NASA Contractor Report 198315

Validation of Aircraft Noise Models at Lower Levels of Exposure

Juliet A. Page, Kenneth J. Plotkin, Jeffrey N. Carey, and Kevin A. Bradley
Wyle Laboratories, Arlington, Virginia

Contract NAS1-20103

June 1996

National Aeronautics and
Space Administration
Langley Research Center
Hampton, Virginia 23681-0001

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF TABLES

1.0 INTRODUCTION

Noise levels around airports and airbases in the United States are computed via the FAA's Integrated Noise Model (INM)[1,2,3] or the Air Force's NOISEMAP (NMAP)[4] software. Many other countries use these or similar software. These models are generally used to compute day-night average sound level (L_{dn}, or alternatively DNL) in the vicinity of the airport. The "vicinity" usually means areas exposed to L_{dn} of 65 dB or greater. At medium to large airports, this corresponds to distances within 6 to 9 miles from the runway threshold.[5] The noise models were developed and validated for use within these areas. In previous studies, the predictive capabilities of INM and NMAP have been validated within the 65 dB L_{dn} contour line at a number of airports.

There is increasing interest in aircraft noise at larger distances from airports. Community planning and environmental assessments sometimes consider L_{dn}'s as low as 60 or 55 dB. There are also issues of enroute noise, away from the vicinity of airports.[6] These are situations beyond the original intent of these models. Accordingly, a project was undertaken to evaluate the applicability of INM and NMAP at larger distances. This study was centered on a measurement program around a major air carrier airport. Measurements included the sound exposure levels and sound time histories of individual aircraft, plus acquisition of radar tracking data for these aircraft. Measurement sites included locations out to the limits of the 55 dB L_{dn} contour. This represents distances two to three times as large as those associated with the 65 dB L_{dn} contour.

The measurement program was conducted in the context of the algorithms of the noise models. There are several potential areas where the current models might not be adequate. They are:

1. Modeling of the location, speed, and engine power of the aircraft.
2. Data base of noise emissions as a function of power, speed, and distance.
3. Algorithms which were originally developed for long, straight flight segments.
4. Atmospheric effects.
5. Effects of terrain and ground cover.

Not all of the factors listed above could be controlled or measured. In particular, the following factors were not controlled:

- The data base of noise emissions is based on extensive measurements collected as part of certification. It cannot be reasonably examined as part of a modest program. However, by its nature of being derived from this level of measurements, there is no reason to expect any systematic problems.
- In the absence of direct measurements of power, power was assumed to correspond to the standard values in the INM database profiles.

The following factors were controlled:

- Aircraft flight paths, speeds, and types were obtained from radar tracking, and were therefore known.
- Surface weather data were collected. Analysis concentrated on days with low wind conditions.
- Aircraft weights were estimated from stage lengths, as determined from flight itineraries.
- The selected airport, and measurement sites, were in a semi-rural area with flat (and fairly nondescript) terrain.

Section 2 of this report presents a summary of the major algorithms used in INM and NMAP. Sections 3 and 4 present the measurement plan and its execution. Section 5 presents analysis of the measurements. Section 6 presents the results of the measurements and algorithm analysis. Conclusions and recommendations are presented in Section 7.

2.0 FORMULATION OF NOISE MODELS

2.1 Line Sources

Both INM and NMAP are semi-empirical models, with the fundamental data source being measured noise levels from straight, constant power overflights. For civil aircraft, these data are usually collected by the manufacturers as part of noise certification tests. For military aircraft, these data are usually collected by personnel from military laboratories. Figure 2-1 is a sketch of the basic geometry of an overflight. It is typical that data are collected at a single distance d. The preferred value of distance d (which usually corresponds to the height above ground) is 300 meters (1,000 feet). Tests of military aircraft are usually conducted at this preferred altitude. The height for civil aircraft tests range from 100 meters (330 feet) to 800 meters (2,625 feet), corresponding to requirements of certification tests for various aircraft types. It is standard practice to collect full analog recordings of overflight test sounds, and to reduce these data into one-third octave bands at 0.5-second (or finer) intervals. Recording and analysis procedures for civil aircraft are specified by regulation.[7] Measurements are made for a variety of speeds, power settings, and aircraft configuration. The specific test matrix depends on the particular aircraft. Tests include, as a minimum, takeoff and approach power.[3]

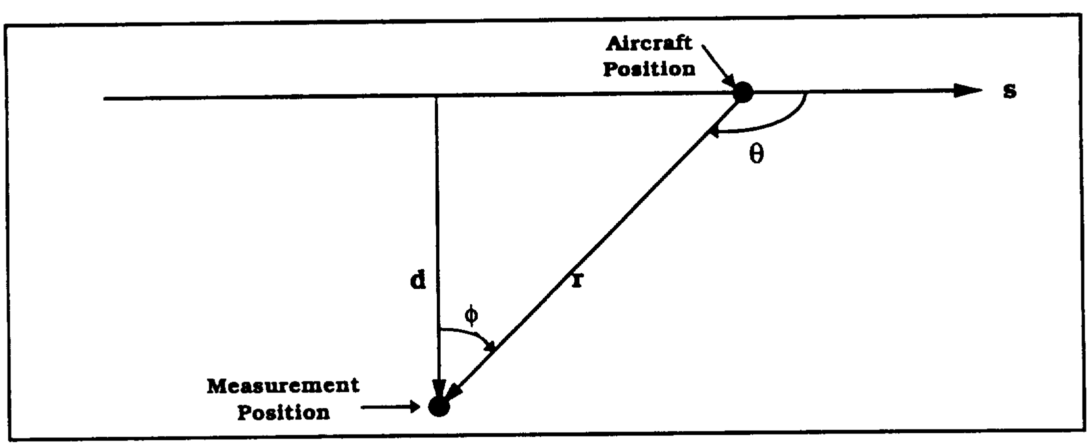


Figure 2-1. Geometry of Nominal Overflight Measurement.

Noise from an overflight at a given condition is represented by the sound exposure level:

$$SEL = 10 \log_{10} \frac{\int_{t_1}^{t_2} p_A^2(t)dt}{p_{ref}^2 \, t_{ref}} \qquad (2\text{-}1)$$

where $p_A^2(t)$ is the time-history of the A-weighted sound pressure squared, p_{ref} is the reference sound pressure level (20 μPa) and t_{ref} is the reference time (one second). The integration is conducted over time period t_1 through t_2 which encompasses the noise event; this usually corresponds to the time when the noise is within 10 dB of its maximum.

The noise models require tables of SEL at a geometric sequence of distances (for INM, 80, 100, 125, ... meters; similar sequence in feet for NMAP). These tables are contained in the INM database, generally having been prepared by the manufacturer for standard temperature and humidity conditions. NMAP's data base contains SEL and spectra at the 300-meter (1,000-foot) reference distance, and the table is prepared for user-specified temperature and humidity by one of its component programs, Omega10.

Reference 3 specifies two general procedures for preparing SEL at distances other than the measurement condition: the "integrated procedure" and the "simplified procedure".

In the integrated procedure, spectra at each 0.5-second analysis interval are organized according to the emission angle, θ in Figure 2-1. For each required distance d, the corresponding radius r at each θ is computed. The one-third octave band spectrum for each point is then adjusted by inverse square law and air absorption, with the distances for both effects being based on the measurement-condition r vs, the r required for the table. The A-weighted sound pressure from this adjusted time history is then integrated per Equation (2-1), with the time base adjusted to account for the effective time intervals no longer being 0.5 second.

In the simplified procedure, inverse square law and air absorption changes are made only for the spectrum at the maximum sound level, with the propagation adjustment based on measured versus required d. This difference is applied to the reference-distance SEL. Additionally, a "duration factor" consisting of 7.5 times the common logarithm of the ratio of measured versus required d is applied. The duration factor accounts for the noise emanating from a line source, versus the point source implicit in the adjust-by-d-only propagation adjustment.

With regard to the simplified procedure, it is interesting to note that a duration adjustment with a factor of 10, not 7.5, is correct for cases of no air absorption, cases of air absorption following an exponential decay law, or air absorption following a power law (whole or fractional power). Air absorption in a given frequency band follows an exponential decay law. The attenuation of the A-weighted level is somewhat more complex, because the spectral shape changes. The empirically derived factor of 7.5 apparently reflects this effect. The empirical factor may also be influenced by the analyzed data being only that within the A-weighted 10 dB down points, rather than a true complete line source time-history.

Reference 3 specifies that (assuming full spectral data are available) noise table values are to be prepared by the integrated procedure at distances up to 800 meters, and by the simplified procedure at distances greater than 800 meters. The tables are prepared using reference temperature and humidity.

NMAP's data base consists of SEL and the spectrum of the maximum level, at 300 meters (1,000 feet), adjusted to reference temperature and humidity. During a NMAP run, the Omega10 module prepares a noise table using user-specified local temperature and humidity. Omega10 uses a procedure which is effectively the same as the simplified procedure, but with a factor of 6.0 (rather than 7.5) in the duration adjustment. Again, this factor of 6 is derived empirically.

Validation testing of this algorithm can be accomplished by ensuring a range of slant distances, especially including distances beyond 800 meters.

2.2 Flight Segments

Actual flight paths are represented by sequences of straight and curved segments. Each model deals with these segments by adjusting the infinite-length SEL according to the segment length and position.

Ideally, finite segment effects would be handled by a procedure similar to the integrated procedure of Reference 3. This is not possible because neither model contains the full database needed, and it would also entail impractical computation times.

Both INM and NMAP adjust for segmentation by integrating an idealized point source along the finite segment being considered, and normalizing it by an integration of the source along the full infinite track. This proportion is referred to as the noise fraction. NMAP assumes an omnidirectional source, with $1/r^2$ spherical spreading propagation loss. By itself, this would lead to a simple noise fraction of $\Delta\phi/180°$, where $\Delta\phi$ is the net angle (as defined in Figure 2-1) subtended by the segment. To approximately account for air attenuation, a $1/r$ loss factor is assumed, yielding an approximate $1/r^3$ law and a noise fraction related to $\Delta\sin\phi$ rather than $\Delta\phi$. This is reasonable for segments where the point of closest approach is within the segment, but becomes decreasingly realistic for segments where the bounding ϕs are large and in the same direction. Such segments are, however, generally not the major contributor to noise at a given point.

INM develops segment adjustments by considering a source with a fourth-power 90-degree dipole model. This is considered in Reference 1 to be a source represented by $\cos^2\phi/r^2$, but is mathematically exactly equivalent to $\cos\phi/r^3$ or to $1/r^4$. INM's form leads to a noise fraction with a factor $\Delta\phi + \Delta(\sin\phi\ \cos\phi)$, as opposed to the $\Delta\phi$ from for inverse square law or the $\Delta\sin\phi$ NMAP form. INM 4.11 used an approximate algorithm for this noise fraction, while the current version (5.x) uses the exact relation. INM also contains a refinement of applying a directivity factor when the receiver is ahead or behind a finite segment. As with NMAP's noise fraction, INM's finite segment adjustment is reasonable for segments astride the receiver position, but is based on a power-law propagation factor which is less reliable for segments far ahead or behind.

The noise fraction is an element which must be tested. The approach to testing this is to examine measurement situations which are adjacent to segment bounds, or to model track segmentation in alternate ways.

2.3 Turns

Curved flight segments are handled in slightly different ways by the two models. NMAP uses an analytic noise fraction form which exploits the $1/r^3$ noise source model. INM models turns as sequences of straight segments, with rules as to how much the corresponding secants can deviate from the originally specified arc. Testing this part of the models is an extension of segment testing.

2.4 Lateral Attenuation

Both INM and NMAP use relations that are essentially single-parameter fits to elevation angle. There is no adjustment for specific type of ground cover. The lateral attenuation models differ considerably from each other, and the supporting data for each has wide scatter. This is a weak point of both models, which is expected to be addressed in the future by more recent ground-impedance based models. It is expected that variance of measured versus predicted levels will increase at smaller elevation angles.

2.5 Other Elements

The effect of speed is handled the same way in both models: the noise emission is assumed to be independent of speed, so that SEL is adjusted inversely proportionally (proportionally in a decibel sense) to speed. Variation of speed on a segment is treated by procedures equivalent to linear interpolation between the segment end points. These details are intimately connected to segmentation, and empirical tests of the validity of segmentation are not likely to explicitly test these.

3.0 ACOUSTIC MEASUREMENT PROGRAM

A measurement test plan was developed such that maximum yield would be obtained from the flight test measurements. Airport site selection criteria were established and potential airports were identified. Final airport selection was made considering technical feasibility, availability of FAA radar tracking data, and program costs. Execution of the measurement program ensued after obtaining NASA approval.

3.1 Airport Selection

The following airport selection criteria were used to identify potential measurement locations:

- Medium- to large-sized airport with many operations.
- Mix of short-, medium-, and long-range aircraft.
- Availability of twin-, tri-, and four-engine aircraft.
- Stage 2 and 3 aircraft.
- Surrounding community with low background noise.
- Availability of ARTS radar data.
- Completed Part 150 study or source for existing low noise contours.

Dulles International Airport (IAD) fulfilled all of the requirements listed above, and given its close proximity to Wyle Laboratories' Arlington, VA offices, travel costs would be kept to a minimum.

3.2 Measurement Site Selection

Once IAD had been identified, preliminary measurement site selection was made considering the following:

- Expected L_{dn} noise contour locations.[9]
- Flight tracks based on projected seasonal weather conditions.[9]
- Likelihood and levels of background noise.
- Equipment security.
- Location accessibility.

