	38	50	2624	94	86	68	53	95	82	304
27.15	3734	95	35	49	28	42	33	38	2646	84	92	65	57	86	88	296
27.00	3736	99	28	52	38	24	40	44	2636	116	66	82	56	83	83	289
26.85	3742	91	39	55	25	29	46	54	2644	103	65	68	62	86	83	292
26.70	3747	87	43	49	32	36	47	53	2652	93	60	65	58	95	94	283
26.55	3749	86	43	48	34	34	51	64	2645	89	66	61	69	92	86	281
26.40	3753	87	47	43	32	35	57	54	2666	74	67	70	68	91	90	272
26.25	3764	94	35	57	35	35	51	49	2669	80	77	65	58	94	82	283
26.10	3767	95	40	53	36	31	53	61	2679	66	79	59	50	101	95	269
25.95	3768	98	39	50	34	39	51	54	2680	69	74	62	52	103	92	271
25.80	3775	94	44	48	26	55	44	48	2673	78	71	72	62	94	106	260
25.65	3783	99	34	49	31	45	51	63	2650	86	79	65	63	112	92	264
25.50	3792	92	40	46	35	42	58	50	2643	86	76	71	62	133	99	259
25.35	3798	94	34	49	33	48	54	53	2623	87	72	84	74	128	102	263
25.20	3808	97	30	60	33	41	52	50	2620	101	68	83	66	131	109	267
25.05	3813	95	30	58	42	38	55	47	2619	87	92	68	58	126	123	275
24.90	3816	94	39	49	41	50	52	47	2588	105	85	75	69	119	124	279
24.75	3819	96	39	53	42	35	62	46	2571	101	86	81	74	126	139	268
24.60	3825	93	43	56	38	38	45	54	2558	88	103	75	75	148	144	267
24.45	3831	91	51	44	43	41	50	44	2556	74	99	83	82	155	157	261
24.30	3840	97	44	49	39	38	42	51	2547	78	101	77	88	163	151	275
24.15	3844	98	47	50	26	41	42	54	2537	79	92	101	96	148	162	271

Table 2 (3 of 5)