An on-location survey of the proposed sites lead to the final selection. This survey identified specific locations and considered local noise sources such as automobile traffic, construction, schools, as well as site accessibility and security. Permission to install equipment from the land owners was obtained wherever feasible.

All noise monitoring sites were located within 9 nautical miles of Dulles International Airport in Loudoun County, Virginia. This includes the region that normally constitutes the airport "vicinity" for noise exposure analyses. Two general monitoring areas were selected based on projected seasonal runway usage: (1) north of Runway 01L; and (2) west of Runway 30. The monitors were placed in rural areas, within residential communities and farmland property. Tables 3-1 and 3-2 provide a description of each location.

Table 3-1
Noise Monitoring Locations Near Dulles International Airport

Site No.	Site Description	Location Relative to Airfield
1	Wooded area at intersection of Route 607 and Beaverdam Run	North
2	St. David's Church, on Route 641 south of Ashburn junction	Northwest
3	Residential area at the end of Island Avenue in Potomac Farms	North
4	Wooded area at Intersection of Route 625 and Broad Run	North
5	Near intersection of Route 643 and gas pipeline, southeast of Ryan	North
6	Wooded area near intersection of Route 772 and gas pipeline, southwest of Ryan	Northwest
7	Horse farm on Route 616, 0.25 mile north of Route 50	West
8	Wooded area on Route 616, 1.5 miles north of Route 50	West
9	Near farm houses on Route 842, 0.5 mile east of Arcola	West
10	Farmland on Route 860, 1.5 miles north of Route 50	West
11	Residential area on Beaver Meadow Road, southwest of National Weather Service Center	West
12	Residential area at end of Beers School Rd. at airport property line	West
13	Residential area near intersection of Routes 641 and 642, in Ashburn	Northwest
14	Wooded area at intersection of Routes 50 & 616, 1 mile west of Glascock landing field	West

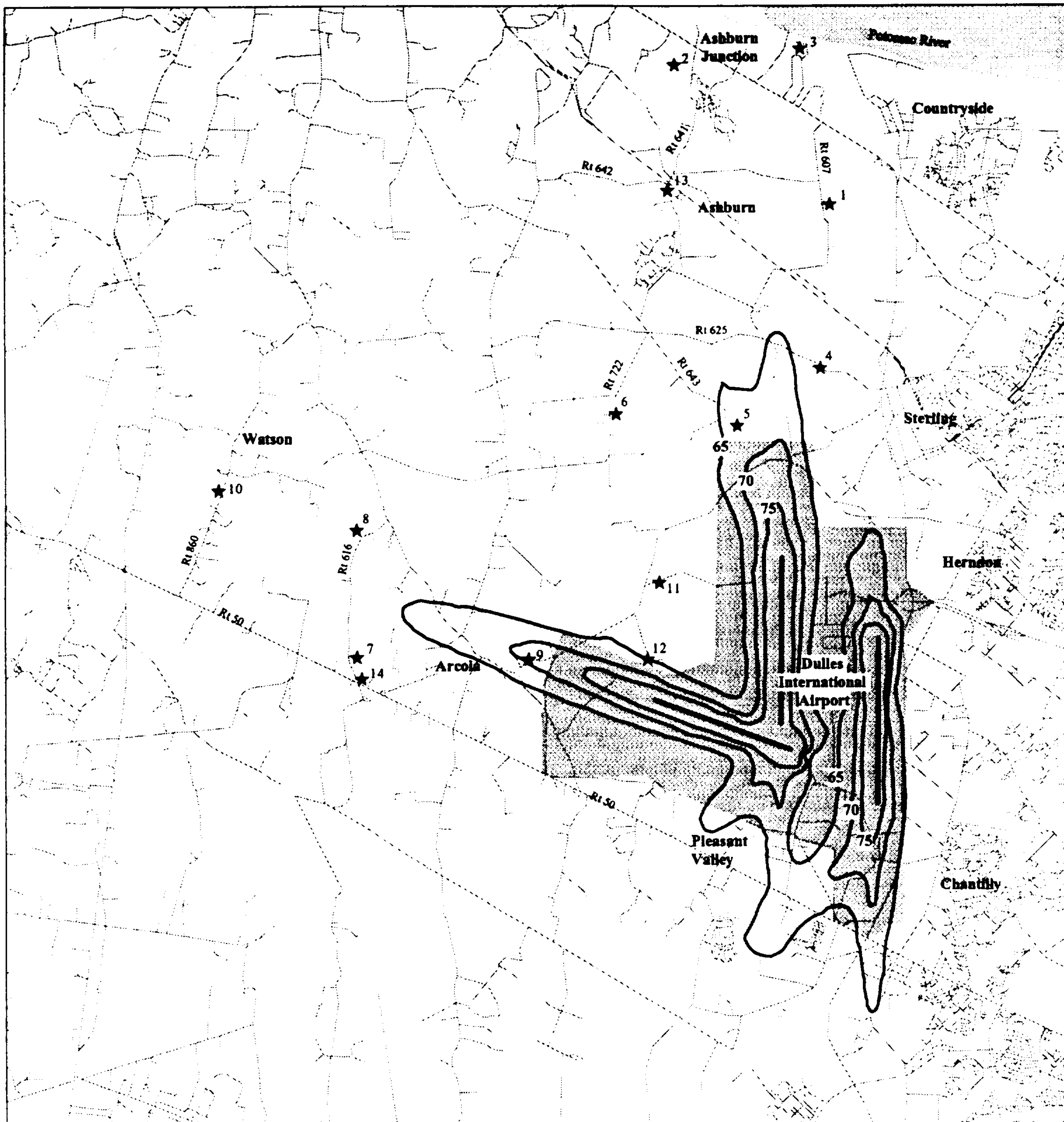
Table 3-2

Distance From Runway Threshold to Monitor Site (nm)

Site	Runway				
	01L	**19R**	**1R**	**12**	**30**
#01	6.02	4.13	6.95	6.03	6.31
#02	7.73	5.87	8.85	7.36	8.04
#03	7.93	6.04	8.90	7.80	8.23
#04	4.18	2.29	5.13	4.28	4.47
#05	3.56	1.71	4.72	3.37	3.87
#06	2.35	2.06	3.77	1.15	2.61
#07	5.04	5.04	6.33	3.58	5.21
#08	5.38	4.98	6.76	3.97	5.60
#09	3.14	3.11	4.50	1.71	3.34
#10	7.06	6.62	8.42	5.63	7.27
#11	2.17	1.51	3.58	1.32	2.46
#12	1.83	1.78	3.25	0.74	2.09
#13	2.08	1.42	3.49	1.29	2.37
#14	5.01	5.01	6.29	3.55	5.18

Figure 3-1 depicts a map of Dulles International Airport and vicinity with the current L_{dn} contours[9] and the 14 noise monitoring locations. In most cases, the monitors were located outside the 65 dB L_{dn} contour footprint at varying distances from the nominal flight tracks.[9] The geometric relationships between the monitoring locations and the nominal flight tracks ensured that noise measurements would be obtained for aircraft operating directly overhead and sideline, over a wide range of altitudes and elevation angles. Three sites were within the 65 dB L_{dn} contour.

It should be noted that use of the current L_{dn} contours in this report was for the purpose of providing a reference noise environment to aid in the selection of the noise monitoring locations. The L_{dn} contours shown in Figure 3-1 are a modified version of the current contours in that they were digitized from the original exhibit and registered in a geographic information system (GIS). These modified contours are a good representation of the originals so far as the shape and extent of the footprint; however, due to the digitization process, the contour lines are not as smooth as the originals. These contours should not be considered the official L_{dn} contours for Dulles International Airport nor should they be used for any land-use planning purposes. As Figure 3-1 indicates, most of the noise monitoring sites were located outside of the 65 dB L_{dn} contour, consistent with the main objective of the study: to examine the predictive capabilities of the INM at low-levels of exposure.



Scale

0 5000 10000

Feet

N

Legend

★ Monitor location

—65— Ldn Contour

Water

Airport Property

Figure 3-1

Noise Monitoring locations at Dulles International Airport

3.3 Noise Monitor Installation and Instrumentation

Noise monitoring was conducted during the period from 21 October through 15 December 1994, at the 14 locations around Dulles International Airport. Instrumentation at each site consisted of a Larson-Davis Model LD-820 sound level meter with a Bruel & Kjaer 4176 condenser microphone. This system is a battery-operated, digital storage, integrating sound level meter designed for unattended field use. For this program, the meters were programmed to measure and record the following information:

1. Hourly and daily mean, maximum, and minimum A-weighted sound levels, along with hourly and daily statistical summaries of A-weighted sound levels which were exceeded 1 percent, 10 percent, 50 percent, and 90 percent of the time. All measurable noise sources were documented in this fashion.
2. Time, maximum A-weighted sound level, sound exposure level, and duration of individual noise events which exceeded a set threshold; this varied with each monitoring station. This information was used to document the noise levels of individual aircraft operations.
3. Time-histories of A-weighted levels during noise events.

During the instrumentation setup, at each site, the meter threshold for measuring aircraft operations was determined according to the ambient noise levels along with the observed aircraft arrival and departure noise levels. In all cases the threshold was set approximately 10 decibels above the local ambient noise levels and below the maximum A-weighted sound levels of the observed aircraft operations. The instruments were secured in environmental cases and powered with external batteries which lasted approximately one week between charges.

4.0 MEASUREMENT PROGRAM EXECUTION

Each noise monitoring site was serviced every two to three days during the monitoring period. This schedule was sufficient due to the external battery life and the high memory capacity of the meters. A site visit consisted of checking the meters operational status, battery power, free memory, and the number of recorded exceedances. A calibration procedure was conducted to ensure the system was operating within tolerance. If the unit had acquired a large number of data records, all data were then downloaded to a portable computer for permanent retention and subsequent analysis. Records of these values, along with the time and date, were noted in a site log.

Immediately following field data collection, verification analysis examined the operational status of each noise monitoring system. The data collected at each monitoring location was printed out in several different reports including: a summary report (Figure 4-1) describing the system parameters; an interval report containing hourly integrated noise metrics and statistical levels; and an exceedance report* containing noise metrics associated with individual events, including calibration records. All data were received at each site, with few exceptions throughout the measurement period. Adverse weather conditions and final instrumentation adjustments precluded use of the measurement data before 24 October. No data were collected at Site 8 due to the instrumentation being stolen during the early part of the measurement program. At various times, local weather conditions precluded use of the acoustic data in the analysis. The conditions under which the data was screened are discussed in Section 5 along with the weather report format. All noise monitoring systems remained in calibration during the majority of the measurement period.

---

* The instrument inappropriately uses the term "exceedance" to denote individual noise events. The nomenclature "exceedance report" or "exceedance record" is used as necessary in this report when referring to those instrument records. It should not be confused with exceedance percentile levels.

```
-------------------------------------------------------------------------------
                                                         File: P121212
SUMMARY REPORT                                       12-13-1994 11:52:40
                                                     MODEL 870  SN A0504
-------------------------------------------------------------------------------
   WYLE LABS                                  Firmware Version  0.156
   DULLES AIRPORT                             Detector          Slow
   NOV 94                                     Weight            A
   SITE12                                     Hysteresis        3
                                              RMS EXCD Level 1  65
                 Overall                      RMS EXCD Level 2  95
Start Time 05Dec1994 15:30:40                 Peak EXCD Level   140
Run Time       166:32:18.2                    UWPk EXCD Level   200
Leq              70.1                         Dose Period       24
SEL              127.9
Lmin             19.4                         Exceedance records 2241
Lmin Time   06Dec1994 02:33:54                Interval records   168
Lmax             113.7                        History records    0
Lmax Time   05Dec1994 15:30:40                Daily records      8
Peak             124.8                        Cal records        0
Peak Time   10Dec1994 12:37:16                Background Leq     51.1
UWPk             128.5                        Total Excd Leq     83.8
UWPk Time   10Dec1994 21:48:32                Total Excd Time 7:01:49.5
Dose             7.09                         Free Memory        73922
Proj Dose        1.01                         Battery Level      80% INT
Exchange rate     3dB                         Power Mode         Normal
Threshold         0                           EXT Cut Off        *
Criterion         90                          Number of RUNS     2
L1      74.6      L50     42.5                Pause Time 0:00:00
L10     57.4      L90     29.9                Number of PAUSES   0
 33     46.8      L99     22.8
RMS Exceedances #1  4350               Excd Min Duration  3
RMS Exceedances #2  1                  Excd Save A:D      *
Peak Exceedances    0                  Excd Exchange Rate 3dB
UWPk Exceedances    0
Overloads           0                  Interval period   01:00   Ln's Yes
                                       Interval Save A:D              *
                                       Interval Exchange Rate 3dB
                                       Interval Threshold     0
                                       History  period 1 s Peaks: Peak
*        Avg  *
*        Max    Min   *
*        Excds         Excd Level *
*        Avg  *
*        Max    Min   *                CALIBRATION Time 20Oct1994 18:38:40
*        Excds         Excd Level *    CAL Check Time   30Nov1994 10:15:54
*        Avg  *                        CAL Offset       10.5
*        Max    Min   *                CAL Check Level  104.6
*        Excds         Excd Level *    Auto Cal Mode    No

0:
```

Figure 4-1. Noise Monitor Sample Summary Report, Site 12, December 12, 1994.