OBSERVED DEVIATIONS FROM LOCALIZER CENTERLINE

TIME PERIOD: 1/17/92 TO 4/10/92 4254 AIRCRAFT

RANGE (NMI)	NO. OF OBSERVATIONS	NO. OF AIRCRAFT AWAY FROM OTHER APPROACH -900	-800	-700	-650	-600	-550	-500		NO. OF AIRCRAFT TOWARD OTHER APPROACH 500	550	600	650	700	800	900
24.00	3851	93	52	43	25	44	56	51	2520	80	92	101	92	166	174	262
23.85	3853	84	58	43	33	39	48	53	2507	93	96	94	96	168	187	254
23.70	3856	87	44	50	32	44	46	47	2486	110	106	93	87	183	200	241
23.55	3861	82	46	45	40	38	51	48	2477	99	126	83	87	192	215	232
23.40	3865	78	40	55	34	38	44	51	2493	94	105	85	93	209	220	226
23.25	3866	74	35	56	35	35	49	46	2501	90	104	98	97	209	211	226
23.10	3871	71	38	64	38	27	36	53	2502	95	108	95	97	204	221	222
22.95	3877	74	33	58	43	33	36	33	2523	100	104	95	96	209	219	221
22.80	3881	69	44	49	32	40	34	46	2527	94	101	108	106	198	209	224
22.65	3889	71	40	45	33	39	48	32	2541	101	107	93	106	214	196	223
22.50	3895	62	39	51	33	34	45	38	2565	111	88	90	116	241	156	226
22.35	3901	59	36	47	36	31	48	40	2590	108	86	103	103	252	135	227
22.20	3906	62	28	48	29	33	37	49	2613	96	88	104	114	257	130	218
22.05	3911	58	35	38	28	27	37	54	2622	105	84	116	108	252	126	221
21.90	3917	57	22	48	20	35	34	47	2624	111	106	111	122	233	130	217
21.75	3921	49	23	46	20	36	39	33	2646	107	118	107	129	235	121	212
21.60	3926	45	29	40	25	31	34	41	2673	107	106	129	119	228	108	211
21.45	3931	40	30	44	29	29	37	32	2719	97	115	116	122	201	108	212
21.30	3935	34	35	50	24	25	39	37	2747	119	109	112	109	198	97	200
21.15	3939	36	31	56	21	25	40	36	2789	117	107	106	139	161	90	185
21.00	3943	42	26	55	27	22	44	40	2840	99	106	102	129	162	92	157
20.85	3945	46	30	50	27	22	42	43	2871	95	123	90	139	149	83	135
20.70	3949	46	33	45	28	29	37	45	2910	102	106	110	132	126	78	122
20.55	3953	46	27	48	25	36	41	51	2931	107	104	111	137	118	51	120
20.40	3954	44	32	38	30	29	42	59	2967	105	108	131	103	105	49	112
20.25	3959	47	27	40	23	30	49	57	3004	107	104	137	89	90	47	108
20.10	3960	45	27	35	21	40	46	46	3068	81	108	141	73	84	52	93
19.95	3964	44	22	43	29	27	30	54	3100	94	101	135	65	82	50	88
19.80	3966	44	19	45	22	33	39	39	3127	105	128	96	65	76	52	76
19.65	3970	43	19	41	24	35	39	39	3147	116	135	80	64	65	56	67
19.50	3980	46	15	38	24	36	33	42	3199	106	136	71	50	75	44	65
19.35	3980	39	20	34	22	22	46	43	3235	123	115	66	44	68	35	68
19.20	3984	40	18	31	13	32	33	50	3268	128	118	55	44	53	36	65
19.05	3992	35	21	34	12	26	25	54	3304	145	95	55	35	47	39	65
18.90	4000	36	15	33	15	22	43	41	3321	156	90	48	27	49	33	71
18.75	4003	36	10	32	17	25	38	44	3342	153	74	56	29	43	36	68
18.60	4006	35	9	33	19	29	29	50	3363	139	76	50	22	50	32	70
18.45	4008	29	19	24	19	27	46	42	3398	113	66	44	29	42	44	66
18.30	4011	25	17	37	13	33	38	44	3402	109	61	37	28	52	45	70
18.15	4012	24	18	34	22	30	39	50	3393	89	60	39	33	53	48	80
18.00	4017	28	14	37	22	25	47	45	3367	89	54	44	38	53	52	102
17.85	4020	24	21	34	24	32	34	45	3350	74	55	61	35	50	53	128
17.70	4024	21	27	33	27	17	37	44	3337	82	50	42	39	68	54	146
17.55	4028	21	24	34	18	31	35	34	3329	70	70	52	32	64	57	157
17.40	4032	24	20	31	14	36	40	31	3327	69	58	56	41	77	58	150
17.25	4034	23	21	27	17	37	33	38	3333	71	53	60	47	77	54	143
17.10	4038	28	19	24	17	32	36	43	3358	68	46	49	51	79	54	134
16.95	4044	26	25	25	18	26	36	35	3382	66	59	47	44	66	56	133
16.80	4049	28	22	30	16	25	33	35	3415	72	38	49	40	72	46	128
16.65	4054	33	19	33	14	23	33	33	3438	57	64	41	40	71	31	124
16.50	4059	28	27	30	18	24	30	48	3454	54	58	35	41	62	35	115
16.35	4059	25	28	31	27	32	28	31	3473	60	50	45	32	51	40	106
16.20	4064	28	31	32	25	31	28	37	3482	59	40	43	33	54	47	94

OBSERVED DEVIATIONS FROM LOCALIZER CENTERLINE

TIME PERIOD: 1/17/92 TO 4/10/92 4254 AIRCRAFT

RANGE (NMI)	NO. OF OBSERVATIONS	NO. OF AIRCRAFT AWAY FROM OTHER APPROACH -900	-800	-700	-650	-600	-550	-500		NO. OF AIRCRAFT TOWARD OTHER APPROACH 500	550	600	650	700	800	900
16.05	4068	28	29	38	18	32	41	35	3485	51	49	28	42	64	41	87
15.90	4074	33	24	36	23	25	33	42	3496	52	53	37	34	61	40	85
15.75	4076	33	23	30	18	28	37	38	3517	62	41	39	34	60	40	76
15.60	4079	31	17	38	16	23	35	47	3531	54	46	34	40	59	37	71
15.45	4084	29	21	33	17	26	27	50	3539	54	51	42	32	61	40	62
15.30	4091	31	16	29	22	26	38	46	3546	49	52	45	37	51	38	65
15.15	4094	32	18	29	15	31	37	37	3558	61	48	44	31	53	36	64
15.00	4097	32	21	27	22	24	28	40	3569	66	38	53	34	50	32	61
14.85	4098	23	25	35	17	23	35	34	3589	51	48	54	30	46	38	50
14.70	4100	25	22	33	17	30	30	28	3611	55	53	41	25	61	29	40
14.55	4107	29	19	27	21	23	26	41	3629	61	39	50	25	49	28	40
14.40	4111	32	19	19	23	22	30	36	3660	53	47	35	29	43	24	39
14.25	4115	30	18	22	19	21	31	32	3681	57	46	35	31	32	21	39
14.10	4118	29	12	30	15	22	23	29	3720	42	43	30	31	38	20	34
13.95	4122	30	11	36	9	19	25	28	3743	38	36	36	30	32	23	26
13.80	4127	31	11	27	11	15	23	27	3776	37	33	32	26	27	20	31
13.65	4128	28	14	17	15	19	21	26	3786	45	33	26	22	29	18	29
13.50	4131	28	15	17	12	17	17	26	3807	47	25	24	24	29	20	23
13.35	4133	22	13	18	18	21	14	18	3831	37	20	30	24	25	18	24
13.20	4136	18	13	25	7	18	18	17	3847	38	25	22	23	23	19	23
13.05	4139	19	12	24	10	10	21	18	3862	36	21	25	17	24	16	24
12.90	4144	19	10	17	24	9	11	17	3879	29	22	24	19	20	18	26
12.75	4146	18	10	20	12	12	15	16	3891	30	29	14	20	18	18	23
12.60	4149	20	8	16	18	14	12	18	3899	31	19	18	20	15	20	21
12.45	4153	20	14	14	6	15	14	19	3903	27	23	28	15	25	10	20
12.30	4154	17	15	17	7	9	16	19	3910	28	30	29	12	17	9	19
12.15	4159	17	11	17	11	5	16	19	3925	35	22	20	18	11	12	20
12.00	4160	10	17	8	13	11	15	20	3939	32	14	18	17	15	11	20
11.85	4162	8	12	14	10	10	14	23	3950	30	24	8	17	13	13	16
11.70	4166	8	12	10	11	11	18	16	3961	32	16	15	12	14	15	15
11.55	4170	8	6	12	8	17	10	18	3972	31	16	13	10	17	13	19
11.40	4173	8	6	11	3	12	18	16	3983	31	16	14	10	13	14	18
11.25	4178	6	7	9	11	2	13	18	3997	30	14	15	10	14	12	20
11.10	4181	7	9	9	8	4	13	10	4016	21	19	13	9	19	11	13
10.95	4184	3	15	8	9	5	4	9	4028	19	18	13	11	20	11	11
10.80	4186	2	7	14	10	5	6	5	4038	22	22	10	9	15	11	10
10.65	4190	3	4	13	8	7	7	8	4045	23	13	12	9	15	14	9
10.50	4192	4	3	8	8	7	10	12	4047	24	13	10	12	15	11	8
10.35	4195	4	7	4	10	6	13	6	4047	24	16	17	10	16	9	6
10.20	4198	3	5	7	8	8	8	11	4049	20	15	20	12	15	10	7
10.05	4204	3	3	6	6	9	7	11	4054	22	19	11	9	24	11	9
9.90	4207	2	7	4	1	9	13	11	4064	22	15	10	8	23	10	8
9.75	4210	4	5	4	5	4	12	14	4075	17	13	14	12	14	10	7
9.60	4216	3	7	5	1	7	11	8	4087	21	16	8	14	12	9	7
9.45	4218	2	4	7	3	5	6	11	4101	12	17	16	7	14	9	4
9.30	4221	2	5	4	6	1	7	15	4102	20	14	12	8	11	11	3
9.15	4226	2	3	9	3	6	7	16	4103	22	12	9	9	13	8	4
9.00	4228	1	6	8	2	4	10	16	4101	22	12	12	7	17	8	2
8.85	4233	2	6	6	4	6	7	18	4106	16	20	7	7	16	10	2
8.70	4234	2	3	9	3	6	6	12	4125	16	11	12	5	14	8	2
8.55	4235	2	1	7	5	2	10	10	4139	16	10	3	6	16	8	0
8.40	4236	1	2	4	4	5	5	9	4149	14	11	4	9	9	7	3
8.25	4239	2	1	6	2	3	6	8	4155	16	8	7	8	8	7	2