The interval report provided a quick check that the noise monitor had functioned continuously throughout the previous measurement period. Figure 4-2 shows the main elements of this report for Site 12 during the period 5–7 December 1994. Included are the date and time of the hourly record, L_{eq} , L_{max} , Peak level, sound exposure level (SEL), and the exceedance percentile levels L_{01} , L_{10} , L_{50} , and L_{90} . The L_{eq} is the energy-average A-weighted sound level over the measurement period. The L_{90} exceedance percentile level, which is the sound level exceeded 90 percent of the time, generally represents the ambient or background sound level in the absence of identifiable noise sources. Throughout the measurement program, the L_{90} exceedance percentile levels were used to track the ambient sound levels at each site. These levels were influenced primarily by airport operations and vehicular traffic on nearby roadways. No other continuous identifiable noise sources were observed at any of the locations, during the monitoring period, that would significantly contribute to the ambient level.

Table 4-1 shows the hourly L_{eq} and L_{90} values for Site 12 during 24–31 October 1994, for example. The day-night average sound level and mean 90-percentile sound level are computed from the hourly values, for each day. Blank intervals over the monitoring periods indicate times during which the instrumentation was being serviced or when data were excluded due to adverse weather conditions.

Table 4-2 shows the summary information for all 13 monitoring locations for the entire 53-day monitoring period. Listed for each location are the number of hours of usable monitoring data, the mean day-night average sound level, and the mean 90-percentile sound level.

Figure 4-3 shows a sample exceedance report, including the following information for individual acoustic events that exceeding the preset threshold: the date and time of the event, the duration, L_{eq}, L_{max}, Peak level, and SEL. L_{max} is the maximum A-weighted sound level during the event. The sound exposure level (SEL) represents the total acoustic energy of the event. It is the fundamental quantity for each event, and is accumulated to develop L_{dn} . These data records were correlated with radar flight track information to determine the measured sound levels of individual aircraft operations. In this study, the SEL was identified for each event.

INTERVAL REPORT
'eriod 01:00 h:m

File: P121212
12-13-1994 12:02:58
Model 870 SN: A0504

Date	Time	Duration	Leq dBA	Lmax dBA	Peak dBA	SEL dBA	L1 dBA	L10 dBA	L50 dBA	L90 dBA
05Dec1994	15:30:40	00:22.50	113.5	113.7	117.5	127.1	113.7	113.7	113.5	113.5
05Dec1994	16:00:00	59:59.96	54.3	76.8	90.1	89.9	65.7	55.6	43.2	38.9
05Dec1994	17:00:00	1:00:00	66.9	88.2	104.6	102.5	80.9	64.9	44.7	40.4
05Dec1994	18:00:00	1:00:00	66.3	89.7	103.8	101.9	79.8	59.6	44.9	37.8
05Dec1994	19:00:00	1:00:00	58.9	86.4	99.8	94.5	70.8	54.8	40.7	33.9
05Dec1994	20:00:00	1:00:00	47.9	66.7	81.4	83.5	59.5	51.0	39.6	32.7
05Dec1994	21:00:00	1:00:00	53.3	76.9	91.6	88.9	66.0	50.0	35.6	30.4
05Dec1994	22:00:00	1:00:00	47.4	65.1	79.8	83.0	60.7	49.1	35.8	28.7
05Dec1994	23:00:00	1:00:00	63.6	87.3	100.1	99.2	78.3	49.7	30.9	25.5
06Dec1994	00:00:00	1:00:00	44.3	65.8	79.4	79.8	58.4	42.9	26.9	22.4
06Dec1994	01:00:00	1:00:00	63.8	91.2	105.9	99.3	63.2	37.9	25.0	21.8
06Dec1994	02:00:00	1:00:00	30.7	48.2	63.9	66.3	43.0	33.0	21.5	19.9
06Dec1994	03:00:00	1:00:00	27.0	59.2	88.8	62.6	32.8	28.2	22.5	20.3
06Dec1994	04:00:00	1:00:00	39.2	61.8	76.2	74.8	55.2	34.0	27.9	23.3
06Dec1994	05:00:00	1:00:00	47.6	69.3	80.8	83.2	61.5	42.7	35.0	30.1
06Dec1994	06:00:00	1:00:00	67.6	89.4	102.3	103.2	82.7	54.6	38.6	34.6
06Dec1994	07:00:00	1:00:00	60.4	83.0	97.0	96.0	74.1	57.6	46.5	40.2
06Dec1994	08:00:00	1:00:00	60.1	83.8	97.3	95.7	74.0	55.4	46.1	41.5
06Dec1994	09:00:00	1:00:00	66.6	92.0	106.9	102.2	78.6	58.2	45.5	37.5
06Dec1994	10:00:00	1:00:00	59.5	85.2	100.2	95.0	72.9	49.6	38.1	32.2
06Dec1994	11:00:00	1:00:00	65.9	93.2	107.2	101.4	73.0	52.1	36.3	31.7
06Dec1994	12:00:00	1:00:00	63.7	85.8	99.7	99.3	77.0	59.6	42.6	33.7
06Dec1994	13:00:00	1:00:00	49.1	68.8	83.9	84.6	63.0	50.0	37.3	29.1
06Dec1994	14:00:00	1:00:00	49.9	67.9	79.6	85.5	60.6	52.9	43.4	35.9
06Dec1994	15:00:00	1:00:00	50.1	65.9	79.2	85.7	61.7	53.7	43.2	36.3
06Dec1994	16:00:00	1:00:00	54.7	75.1	87.4	90.3	66.7	56.7	44.6	38.2
06Dec1994	17:00:00	1:00:00	67.3	88.3	104.2	102.9	81.9	65.9	49.9	41.5
06Dec1994	18:00:00	1:00:00	64.4	87.2	99.9	100.0	78.4	60.9	47.2	40.3
06Dec1994	19:00:00	1:00:00	58.2	81.5	93.7	93.8	71.3	55.7	43.1	36.6
06Dec1994	20:00:00	1:00:00	54.0	72.7	85.7	89.6	66.4	56.6	43.4	37.6
06Dec1994	21:00:00	1:00:00	50.0	71.0	82.4	85.6	62.3	52.3	42.1	35.4
06Dec1994	22:00:00	1:00:00	61.7	84.4	97.2	97.3	76.4	51.6	37.6	30.6
06Dec1994	23:00:00	1:00:00	61.2	86.6	98.9	96.8	67.4	52.5	37.6	31.4
07Dec1994	00:00:00	1:00:00	53.0	80.2	92.4	88.6	62.0	37.8	28.8	26.1
07Dec1994	01:00:00	1:00:00	45.7	68.9	81.9	81.3	61.2	34.6	27.7	25.0
07Dec1994	02:00:00	1:00:00	27.6	46.3	76.6	63.2	36.7	29.2	25.2	23.5
07Dec1994	03:00:00	1:00:00	30.3	48.1	77.9	65.9	38.2	31.7	28.6	26.3
07Dec1994	04:00:00	1:00:00	46.1	67.6	89.0	81.7	60.7	37.9	30.1	26.9
07Dec1994	05:00:00	1:00:00	51.7	76.5	105.6	87.3	65.9	41.3	37.1	34.0
07Dec1994	06:00:00	1:00:00	51.0	72.3	88.0	86.6	63.6	49.9	42.6	38.9
07Dec1994	07:00:00	1:00:00	57.0	76.3	98.9	92.6	70.6	58.4	46.2	43.4
07Dec1994	08:00:00	1:00:00	60.5	83.4	98.5	96.1	72.4	55.4	45.8	43.1
07Dec1994	09:00:00	1:00:00	57.2	77.5	92.5	92.8	72.1	54.9	45.5	42.0
07Dec1994	10:00:00	1:00:00	55.0	76.0	91.7	90.6	70.2	53.3	42.6	39.2
07Dec1994	11:00:00	1:00:00	48.3	70.3	83.7	83.9	59.9	50.9	40.7	37.5
07Dec1994	12:00:00	1:00:00	50.1	73.6	92.6	85.7	59.9	51.8	43.1	37.8
07Dec1994	13:00:00	1:00:00	46.6	67.1	83.7	82.2	59.0	49.3	35.6	31.3
07Dec1994	14:00:00	1:00:00	51.9	73.3	86.8	87.5	65.2	53.0	42.0	33.7
07Dec1994	15:00:00	1:00:00	56.3	80.8	94.7	91.9	65.3	56.0	41.5	34.4

Figure 4-2. Sample Interval Report, Site 12, 5–7 December 1994.

Table 4-1

Hourly Sound Levels Measured at Site #12, 24 October 1994 to 31 October 1994

Hour	Site #12 October-24-1994		Site #12 October-25-1994		Site #12 October-26-1994		Site #12 October-27-1994		Site #12 October-28-1994		Site #12 October-29-1994		Site #12 October-30-1994		Site #12 October-31-1994	
	Leq (dB)	L90 (dB)	Leq (dB)	L90 (dB)	Leq (dB)	L90 (dB)	Leq (dB)	L90 (dB)	Leq (dB)	L90 (dB)	Leq (dB)	L90 (dB)	Leq (dB)	L90 (dB)	Leq (dB)	L90 (dB)
0000	37.3	28.1	51.3	28.6	64.2	30.6	55.9	24.2	52.0	29.8	48.6	30.1	42.0	26.6	47.9	32.4
0100	26.8	22.4	42.1	26.3	33.4	27.4	32.4	22.3	38.6	29.8	36.7	25.7	36.3	26.1	43.5	31.3
0200	25.6	20.8	27.9	24.4	35.9	30.3	28.9	22.6	36.1	31.3	35.9	25.6	29.9	26.5	30.8	28.4
0300	25.7	20.2	31.3	23.4	33.2	30.1	38.0	23.6	38.4	27.6	32.3	28.0	33.3	25.1	30.8	27.3
0400	29.4	21.3	39.0	26.1	40.5	29.1	37.1	25.0	40.1	29.7	33.8	27.8	28.4	23.5	46.2	27.2
0500	43.6	29.7	50.4	31.8	50.1	32.1	61.4	34.2	54.3	35.4	50.8	32.0	47.9	25.0	34.1	31.6
0600	47.4	41.8	49.2	40.6	52.6	42.6	53.0	43.2	62.4	43.4	53.6	37.2	33.7	27.4	49.4	33.4
0700	54.9	43.4	60.3	42.3	58.5	45.8	55.5	46.2	56.1	47.4	54.0	42.6	48.6	29.9	44.8	37.0
0800	54.3	44.1			54.8	45.0			56.3	48.2	54.7	45.7	54.5	36.8	58.1	42.0
0900	56.6	38.4	71.7	40.1	65.3	43.4			52.6	45.1	58.0	45.6	55.3	36.1	50.0	41.0
1000	45.5	33.7	73.5	35.9	64.9	41.0			52.9	38.0	54.1	42.6	44.8	34.0	55.3	41.9
1100					51.3	35.0			50.2	32.7	52.0	37.6	50.5	29.1	48.4	43.5
1200	67.9	35.5			69.1	37.9			50.3	38.1	50.4	37.3	51.7	30.9	50.2	38.5
1300	57.5	35.0	65.6	36.3	70.3	35.5			50.3	37.0	48.2	31.2	50.1	34.5	59.9	38.0
1400			61.6	34.0	61.2	37.4	57.4	40.8	55.2	37.3	49.4	32.3	48.4	29.8	51.9	37.5
1500	52.3	37.5	66.1	35.1	67.4	39.6	66.7	41.2	51.9	37.2	55.3	35.0	55.0	31.4	49.8	35.4
1600	52.3	37.1	64.2	36.2	69.1	40.5	67.6	40.4	55.2	36.0	53.5	33.6	55.2	32.1	53.3	38.3
1700	57.0	40.7			70.1	43.6	68.3	42.4	52.3	40.4	63.3	39.0	51.7	31.2	53.0	37.4
1800	52.9	42.2	65.8	38.7	69.4	41.4	68.3	39.4	52.5	37.9	50.1	34.6	70.1	41.4	51.9	41.3
1900	55.1	40.8	61.6	36.5	64.7	36.8	72.9	35.6	71.1	39.0	52.7	31.6	68.2	42.6	53.1	41.7
2000	55.1	40.3	54.9	36.3	61.1	34.4	61.5	32.7	53.5	37.7	49.6	32.5	50.0	40.8	55.3	40.3
2100	53.1	40.3	52.6	38.0	52.1	36.0	49.5	34.2	53.3	37.8	55.4	34.4	52.3	38.4	51.3	40.5
2200	59.9	38.8	48.9	37.4	57.6	32.0	49.6	36.6	54.2	36.1	49.7	31.4	53.0	37.8	50.9	40.8
2300	47.3	35.3	68.5	39.2	67.6	25.7	66.0	34.0	61.8	36.6	45.9	29.3	51.9	35.5	64.5	39.3
LD (dB)	58.7	40.2	67.0	37.9	66.4	41.1	67.1	41.0	60.3	41.8	55.5	39.9	61.0	36.9	54.0	40.2
LN (dB)	50.9	35.0	59.2	35.1	60.1	34.7	58.3	35.5	56.4	36.3	48.0	31.3	46.9	31.4	55.5	35.1
DNL (dB)	59.7		68.0		68.2		67.6		63.7		56.6		59.9		61.7	
LMEAN	57.1	38.9	65.4	37.0	64.9	39.6	65.4	39.6	59.2	40.4	53.9	38.2	59.1	35.5	54.6	38.9
Hrs (Day)	13	13	11	11	15	15	9	9	15	15	15	15	15	15	15	15
Hrs (Night)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Hrs (Total)	22	22	20	20	24	24	18	18	24	24	24	24	24	24	24	24

Leq = Hourly Average Sound Level in decibels.
L90 = Hourly 90-Percentile Sound Level in decibels.
LMEAN = Daily Average Sound Level in decibels.
DNL (dB) = Day-Night Average Sound Level in decibels.