OBSERVED DEVIATIONS FROM LOCALIZER CENTERLINE

TIME PERIOD: 1/17/92 TO 4/10/92 4254 AIRCRAFT

RANGE (NMI)	NO. OF OBSERVATIONS	NO. OF AIRCRAFT AWAY FROM OTHER APPROACH -900	-800	-700	-650	-600	-550	-500		NO. OF AIRCRAFT TOWARD OTHER APPROACH 500	550	600	650	700	800	900
8.10	4242	1	2	7	1	3	8	11	4157	11	13	7	2	8	10	1
7.95	4245	1	3	5	5	3	6	7	4172	7	11	6	5	7	6	1
7.80	4248	1	2	2	2	9	3	8	4183	9	9	3	4	6	6	1
7.65	4250	1	2	2	0	5	2	11	4189	7	9	6	5	5	3	3
7.50	4253	1	0	5	1	3	4	8	4195	6	9	5	4	6	4	2
7.35	4256	2	1	2	2	2	2	11	4199	7	6	5	6	5	5	1
7.20	4259	0	5	1	0	2	5	8	4205	5	6	9	4	5	4	0
7.05	4261	0	2	6	0	1	2	6	4215	6	8	6	4	2	3	0
6.90	4263	0	1	3	3	2	2	2	4225	4	8	7	1	4	1	0
6.75	4263	0	0	3	3	4	2	4	4219	11	8	3	3	2	1	0
6.60	4265	0	1	2	2	4	2	5	4224	6	9	3	2	4	1	0
6.45	4267	0	1	3	1	5	2	5	4226	9	5	5	3	0	2	0
6.30	4270	0	2	0	3	3	2	7	4230	10	6	4	1	1	1	0
6.15	4271	0	0	2	3	3	4	1	4233	11	5	5	2	1	1	0
6.00	4273	0	0	2	1	5	1	6	4237	7	6	4	1	2	1	0
5.85	4274	0	0	0	1	1	4	5	4243	6	6	4	2	0	1	1
5.70	4274	0	0	0	1	0	2	3	4247	9	4	5	1	0	1	1
5.55	4276	0	1	1	0	1	3	4	4248	9	3	2	2	1	0	1
5.40	4278	0	0	1	1	2	2	4	4249	8	3	3	2	2	0	1
5.25	4278	0	0	0	2	1	1	3	4252	10	0	6	2	0	0	1
5.10	4280	0	0	1	0	1	1	3	4256	9	2	2	2	1	1	1
4.95	4281	0	0	2	1	0	0	3	4259	5	1	7	1	0	1	1
4.80	4283	0	0	1	0	1	0	2	4258	6	8	3	1	2	0	1
4.65	4284	0	0	0	0	0	1	0	4262	8	7	2	0	3	0	1
4.50	4285	0	0	0	0	0	0	1	4269	3	5	2	2	1	1	1
4.35	4285	0	0	0	0	0	0	1	4271	3	3	3	1	2	0	1
4.20	4287	0	0	1	0	0	0	0	4274	2	2	4	2	1	0	1
4.05	4287	0	0	0	1	0	0	1	4272	5	3	2	1	1	0	1
3.90	4288	0	0	0	0	1	0	2	4274	4	3	0	1	2	0	1
3.75	4289	0	0	2	0	0	0	0	4277	4	2	2	1	0	0	1
3.60	4289	0	0	0	1	0	0	1	4280	4	1	1	0	0	0	1
3.45	4290	0	0	0	0	2	0	0	4285	1	0	1	0	0	0	1
3.30	4292	0	0	1	1	0	0	1	4287	0	0	0	1	0	0	1
3.15	4291	0	0	0	0	1	0	1	4285	1	1	0	1	0	0	1
3.00	4291	0	0	0	0	0	0	2	4286	1	0	0	1	0	0	1
2.85	4291	0	0	0	0	0	0	0	4287	1	0	1	1	0	0	1
2.70	4292	0	0	0	0	0	0	1	4288	0	0	2	0	0	0	1
2.55	4292	0	0	0	0	0	0	0	4290	0	1	0	0	0	0	1
2.40	4293	0	0	0	0	0	0	1	4291	0	0	0	0	0	0	1
2.25	4293	0	0	0	0	0	0	0	4292	0	0	0	0	0	0	1
2.10	4294	0	0	0	0	0	0	0	4292	0	0	0	1	0	0	1
1.95	4294	0	0	0	0	0	0	0	4292	0	1	0	0	0	0	1
1.80	4294	0	0	0	0	0	0	1	4292	0	0	0	0	0	0	1
1.65	4294	0	0	0	0	0	0	0	4293	0	0	0	0	0	1	0
1.50	4293	0	0	0	0	0	0	0	4292	0	0	0	0	1	0	0
1.35	4291	0	0	0	0	0	0	0	4290	0	1	0	0	0	0	0
1.20	4291	0	0	0	0	0	0	0	4291	0	0	0	0	0	0	0
1.05	4285	0	0	0	0	0	0	0	4285	0	0	0	0	0	0	0
0.90	4279	0	0	0	0	0	0	0	4279	0	0	0	0	0	0	0
0.75	4277	0	1	0	0	0	0	0	4276	0	0	0	0	0	0	0
0.60	4269	1	0	0	0	0	0	0	4268	0	0	0	0	0	0	0
0.45	4257	0	0	0	0	0	0	0	4257	0	0	0	0	0	0	0
0.30	4241	0	0	0	0	0	0	0	4241	0	0	0	0	0	0	0
0.15	4173	0	0	0	0	0	0	0	4173	0	0	0	0	0	0	0