LD (dB) = Daytime Average Sound Levels in decibels (0700–2200).
LN (dB) = Nighttime Average Sound Level in decibels (0000–0700 and 2200–2400).

File: P121212
12-13-1994 11:52:44

EXCEEDANCE REPORT

'xcd Levels RMS 1: 65dB RMS 2: 95dB Peak: 140dB Uwpk: 200dB

Model 870 SN: A0504

Excd	Date	Time	Duration	Leq dBA	Lmax dBA	Peak dBA	Uwpk dB	SEL dBA	Sym %
1	05Dec1994	15:30:40	00:22.50	113.5	113.7	117.5	124.8	127.1	0.0
2	05Dec1994	16:08:35	00:10.87	65.4	67.1	80.7	97.0	75.8	39.1
3	05Dec1994	16:12:49	00:10.68	65.0	67.8	83.3	97.0	75.3	8.2
4	05Dec1994	16:14:33	00:16.25	63.9	66.6	80.5	97.0	76.0	39.1
5	05Dec1994	16:26:56	00:11.81	65.4	67.2	80.1	97.0	76.1	64.8
6	05Dec1994	16:36:25	00:04.93	63.6	65.7	82.6	97.0	70.5	18.0
7	05Dec1994	16:39:13	00:14.31	64.2	66.7	79.7	97.0	75.8	73.0
8	05Dec1994	16:49:24	00:07.37	65.8	67.4	80.7	97.0	74.5	23.4
9	05Dec1994	16:59:27	00:20.00	72.3	76.8	90.1	101.5	85.3	56.3
10	05Dec1994	17:06:15	00:14.03	67.4	70.9	84.4	97.0	78.9	46.5
11	05Dec1994	17:07:33	00:14.40	69.5	72.8	86.1	97.7	81.1	31.6
12	05Dec1994	17:19:23	00:34.25	78.6	84.8	99.9	104.4	93.9	25.8
13	05Dec1994	17:20:35	00:34.31	79.4	85.9	98.2	105.8	94.8	28.9
14	05Dec1994	17:22:24	00:06.03	65.4	67.4	78.2	97.7	73.2	14.4
15	05Dec1994	17:23:12	00:18.34	73.3	76.8	90.7	100.4	85.9	37.5
16	05Dec1994	17:26:34	00:24.56	75.1	79.6	91.7	102.2	89.0	53.5
17	05Dec1994	17:29:57	00:25.53	75.2	78.6	90.9	101.5	89.2	44.1
18	05Dec1994	17:36:24	00:21.59	75.0	81.0	93.9	102.2	88.4	30.1
19	05Dec1994	17:40:55	00:31.75	82.2	88.2	104.6	111.4	97.2	43.8
20	05Dec1994	17:42:37	00:04.40	63.7	65.3	75.9	97.0	70.2	4.7
21	05Dec1994	17:44:48	00:26.12	72.6	76.1	89.8	100.0	86.7	46.1
22	05Dec1994	17:48:14	00:23.40	70.3	74.9	89.8	98.2	83.9	40.6
23	05Dec1994	17:49:48	00:27.53	72.6	78.2	92.8	100.0	87.0	51.2
24	05Dec1994	17:52:07	00:14.15	68.6	70.7	84.5	98.7	80.1	39.8
25	05Dec1994	17:53:57	00:14.68	68.1	70.9	84.4	100.0	79.8	64.4
26	05Dec1994	17:55:38	00:35.59	77.4	84.6	97.8	105.4	92.9	39.1
27	05Dec1994	17:56:36	00:22.34	71.0	75.3	88.4	99.8	84.5	39.1
28	05Dec1994	17:59:17	00:13.93	67.3	71.3	84.3	98.2	78.7	58.6
29	05Dec1994	18:04:46	00:21.12	73.0	77.2	90.3	101.5	86.3	56.3
30	05Dec1994	18:07:42	00:37.62	80.5	89.2	103.4	106.0	96.3	23.4
31	05Dec1994	18:09:50	00:17.90	67.2	69.3	83.2	98.7	79.7	64.4
32	05Dec1994	18:14:56	00:27.96	71.6	76.3	90.8	101.1	86.1	39.1
33	05Dec1994	18:21:39	00:21.93	74.4	79.4	93.3	101.1	87.8	41.8
34	05Dec1994	18:30:57	00:38.06	79.8	87.4	101.8	104.9	95.6	27.3
35	05Dec1994	18:31:47	00:03.12	64.4	65.8	79.1	97.0	69.3	9.8
36	05Dec1994	18:34:12	00:17.93	68.6	71.7	84.3	98.2	81.1	46.1
37	05Dec1994	18:37:39	00:22.87	70.5	74.6	88.6	98.7	84.1	30.9
38	05Dec1994	18:45:16	00:22.87	69.8	73.6	86.6	99.1	83.4	46.1
39	05Dec1994	18:51:11	00:34.62	81.7	89.7	103.8	107.7	97.1	42.6
40	05Dec1994	19:12:23	00:03.15	64.0	65.4	80.2	97.7	69.0	18.8
41	05Dec1994	19:22:34	00:35.25	73.1	78.4	91.6	100.4	88.6	48.8
42	05Dec1994	19:58:46	00:27.18	78.0	86.4	99.8	102.8	92.4	42.2
43	05Dec1994	20:31:32	00:10.00	64.1	65.8	78.6	96.4	74.1	62.9
44	05Dec1994	21:04:20	00:06.81	64.2	66.6	79.6	96.4	72.5	11.7
45	05Dec1994	21:43:38	00:06.96	63.3	65.4	76.6	96.4	71.7	2.0
46	05Dec1994	21:44:59	00:34.81	71.3	76.9	91.6	99.1	86.7	48.0
47	05Dec1994	21:47:31	00:10.18	67.3	70.8	81.4	97.7	77.4	46.5
48	05Dec1994	21:59:42	00:06.15	66.1	68.2	79.7	97.0	74.0	23.0

Figure 4-3. Sample Exceedance Report, Site 12, December 12, 1994.

Table 4-2

Summary of Continuous Noise Monitoring,
Dulles International Airport,
24 October to 15 December 1994

Monitoring Site No.	Hours	Ldn (dB)	L90 (dB)
1	791	58.6	39.1
2	628	60.7	50.6
3	927	55.1	38.4
4	940	65.2	52.7
5	981	61.9	39.7
6	569	54.1	39.2
7	139	59.4	41.7
9	936	67.4	40.1
10	853	58.9	41.2
11	923	56.6	44.0
12	922	65.2	40.6
13	266	63.4	39.8
14	110	62.7	41.9

Hours = Total hours of valid data.
Ldn = Day-Night Average Sound Level in decibels.
L90 = 90-Percentile sound level in decibels
(a measure of the ambient or background noise level).

Event time-histories were also recorded by the LD-820s. Figure 4-4 shows a sample time-history for a Boeing 727 departure, recorded at site #1. Here the A-weighted sound level is plotted as a function of time, in seconds. The time-history for a given event started the moment the sound level exceeded the preset threshold. Each time-history contained a maximum of 255 data points with a sampling rate of four data points per second. This rate provided a sample of up to one minute, sufficient for defining an aircraft arrival or departure. While many of the exceedance records were easily correlated with the radar flight track information based on the time of the event only, at times it was necessary to examine the corresponding time-history data to correctly identify the acoustic data associated with the aircraft operation.

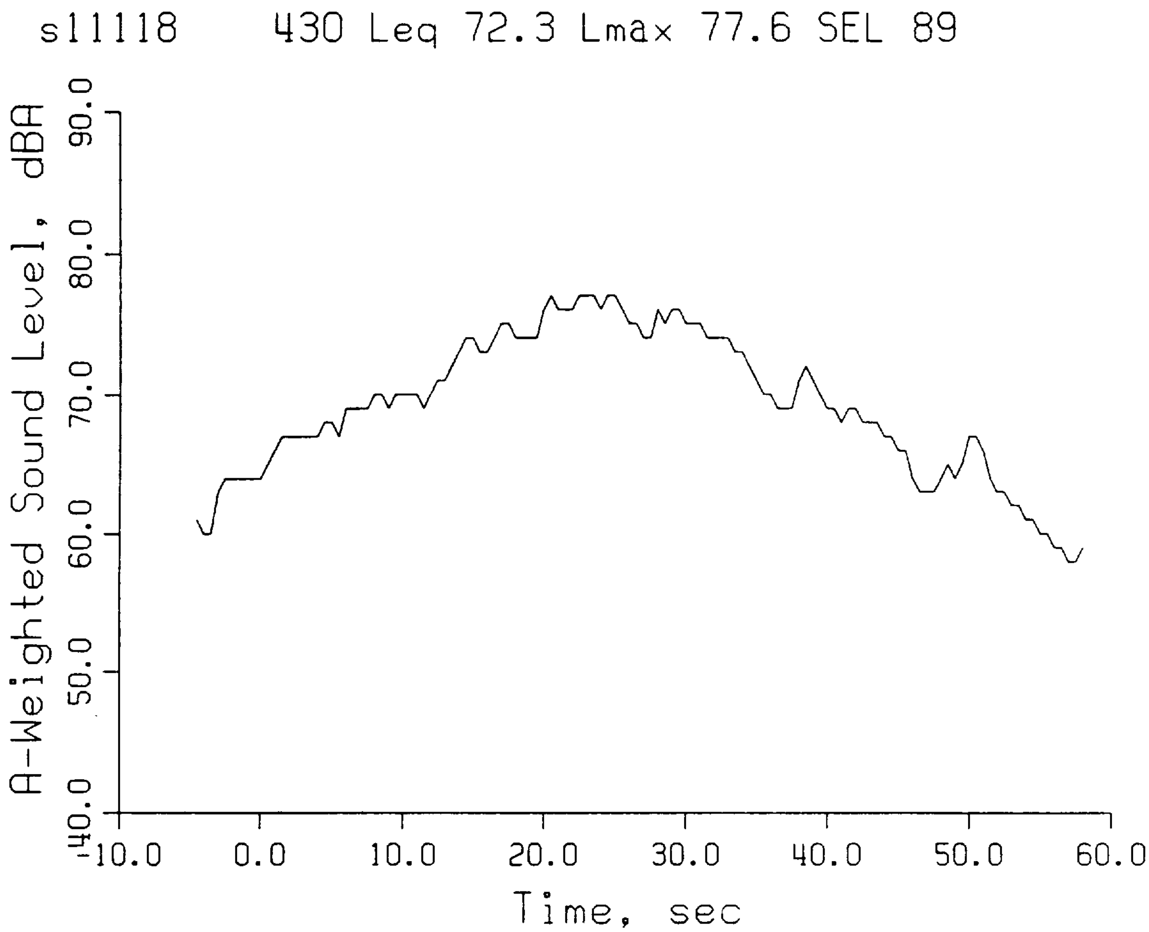


Figure 4-4. Sample-Time History, B-727 Departure at Site #1.

5.0 DATA ANALYSIS

Analyses of the empirical database kernels of the noise methodology codes were intended both to support algorithm study results and to provide physical guidelines and quantify the accuracy in regions exposed to lower levels of noise. Individual events were modeled based on the ARTS data and compared with their recorded noise event, using a combination of time, flight track information, and time-history for accurate correlation. Comparisons were made between predicted and measured values of SEL, rather than values of L_{dn} for daily, weekly, or monthly periods. This "if the individual SELs match, then the L_{dn}'s will also match" approach was used to rule out the possibility of cancellation of errors, which may occur when considering only L_{dn} values. An individual flight analysis also allows for more detailed and more independent variables in the sensitivity studies.

Given the structure and emphasis of the NMAP database on military aircraft, and the limited number of civilian aircraft and engine combinations contained within the NMAP empirical data kernel, any further direct comparisons between NMAP's database components and flight test measurements were precluded.

INM 4.11[2] was exercised using as accurate data as was available. The INM empirical database kernel contains four major components:

- Empirical Noise Source Data at Reference Location and Conditions.
- Standard Flight Profile Data for each aircraft, engine, stage length, operation type combination.
- Standard Velocity Profile Data for each aircraft, engine, stage length, operation type combination.
- Standard Power Profile Data for each aircraft, engine, stage length, operation type combination.

The first component, Empirical Noise Source Data, is based on certification flight test measurements as provided to the FAA by the airframe manufacturers.[7] The remaining components fall into the genre of modeling techniques; as each data component was replaced by as accurate an "as-flown" representation as was feasible. The following sections describe the data processing philosophy, the available data, and the details of the analysis process.

5.1 Data Sources

Weather

Surface weather observation data was obtained from the National Oceanic and Atmospheric Administration (NOAA), National Weather Service station at Dulles International Airport. This facility recorded the local weather conditions in both an hourly and daily report format. Figures 5-1 and 5-2 show the daily and monthly averages, respectively, for November 1994. Included are the minimum, maximum, and average temperature (°F), precipitation (inches of water), the average wind speed (mph) and direction, barometer, temperature, and dewpoint. Figure 5-3 shows a sample of the hourly weather report for 23 November 1994. For each one-hour time period, the average temperature, barometric pressure, precipitation, and wind speed are included. These hourly weather records were examined to filter the corresponding acoustic data. The acoustic data were excluded from the analysis if:

- the wind speed was in excess of 10 knots (11.5 mph), or
- any precipitation occurred during the measurement period.

The acoustic measurement reports were carefully cross-correlated with the weather data, and those exceedance records which occurred during periods of unacceptable weather were flagged accordingly, and were not used in the sensitivity studies.

Radar Data

Radar tracking data was obtained for the entire field measurement period from the Metropolitan Washington Airports Authority (MWAA). Radar data was obtained from the Automated Radar Terminal System IIIA (ARTS).[10] ARTS is a semi-automated air traffic control system using a Univac computer, linked with a beacon tracking system. The system continuously records for each aircraft, carrying an transponder beacon within radar range, the current time, position, velocity, and altitude every 4.5 seconds. Stored in parallel with the tracking beacon and transponder data is aircraft flight plan data, and other interfacility (IF) messages, linking aircraft type, destination, and flight data with the various beacons. Tracking data and IF data are correlated by the transponder beacon code, which is commonly referred to as the "squawk". All ARTS data was stored on 105mB SyDos removable cartridges, and consisted of one or more binary files for each measurement day. Table 5-1 lists the 25 dates for which radar coverage was made available to Wyle Laboratories.

Preliminary Local Climatological Data (WS Form: F-6)

Station: WSCMO, WASH-DULLES, WASH, DC
Month: NOV
Year: 1994

Latitude +3857 Longitude +7727 Gnd Elev. 290 ft. Std Time: EST

Temperature in Fahrenheit : Precip(in.): Snow : Wind : Fastest 1-Min: Sunshine : Sky : Peak Wind

-1- Day	-2- Max	-3- Min	-4- Avg	-5- Dep.	-6a- HDD	-6b- CDD	-7- Water	-8- Snow	-9- Depth	-10- Avg.	-11- Speed	-12- Dir	-13- Mins.	-14- %PSBL	-15- SR-SS	-16- Weather	-17- Speed	-18- Dir
1	69	46	58	8	7	0	0.38	0.0	0	9.6	21	29			9	1,3	32	N
2	61	39	50	0	15	0	0.00	0.0	0	10.9	18	29			3		31	NW
3	71	31	51	2	14	0	0.00	0.0	0	5.4	10	21			10		15	S
4	78	39	59	10	6	0	0.00	0.0	0	5.3	12	18			1		14	S
5	77	48	63	14	2	0	0.00	0.0	0	6.7	09	18			10		12	S
6	78	59	69	21	0	4	0.02	0.0	0	12.5	17	21			7		32	NW
7	62	36	49	1	16	0	0.00	0.0	0	8.5	17	31			2		30	NW
8	71	32	52	4	13	0	0.00	0.0	0	8.4	14	23			2		17	SW
9	78	49	64	16	1	0	0.00	0.0	0	7.2	13	22			10		18	SW
10	60	33	47	0	18	0	0.21	0.0	0	8.3	17	02			5	1	30	N
11	53	28	41	-6	24	0	0.00	0.0	0	4.8	09	32			1		14	N
12	56	25	41	-6	24	0	0.00	0.0	0	3.9	09	18			7		13	S
13	72	33	53	7	12	0	0.00	0.0	0	2.3	07	16			7		09	S
14	72	36	54	8	11	0	0.00	0.0	0	5.1	14	18			6		16	S
15	71	43	57	11	8	0	0.00	0.0	0	4.9	10	33			10		13	NE
16	60	45	53	8	12	0	0.01	0.0	0	8.5	10	03			10	1	20	N
17	52	42	47	2	18	0	0.07	0.0	0	9.2	14	03			10	1	18	NE
18	56	49	53	8	12	0	0.14	0.0	0	8.1	12	34			10	1	16	N
19	62	36	49	5	16	0	0.00	0.0	0	6.8	15	32			0		23	N
20	62	33	48	4	17	0	0.00	0.0	0	4.5	07	12			8		10	SE
21	61	43	52	8	13	0	0.51	0.0	0	6.2	17	16			10	1	21	NW
22	57	38	48	5	17	0	0.00	0.0	0	12.9	18	31			0		33	NW
23	50	33	42	-1	23	0	0.00	0.0	0	12.7	21	28			0		32	NW
24	46	21	34	-9	31	0	0.00	0.0	0	8.4	13	20			0		18	SW
25	55	32	44	2	21	0	0.00	0.0	0	7.3	12	20			9		16	SW
26	52	28	40	-2	25	0	0.00	0.0	0	5.7	12	31			6		17	NW
27	39	29	34	-8	31	0	0.52	T	0	6.7	09	33			10	1,4	15	NE
28	58	36	47	6	18	0	T	0.0	0	9.9	16	20			10	1	28	SW
29	56	28	42	1	23	0	0.00	0.0	0	6.2	10	20			9		15	S
30	52	26	39	-1	26	0	0.00	0.0	0	6.3	15	31			1		22	NW
Sum	1847	1096			474	4	1.86	T		223.2					183			
Avg	61.6	36.5								7.4	Fast	Dir.	Psbl	%	6.1		Max	(mph)
								Misc -------->			210	28	18124				033	NW

Notes:
Last of several occurrences
Column 9 readings are taken at 0700
Column 17 Peak Wind in M.P.H.

Figure 5-1. Daily Average Weather Report for November 1994.

Preliminary Local Climatological Data (WS Form: F-6), Page 2

Station: WSCMO, WASH-DULLES, WASH, DC
Month: NOV
Year: 1994

[Temperature Data]

Average Monthly: 49.1
Departure from Normal: +3.7
Highest: 78 on 4 , 6 , 9
Lowest: 21 on 24

[No. of Days with]

Max 32 or below: 0
Max 90 or above: 0
Min 32 or below: 10
Min 0 or below: 0

[Heating Degree Days (Base 65)]

Total this Month: 474
Departure from Normal: -114
Seasonal Total: 844
Departure from Normal: -107

[Cooling Degree Days (Base 65)]
Total this Month: 4
Departure from Normal: +4
Seasonal Total: 1266
Departure from Normal: +293

[Precipitation Data]

Total for Month: 1.86
Departure from Normal: -1.44
Greatest in 24 hrs. 0.52 on 27

SNOWFALL, ICE PELLETS, HAIL
Total for month: T inches
Greatest snowfall in 24 hrs: T on 27
Greatest snow depth: on

[WEATHER - No. of Days with]

0.01 inch or more Precip: 8
0.10 inch or more Precip: 5
0.50 inch or more Precip: 2
1.00 inch or more Precip: 0

Clear (scale 0-3) 10
Partly Cloudy (scale 4-7) 6
Cloudy (scale 8-10) 14

[Pressure Data]
Highest Sea-Level 30.50 in. on 27
Lowest Sea-Level 29.32 in. on 1

SYMBOLS USED IN COLUMN 16

1 = FOG
2 = FOG REDUCING VISIBILITY TO 1/4 MILE OR LESS
3 = THUNDER
4 = ICE PELLETS
5 = HAIL
6 = GLAZE OR RIME
7 = BLOWING DUST OR BLOWING SAND REDUCING VISIBILITY TO 1/2 MILE OR LESS
8 = SMOKE OR HAZE
9 = BLOWING SNOW
X = TORNADO

M a x i m u m   P r e c i p i t a t i o n
(Delta T) (Minutes)
Precipitation (Inches)
Ended Date
Time
RECORDS// HI OF 77 ON 5TH TIED 77/1975//NEW HI OF 78 ON 6TH
BEAT OLD 73/1975//HI OF 78 ON 9TH BROKE OLD 75/1975//LO OF
59 ON 6TH TIED OLD 59/1977

==

Figure 5-2. Monthly Average Weather Report for November 1994.

Surface Weather Observations - - HDR72403IAD 9411
11/23/94 MF1-10B

0050	29.870	38.0	7	2AC	120	6CI	250	7					6 6
0151	29.880	36.0	2	1AC	120	1CI	250	2					1
0250	29.890	34.0	0	0CI	250								0
0351	29.880	34.0	0										0 0
0451	29.870	34.0	0										0
0550	29.860	33.0	0	0AC	120								0
0650	29.860	35.0	0	0AC	120								0 6
0750	29.860	37.0	0	0AC	120								0
0851	29.850	40.0	0	0AC	120								0
0951	29.830	43.0	0	0AC	120								0 8
1050	29.790	46.0	0	0AC	120								0
1151	29.740	48.0	0	0AC	120								0
1250	29.720	49.0	0	0AC	120	0CI	250	0					0 6
1351	29.680	50.0	0	0AC	120								0
1451	29.660	49.0	0	0AC	120								0
1551	29.665	48.0	0	0AC	120								0 5
1652	29.690	44.0	2	2AC	70								2
1750	29.730	41.0	3	2AC	70	1AC	100	3					3
1850	29.750	41.0	0	0AC	100								0 1
1951	29.785	40.0	5	5AC	100								5
2050	29.800	40.0	10	1SC	45	5AC	70	6	4AC	120	10		10
2151	29.835	36.0	10	2SC	45	6AC	70	8	2AC	110	10		10 2
2250	29.855	34.0	3	3AC	80								3
2350	29.800	33.0	10	10AC	70								10

Synoptic Observations

MID1	0.00	.0		39	38		
0048	0.00	.0	0	43	38	29.880	-.010
0648	0.00	.0	0	38	33	29.870	-.010
1248	0.00	.0	0	50	35	29.725	-.005
1849	0.00	.0	0	50	41	29.760	-.010
MID2	0.00	.0	0	41	33		

Summary of Day (midnight to midnight)

Max Temp	Min Temp	Precip (Ins.)	Snow Fall	Snow Depth	[Peak Wind] Speed/Dir Time	Sky Cover s/s	Sky Cover m/m	Water Equiv.	Fastest Wind
50	33	00.00	.0	0	28NW 2051	0	2		21 28 1351

Sunrise: 0701 Sunset: 1651 Total Sunshine: % Psbl: Character of Sunrise/Sunset:

Weather & Obstructions to Vision

Remarks, Notes and Miscellaneous Phenomena

TIME CHECK== 0039 // SP=00 RS=00//

Figure 5-3. Hourly Weather Report for 23 November 1994.

```
Surface Weather Observations - - HDR72403IAD 9411
11/23/94              MF1-10A

-------------------------------------------------------------------------------------------

SA 0050 120 SCT E250 BKN 20 235/38/14/3114/022/ 610 1071 57 (JTS 05:56Z)
SY 72403 32980 63114 10033 21100 30115 40235 56010 82071 333 10139 20033 555 92306= (JTS05:57Z)

SA 0151 120 SCT 250 -SCT 20 239/36/14/3100/023 (JTS 06:54Z)
SA 0250 CLR 20 242/34/13/3007/024/FEW CI (JTS 07:52Z)
SA 0351 CLR 20 239/34/13/2808/023/ 003 (JTS 08:53Z)
SA 0451 CLR 20 236/34/12/2809/022 (JTS 09:53Z)
SA 0550 CLR 20 233/33/10/2809/021/FEW AC E (JTS 10:52Z)
SA 0650 CLR 25 233/35/5/2810/021/ 607 1070 33 (JTS 11:54Z)
SY 72403 32982 12810 10017 21150 30112 40233 56007 81070 333 10139 20006 555 92312= (JTS11:55Z)

SA 0750 CLR 30 233/37/3/2709/021/FEW AC S (JTS 12:55Z)
SA 0851 CLR 30 230/40/2/2309/020/AC SE-SW (RJR 13:53Z)
SA 0951 CLR 30 223/43/3/2911/018/ 810 1070 (RJR 14:53Z)
SA 1050 CLR 30 209/46/3/2613/014/AC SE-S (RJR 15:52Z)
SA 1151 CLR 30 191/48/2/2712/009/AC SE-S (RJR 16:52Z)
SA 1250 CLR 30 184/49/-3/2916G26/007/ 637 1071 33 (RJR 17:53Z)
SY 72403 32983 12916 10094 21194 30064 40184 56037 81071 333 10100 20006 555 92318= (RJR17:54Z)

SA 1351 CLR 30 171/50/-1/2818G24/003/FEW AC S (RJR 18:53Z)
SA 1451 CLR 30 164/49/-1/2615G25/001/FEW AC N (RJR 19:52Z)
SA 1551 CLR 30 166/48/1/2913G25/002/FEW AC N/ 519 1070 (EW 20:54Z)
SA 1652 70 SCT 30 175/44/6/3212G24/004 (EW 21:55Z)
SA 1750 70 SCT 100 SCT 25 189/41/9/3110/008 (EW 22:52Z)
SA 1850 CLR 25 196/41/13/3112/010/FEW AC/ 129 1070 50 (EW 23:52Z)
SY 72403 32982 13112 10050 21106 30075 40196 51029 81070 333 10100 20006 555 92400= (EW23:55Z)

SA 1951 100 SCT 25 208/40/18/3110/014 (EW 00:53Z)
SA 2050 45 SCT M70 BKN 120 OVC 20 213/40/18/3112/015 (EW 01:53Z)
SA 2151 45 SCT M70 BKN 110 OVC 20 225/36/26/3311/019/VIRGA OVHD/ 229 157/ (EW 02:56Z)
SA 2250 80 SCT 20 231/34/24/3506/021 (EW 03:52Z)
SA 2350 M70 OVC 20 240/33/17/3310/023/BINOVC (JTS 04:56Z)
```

Figure 5-3. Hourly Weather Report for 23 November 1994 (Concluded).

Table 5-1

Dates of Available Radar Coverage and Data File Sizes

Date	Size (MB)	Date	Size (MB)	Date	Size (MB)
20 Oct 94	9.7	1 Nov 94	8.0	1 Dec 94	6.7
23 Oct	8.2	5 Nov	9.6	4 Dec	7.3
24 Oct	10.6	9 Nov	9.0	5 Dec	7.9
25 Oct	10.3	10 Nov	10.5	6 Dec	3.0
26 Oct	10.3	26 Nov	10.0	7 Dec	9.5
27 Oct	11.3			8 Dec	9.9
28 Oct	11.2			11 Dec	7.0
29 Oct	9.7			12 Dec	9.3
30 Oct	6.2			13 Dec	9.6
31 Oct	2.7			14 Dec	8.3

Radar tracking data was pre-screened by the FAA at the Dulles Tower, and only "approved" flight tracks and interfacility messages were provided to Wyle Laboratories. A sample ASCII tabular listing of a flight track, processed and linked with its interfacility messages, is given in Figure 5-4. ARTS data processing is described in Section 5.2.