Table 3

DISPLACEMENT OF ILS LOCALIZER CENTERLINE FROM EXTENDED RUNWAY CENTERLINE
IN NMI AT 0.15NMI INCREMENTS AWAY FROM RUNWAY 25L THRESHOLD

X Value (nmi)	Y Value (nmi)						
01.95000	-0.005045	11.10000	-0.016849	20.25000	-0.028653	29.40000	-0.040455
02.10000	-0.005240	11.25000	-0.017042	20.40000	-0.028846	29.55000	-0.040650
02.25000	-0.005432	11.40000	-0.017236	20.55000	-0.029040	29.70000	-0.040844
02.40000	-0.005626	11.55000	-0.017430	20.70000	-0.029232	29.85000	-0.041036
02.55000	-0.005819	11.70000	-0.017623	20.85000	-0.029427	30.00000	-0.041230
02.70000	-0.006013	11.85000	-0.017817	21.00000	-0.029621	30.15000	-0.041423
02.85000	-0.006207	12.00000	-0.018009	21.15000	-0.029813	30.30000	-0.041617
03.00000	-0.006400	12.15000	-0.018204	21.30000	-0.030007	30.45000	-0.041810
03.15000	-0.006594	12.30000	-0.018398	21.45000	-0.030200	30.60000	-0.042004
03.30000	-0.006786	12.45000	-0.018590	21.60000	-0.030394	30.75000	-0.042198
03.45000	-0.006981	12.60000	-0.018784	21.75000	-0.030587	30.90000	-0.042391
03.60000	-0.007175	12.75000	-0.018977	21.90000	-0.030781	31.05000	-0.042585
03.75000	-0.007367	12.90000	-0.019171	22.05000	-0.030975	31.20000	-0.042777
03.90000	-0.007562	13.05000	-0.019364	22.20000	-0.031168	31.35000	-0.042971
04.05000	-0.007754	13.20000	-0.019558	22.35000	-0.031362	31.50000	-0.043166
04.20000	-0.007948	13.35000	-0.019752	22.50000	-0.031554	31.65000	-0.043358
04.35000	-0.008141	13.50000	-0.019945	22.65000	-0.031749	31.80000	-0.043552
04.50000	-0.008335	13.65000	-0.020139	22.80000	-0.031943	31.95000	-0.043745
04.65000	-0.008529	13.80000	-0.020331	22.95000	-0.032135	32.10000	-0.043939
04.80000	-0.008722	13.95000	-0.020526	23.10000	-0.032329		
04.95000	-0.008916	14.10000	-0.020720	23.25000	-0.032522		
05.10000	-0.009108	14.25000	-0.020912	23.40000	-0.032716		
05.25000	-0.009303	14.40000	-0.021106	23.55000	-0.032910		
05.40000	-0.009497	14.55000	-0.021299	23.70000	-0.033103		
05.55000	-0.009689	14.70000	-0.021493	23.85000	-0.033297		
05.70000	-0.009883	14.85000	-0.021686	24.00000	-0.033490		
05.85000	-0.010076	15.00000	-0.021880	24.15000	-0.033684		