Flight Schedule Data

The *Official Airline Guide* (*OAG*) for the measurement period was used in conjunction with the filed flight plans in the ARTS system to determine the aircraft destination and stage length. This additional equipment type and scheduling information was necessary for the creation of INM input decks.

Fleet Summaries

Statistical data regarding the fleet mixes and specific airframe and engine models aided the selection of the most appropriate INM noise curve for a specific flight track.[11] The airframe descriptors contained in the ARTS IF feed often did not contain specific enough model designators. When necessary, the FedEx Fleet Summary reports were consulted to guide the selection of a "likely" airframe/engine combination. This airframe/engine uncertainty may perhaps be responsible for a portion of the predicted versus measured SEL discrepancies, and its possible impact is quantified in Section 6.

```
*  UAL1554    B727          7060      Departure 1L     1750 (sched)
*
*17:40:28.313  ZCW2240745  FP 686UAL1554 IADT/B727 7060 SWA P2250 270      $0
*18:09:51.938  IAD2310820  DM 686 2310
*18:14:20.648  IAD2314042  TB 686    07
*
```

* Time	Trk	ACID	Beac	X (nm)	Y (nm)	Z (fl)	S (nm)	V (kts)	A (g)
18:09:34.203	143		7060	.2500	.3750	6	1.464	161.257	.03128
18:09:38.828	143	7060	7060	.2500	.5625	8	1.652	164.015	.03128
18:09:43.266	143	7060	7060	.3125	.7500	10	1.849	166.662	.03128
18:09:47.945	143	7060	7060	.3750	1.1250	12	2.230	169.456	.03128
18:09:52.516	143	UAL1554	7060	.3750	1.2500	13	2.355	172.178	.03128
18:09:57.133	143	UAL1554	7060	.4375	1.3750	14	2.494	174.936	.03128
18:10:01.695	143	UAL1554	7060	.4375	1.6250	15	2.744	179.358	.05439
18:10:06.320	143	UAL1554	7060	.5000	1.8750	15	3.002	185.118	.10281
18:10:10.953	143	UAL1554	7060	.5000	2.0625	16	3.190	189.509	.14235
18:10:15.570	143	UAL1554	7060	.5000	2.3125	17	3.440	199.301	.08599
18:10:20.148	143	UAL1554	7060	.5625	2.6250	19	3.758	204.729	.03496
18:10:24.758	143	UAL1554	7060	.5625	2.8750	21	4.008	207.999	.03132
18:10:29.227	143	UAL1554	7060	.5625	3.1875	24	4.321	210.244	.00973
18:10:33.828	143	UAL1554	7060	.5625	3.4375	26	4.571	214.250	-.00483
18:10:38.453	143	UAL1554	7060	.5625	3.6875	29	4.821	214.076	-.00366
18:10:43.109	143	UAL1554	7060	.5625	3.9375	32	5.071	214.191	.02418
18:10:47.688	143	UAL1554	7060	.5625	4.2500	34	5.383	214.940	.01959
18:10:52.320	143	UAL1554	7060	.5625	4.5000	37	5.633	216.166	.03614
18:10:56.945	143	UAL1554	7060	.6250	4.8125	39	5.952	220.207	.03345
18:11:01.539	143	UAL1554	7060	.6250	5.0625	41	6.202	224.259	.03285
18:11:06.141	143	UAL1554	7060	.6250	5.3750	43	6.514	227.838	.03683
18:11:10.766	143	UAL1554	7060	.6250	5.6250	45	6.764	230.288	.04880
18:11:15.336	143	UAL1554	7060	.6250	5.9375	47	7.077	231.795	.02214
18:11:19.977	143	UAL1554	7060	.6250	6.2500	49	7.389	232.514	.01701
18:11:24.578	143	UAL1554	7060	.6250	6.5625	52	7.702	234.668	.00079
18:11:29.172	143	UAL1554	7060	.6250	6.8750	55	8.014	233.200	-.01922
18:11:33.828	143	UAL1554	7060	.6250	7.1875	58	8.327	233.183	-.03405
18:11:38.453	143	UAL1554	7060	.6250	7.4375	62	8.577	231.853	-.01841
18:11:43.008	143	UAL1554	7060	.6250	7.7500	65	8.889	231.761	.00296

Figure 5-4.   Partial Flight Track Listing, B727 Departure.

Measurements

Larson-Davis Model 870 unmanned noise monitoring stations recorded noise events around the clock (see Section 3). Available data include event time-histories, hourly intervals, and a variety of noise metrics.

INM's Empirical Database

Although the ability to change aircraft source-noise data exists in INM, no measurements were made at or near the FAR Part 36[7] measurement locations, due to site access limitations. The standard SEL tables as given in the INM database were used as is.

5.2 ARTS IIIA Data Analysis

Fifteen days of ARTS radar data, for which acceptable weather conditions and complete tracking data were available, were converted into NDADS[11] binary file format. The NDADS program, developed by Wyle Laboratories for the United States Air Force, allows user-enhanced automated generation of flight tracks and profiles and outputs them in INM-compatible format. NDADS was used to separate tracks by aircraft, runway usage, and operation type.

Criteria were established to select ten final data subsets, with a subset defined as a group of operations containing the same aircraft type, stage length, operation type, and runway utilization with similar flight tracks. A description of the selection criteria and the final subset data (which included operations from 12 of the 15 good days) is given later in this chapter. Once the ten subsets were finalized, each flight track was correlated with the noise events at the applicable monitoring sites and modeled in NDADS. The resultant flight tracks, flight profiles, and velocity profiles were exported, and the noise impact was calculated using INM 4.11. Flight track dispersion for each data subset determined the exact track and profile modeling technique used, and the modeling technique did vary from subset to subset.

Raw ARTS data was processed into NDADS format, by separating the raw radar sweep time-ordered data into individual tracks, and linking them with the beacon code indexed track information from the separate IF data files. These IF files include flight plans, departure, arrival and overflight messages, first fix heading, schedule data, equipment codes, and beacon and track identifiers. The sample data shown in Figure 5-4 is an intermediate file format, between the (unprintable) raw binary ARTS data, and the final NDADS direct access format. It has already been assembled into a continuous flight track and cross-referenced with the IF data. Given the close proximity of Dulles with Washington National Airport, and the overlapping radar coverage, aircraft departing from or heading towards National were frequently picked up by the IAD radar system. The interfacility messages were indispensable for separating these overflights from IAD traffic.

Once the available ARTS data was assembled, NDADS was used to categorize and separate it into various subsets of the operations occurring on the 12 days listed in Table 5-2. Each subset consisted of operations (radar tracks) containing: one airframe type, one stage length, same operation type utilizing the same runway and similar flight tracks. At this point, weather data and stage length was taken into consideration. Subsets of data were further screened and operations during time periods for which winds exceed 10 knots, or measurable precipitation occurred, were deleted. Subsets containing departures were separated by trip length, as categorized by the INM stage lengths.

Table 5-2

Final Subset Analysis Dates

Date		
24 October 1994	9 November 1994	1 December
25 October	10 November	13 December
	11 November	14 December
	12 November	
	13 November	
	14 November	
	26 November	

The following criteria were used for identifying the final 10 subsets:

- Minimum of four different aircraft types
- Twin, Tri, and Four-Engine aircraft types
- Stage 2 and 3 aircraft
- Short, medium, and long range
- Similar flight tracks within a dataset
- Curved and Straight flight tracks
- Both departing and arriving operations
- All operations within a subset utilizing the same runway
- Statistically significant number of correlated noise events

The *OAG* was used to identify by flight number the aircraft destinations. Based on Table 5-3, taken from the INM manual Users Guide,[13] stage or trip length was then determined. Aircraft type was also contained in the ARTS IF Messages; however, specific models and engine configurations were often not identified. Based on the air carrier's feet mix, as described in the Fleet Summary manuals,[11] the most likely airframe/engine combination was selected. Appendix A characterizes each of the ten subsets. Included is carrier and fleet ownership information, airframe/engine combinations, flight track description, fleet age, and other pertinent data used in the INM modeling. There is some uncertainty in the equipment selection because actual equipment usage is unknown, and all combinations of airframe/engine types are not contained within the INM noise and profile database. Section 6 quantifies the impact of these approximations.

Table 5-3

INM Stage Length Definitions

Distance	Stage Length
0–500	1
500–1,000	2
1,000–1,500	3
1,500–2,500	4
2,500–3,500	5
3,500–4,500	6
4,500 and Greater	7

Within each subset, flight tracks were plotted (Figures 5-5 and 5-6), and track proximity to measurement site factors were calculated. These track proximity factors included, time, altitude, slant range, velocity, and elevation angle. Based on these and field observations, the exceedance reports were screened, and individual exceedances due to the actual flights were identified.

Table 5-4 summarizes the final ten subsets upon which INM accuracy sensitivity studies were performed. The final tracking data identifiers, proximity factors, and exceedance data were entered into a database, organized by subset and by measurement site (see Appendix B).

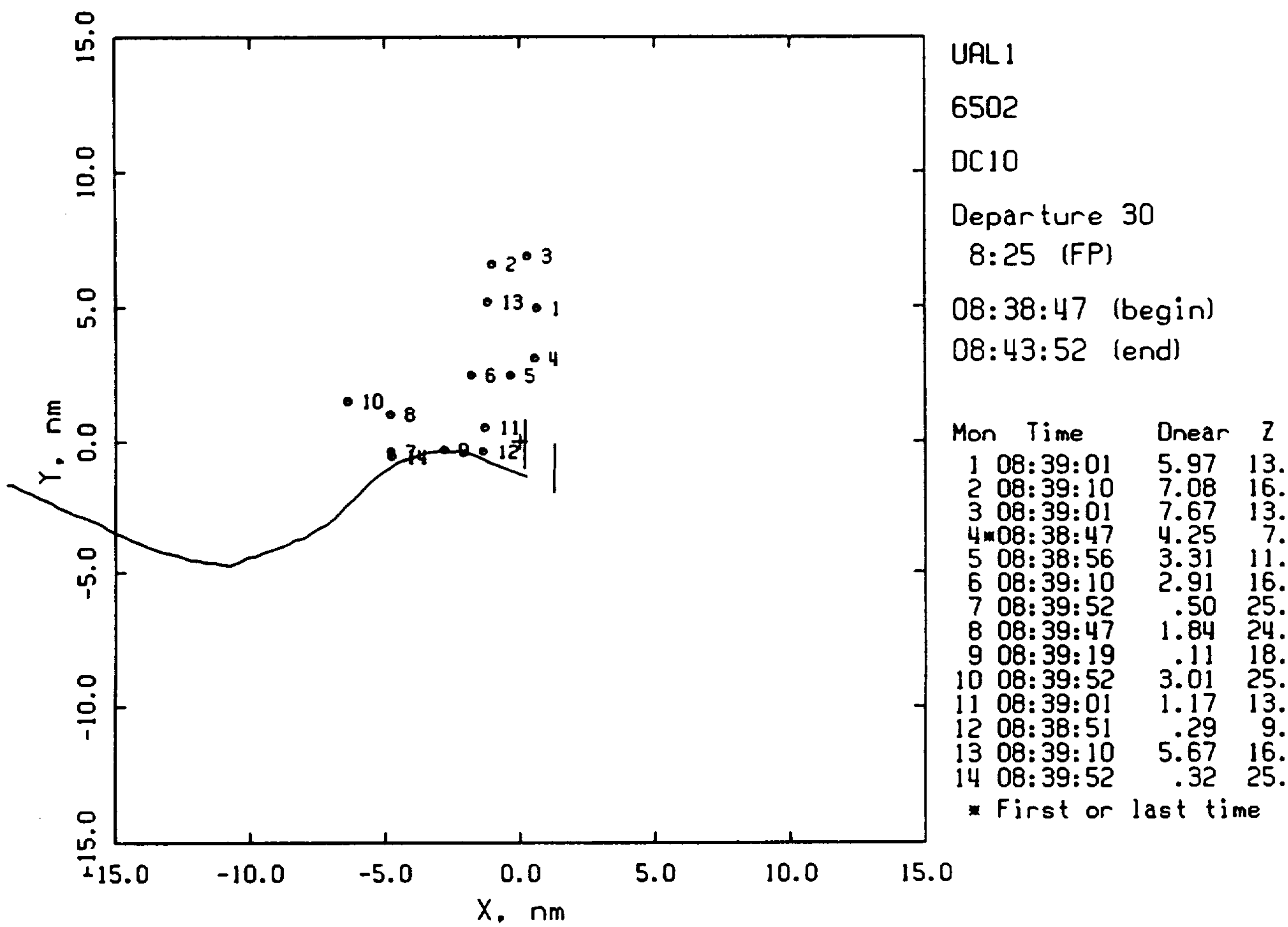


Figure 5-5. Sample Flight Track, DC-10 Departure.

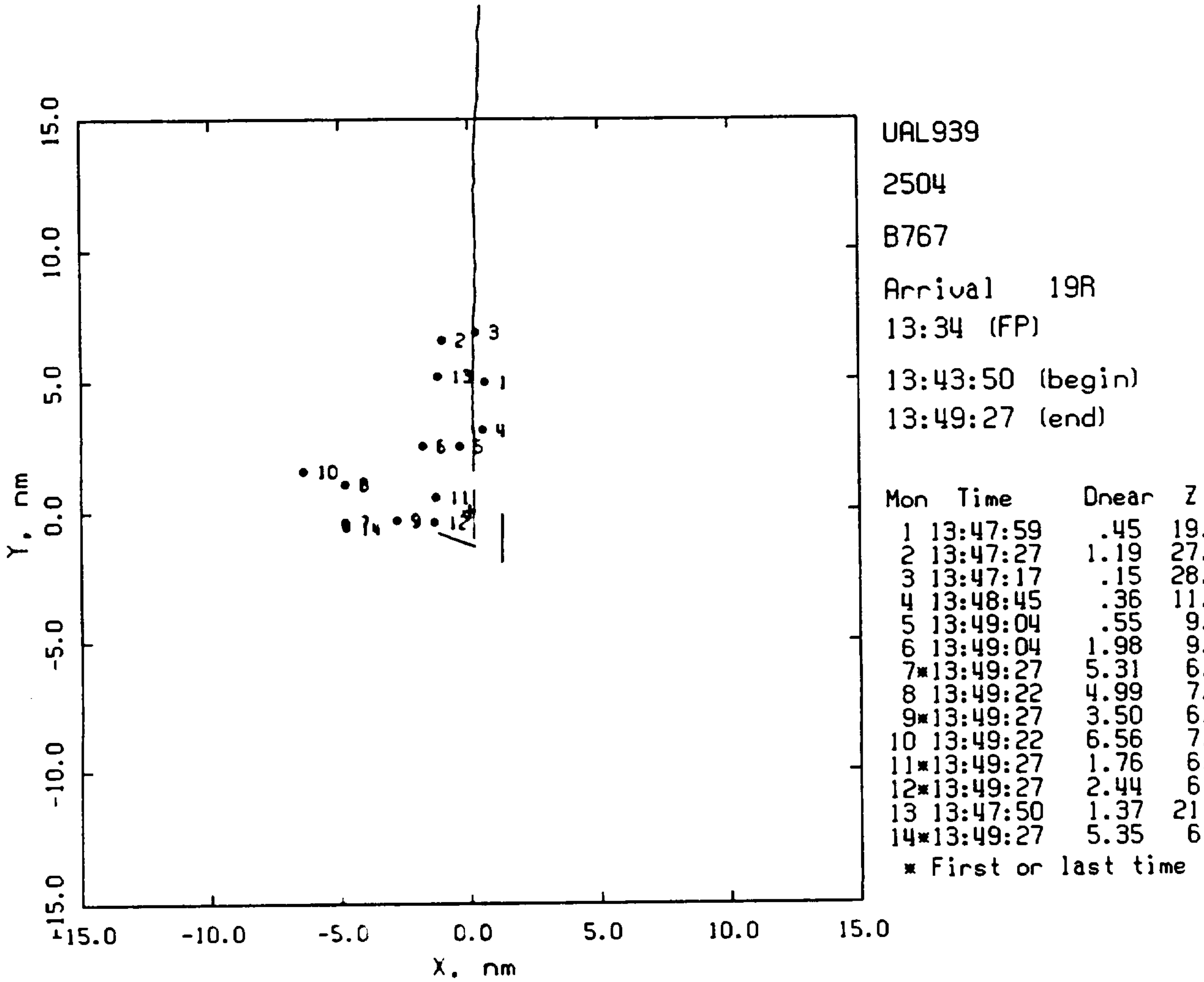


Figure 5-6. Sample Flight Track, B-767 Arrival.

Table 5-4

Final Subsets for Sensitivity Studies

Subset No.	Aircraft Type	No. Engines	Stage Length	Operation	No. Events
1	B727	3	n/a	Arrival	30
2	B727	3	1	Departure	39
3	B747	4	n/a	Arrival	31
4	B757	2	n/a	Arrival	25
5	B767	2	n/a	Arrival	44
6	B767	2	5	Departure	35
7	DC9	2	n/a	Arrival	44
8	DC9	2	1	Departure	43
9	DC10	3	n/a	Arrival	33
10	DC10	3	4	Departure	18

5.3 Correlation With Noise Events

Each individual flight track was correlated with exceedance records at applicable noise monitoring sites. Comparing the internal LD-820 meter clock with the ARTS IIIA radar time, potential correlations were identified. Further analysis of the event levels, duration, and time-history at each site confirmed positive correlations. As noted earlier, periods of adverse weather were omitted from the analysis.

5.4 Flight Track and Profile Modeling

Flight tracks were viewed within the DISARTS[11] module of NDADS. A plot of all data contained in the final correlation analysis is given in Figure 5-7. Within NDADS nominal flight tracks for each operation were "drawn" on the screen using the mouse. Segments consisted of a series of straight and curved segments as required by INM. Special care was taken to ensure accurate spatial proximity in areas close to the noise monitors. Based on segmentation and algorithm segmentation modeling limits within INM, as few segments as possible were used to model the tracks. A discussion of segmentation modeling effects on noise predictions as they pertain to INM and NMAP is contained in Section 2. Nominal flight tracks and profiles were created based on the actual "as-flown" ARTS IIIA radar tracking data. A comparison of these nominal profiles with the INM database kernel standard profiles is given in this section, organized by aircraft type.

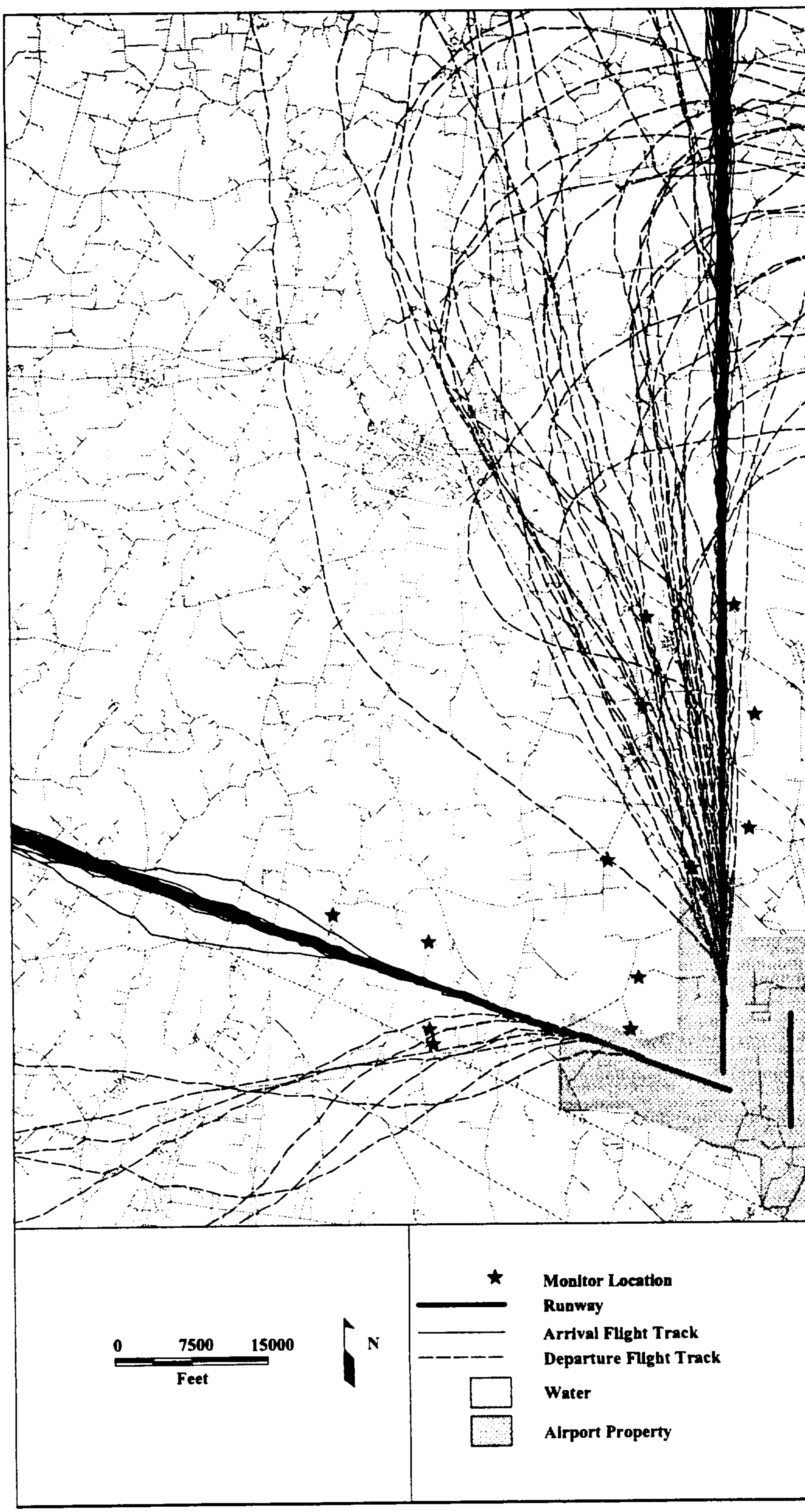


Figure 5-7

Sensitivity Analysis Flight Tracks All Aircraft and Operation Types

The specific airframe engine combination chosen from the INM database was determined by comparing the available equipment by individual operator. Detailed fleet information was obtained from Federal Express.[11] The IF data was used to obtain flight schedule data, including scheduled arrival or departure time, flight number, and operator identification. Typically the IF data also contained equipment usage; however, engine types and airframe series were not distinguished. The scheduled equipment, in more detailed form, was then obtained from the *Official Airline Guide*.[14,15,16]

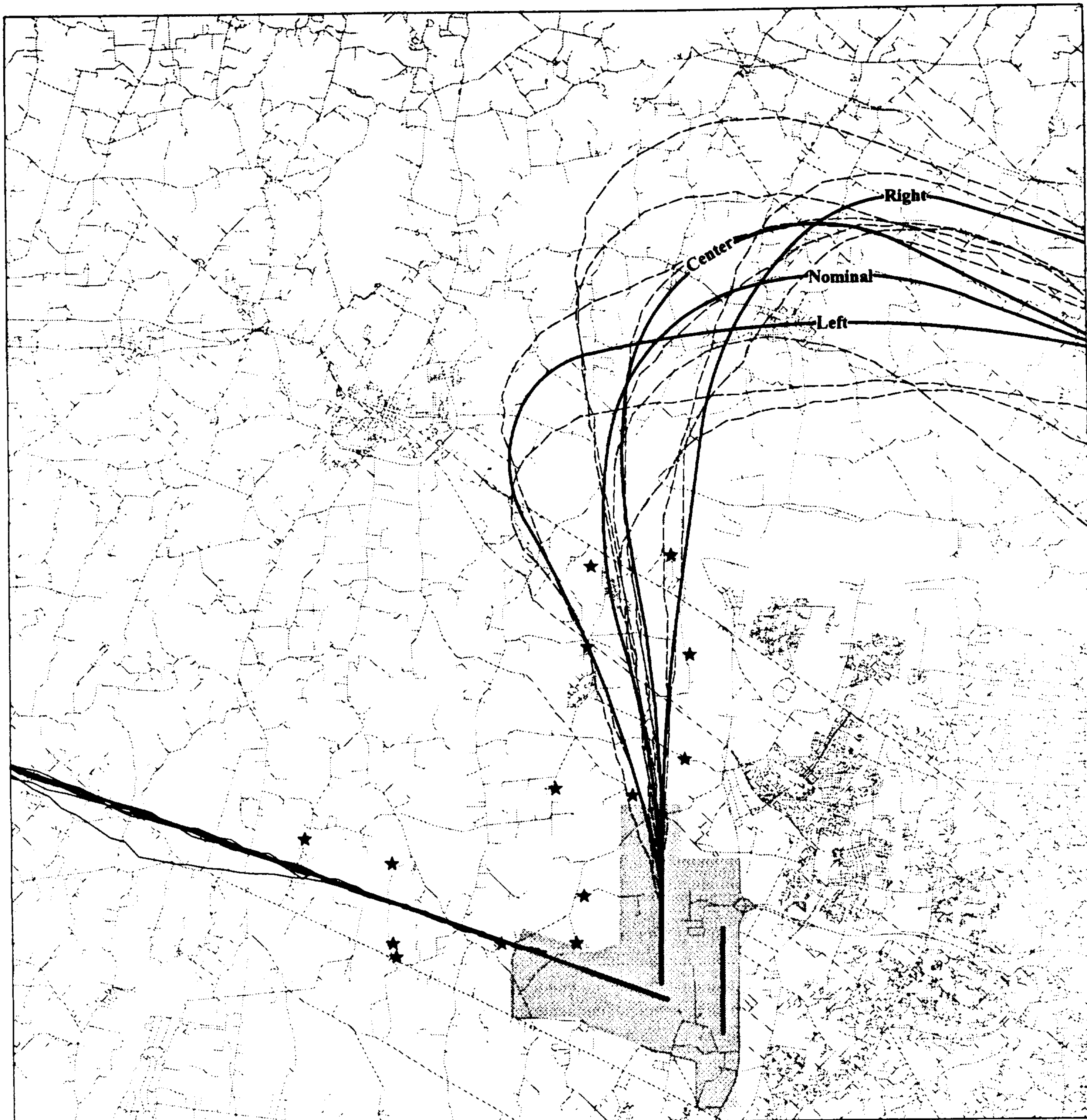
The modeling of operation type was treated on a case-by-case basis. A description by aircraft type follows.

5.4.1 B727 INM Modeling Method

Figure 5-8 contains B-727 arrival and departure flight tracks for which correlated noise monitoring station measurements were obtained.