06.00000	-0.010270	15.15000	-0.022074	24.30000	-0.033876		
06.15000	-0.010463	15.30000	-0.022267	24.45000	-0.034070		
06.30000	-0.010657	15.45000	-0.022461	24.60000	-0.034265		
06.45000	-0.010851	15.60000	-0.022653	24.75000	-0.034457		
06.60000	-0.011044	15.75000	-0.022847	24.90000	-0.034651		
06.75000	-0.011238	15.90000	-0.023042	25.05000	-0.034844		
06.90000	-0.011430	16.05000	-0.023234	25.20000	-0.035038		
07.05000	-0.011625	16.20000	-0.023428	25.35000	-0.035232		
07.20000	-0.011819	16.35000	-0.023621	25.50000	-0.035425		
07.35000	-0.012011	16.50000	-0.023815	25.65000	-0.035619		
07.50000	-0.012205	16.65000	-0.024009	25.80000	-0.035811		
07.65000	-0.012398	16.80000	-0.024202	25.95000	-0.036006		
07.80000	-0.012592	16.95000	-0.024396	26.10000	-0.036198		
07.95000	-0.012786	17.10000	-0.024589	26.25000	-0.036392		
08.10000	-0.012979	17.25000	-0.024783	26.40000	-0.036587		
08.25000	-0.013173	17.40000	-0.024975	26.55000	-0.036779		
08.40000	-0.013366	17.55000	-0.025169	26.70000	-0.036973		
08.55000	-0.013560	17.70000	-0.025364	26.85000	-0.037166		
08.70000	-0.013752	17.85000	-0.025556	27.00000	-0.037360		
08.85000	-0.013946	18.00000	-0.025750	27.15000	-0.037554		
09.00000	-0.014141	18.15000	-0.025943	27.30000	-0.037747		
09.15000	-0.014333	18.30000	-0.026137	27.45000	-0.037941		
09.30000	-0.014527	18.45000	-0.026331	27.60000	-0.038133		
09.45000	-0.014720	18.60000	-0.026524	27.75000	-0.038328		
09.60000	-0.014914	18.75000	-0.026718	27.90000	-0.038522		
09.75000	-0.015108	18.90000	-0.026910	28.05000	-0.038714		
09.90000	-0.015301	19.05000	-0.027105	28.20000	-0.038909		
10.05000	-0.015495	19.20000	-0.027229	28.35000	-0.039101		
10.20000	-0.015687	19.35000	-0.027491	28.50000	-0.039295		
10.35000	-0.015882	19.50000	-0.027686	28.65000	-0.039488		
10.50000	-0.016074	19.65000	-0.027878	28.80000	-0.039682		
10.65000	-0.016268	19.80000	-0.028072	28.95000	-0.039876		
10.80000	-0.016463	19.95000	-0.028265	29.10000	-0.040069		
10.95000	-0.016655	20.10000	-0.028459	29.25000	-0.040263		

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