Arrivals on Runway 12 were modeled with one nominal flight track, velocity profile, and power profile. A single nominal arrival track technique was used. As shown in Figures 5-9 and 5-10, the altitude and velocity profiles were chosen to as closely match the actual radar flight tracks as possible. Table 5-5 contains a comparison of the INM standard with the as-modeled nominal power profile. Powers are applied across the entire segment, with discrete, discontinuous power changes at the segment end points. Radar coverage was available above approximately 700 feet AGL. Below this altitude a transition was applied, and profiles were matched to the INM standard.

B-727 departures from Runway 01L were grouped into three sets of tracks, entitled left, center, and right. Figure 5-8 shows the actual tracks and the three INM modeled tracks. Modeling the B-727 departures as three separate nominal tracks provided a more accurate INM modeled flight track position, relative to the monitor locations, than would using just the one overall INM nominal flight track. Appendix B contains the nominal INM SEL predictions at the appropriate sites for both the "left", "right", and "center" nominal tracks as well as the single nominal track. Table 5-6, a subset of Appendix B, contains these results for B-727 departures at site #5. As can be seen, the mean SEL of 96.3 dB using the three-nominal-track approach is much closer to the actual measurement mean SEL of



0 7500 15000
Feet
N

———	Nominal Track
★	Monitor Location
━━━	Runway
———	Arrival Flight Track
– – –	Departure Flight Track
☐	Water
▒	Airport Property

Figure 5-8

B-727 ARTS and INM Arrivals and Departures

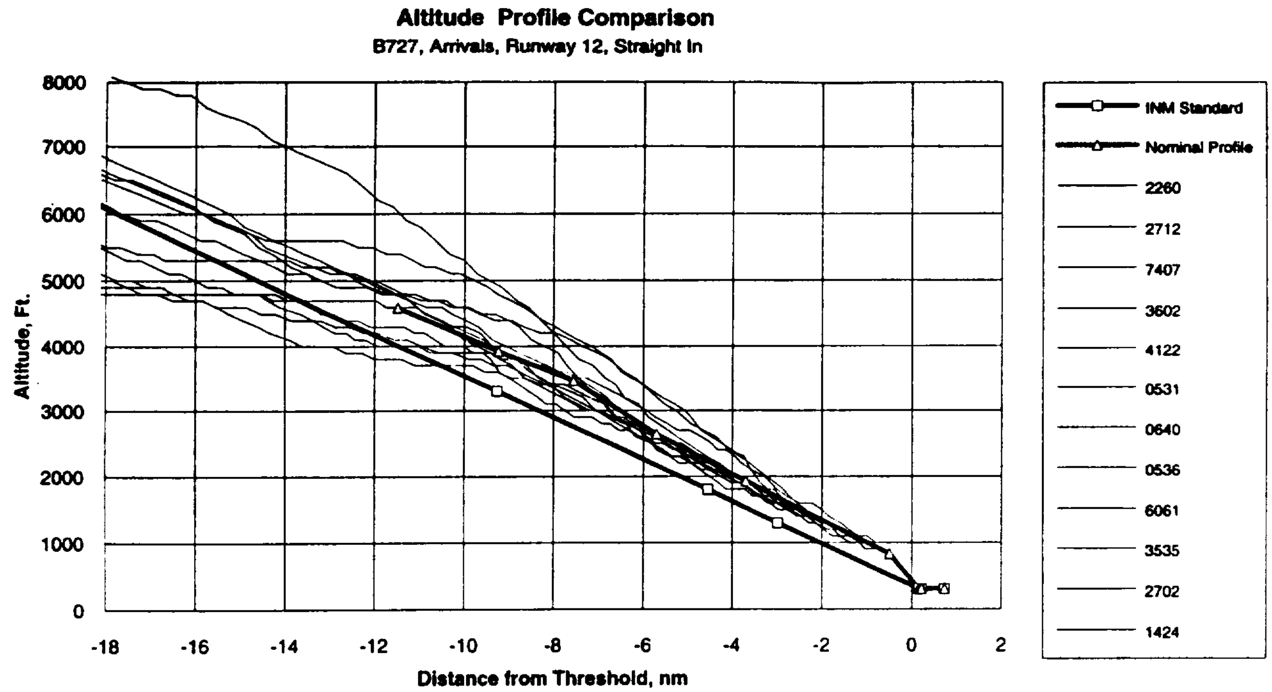


Figure 5-9. B-727 Altitude Profile, Arrivals.

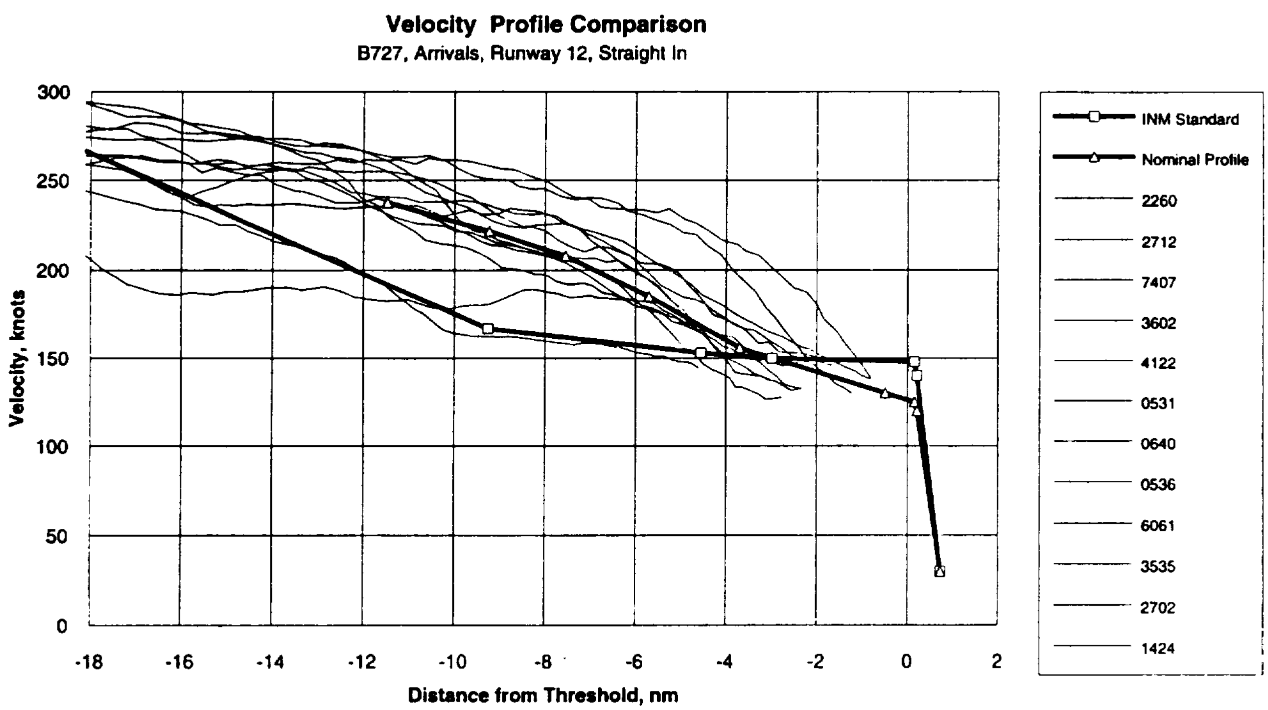


Figure 5-10. B-727 Velocity Profile, Arrivals.

96.7 dB than the single-nominal-track SEL prediction of 95.8 dB. The same holds true for the acoustical means, 97.0 dB three-track prediction versus 99.1 dB actual measurements versus 95.8 dB, single-track prediction.

Table 5-5

B-727 Arrival Power Profile Comparison

Segment No.	Nominal		INM Standard	
	Distance From Threshold	Thrust	Distance From Threshold	Thrust
	69,764		56,289	
1		2,495		2,495
	56,118		27,668	
2		2,495		
	45,885			
3		2,495		
	34,676			
4		3,144		3,144
	22,449		18,127	
5		4,682		4,855
	3,000			
6		4,682		4,855
	-954		-954	
7		4,682		4,682
	-1,302		-1,302	
8		9,300		9,300
	-4,430		-4,430	

Table 5-6

Modeling Technique Comparison for B727 Departures at Site #5

Site #5 Squawk	INM Three-Track Nominal SEL, dB	Measured SEL, dB	INM Single-Track Nominal SEL, dB
2467	96.0	99.6	95.8
6541	96.0	97.4	95.8
5560	96.0	97.0	95.8
2116	96.0	97.3	95.8
7060	96.0	92.3	95.8
6501	96.0	91.9	95.8
6516	100.3	101.5	95.8
0612	100.3	105.5	95.8
0571	93.4	92.2	95.8
7074	93.4	91.9	95.8
Mean	96.3	96.7	95.8
Std. Dev.	2.3	4.7	0.0
Acoust. Mean	97.0	99.1	95.8

Flight velocity and power profiles were treated similarly, using three separate INM models. Figure 5-11 shows the profiles for the ARTS IIIA flight profiles, the three INM nominal profiles, the single nominal INM profile, and the INM standard departure profile. The velocity and power profiles were treated similarly using the three separate INM analyses. Velocity profiles are shown in Figure 5-12.

5.4.2 B-747 INM Modeling Method

B-747 arrival flight tracks on Runway 19R are shown in Figure 5-13. Based on the fleet subset distribution given in Appendix A, INM aircraft #2 (727-200) was used in the INM analysis. A single nominal flight track, flight profile, velocity profile, and power profile was used. Appendix B tabulates the individual results, means, and standard deviations. Insufficient correlated noise events precluded analyzing 747 departures.

5.4.3 B-757 INM Modeling Technique

B-757 arrival flight tracks on Runway 12 were also modeled using one nominal track and profile set. These are shown in Figure 5-14, superimposed on the ARTS actual radar data for those flights with correlated noise measurements. Flight, velocity, and power profiles were treated as for the B-747, using INM aircraft #52 (B757-200 with Pratt & Whitney 2037 engines). Insufficient B-757 departures with matching stage lengths and correlated noise events existed for further sensitivity analyses.

5.4.4 B-767 INM Modeling Method

All Boeing 767s (Figure 5-15) were modeled in INM as B767-200 with JT9D-7R4D engines. This airframe/engine combination was determined by analyzing the fleet mix,[11] OAG,[14,15,16] and ARTS IIIA[10] IF messages. For both arrivals and departures, each individual flight track and profile was modeled separately, yielding no fewer than 10 arrival arrival and 14 departure INM input decks.

An initial nine arrival flight tracks were created in order to evaluate the sensitivity of SEL predictions at a given site with the SEL measurement. Table 5-7 describes the variation at site with arrival track and profile modeling.

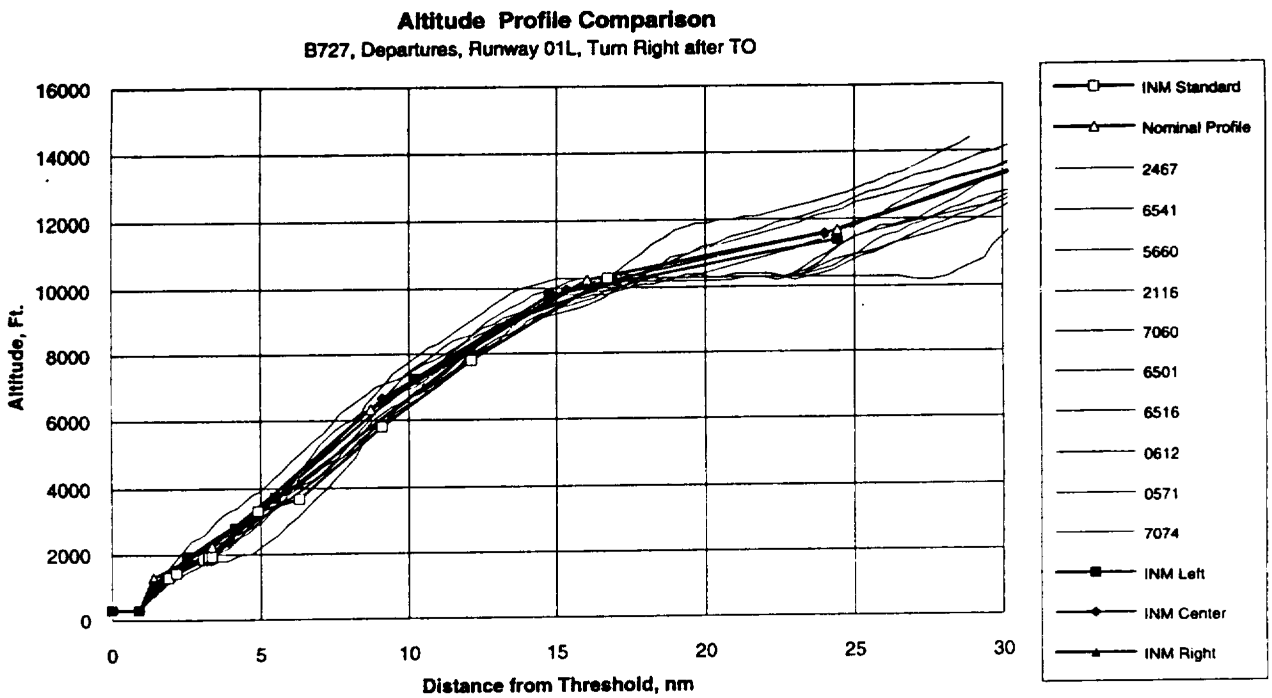


Figure 5-11. B-727 Altitude Profile, Departures.

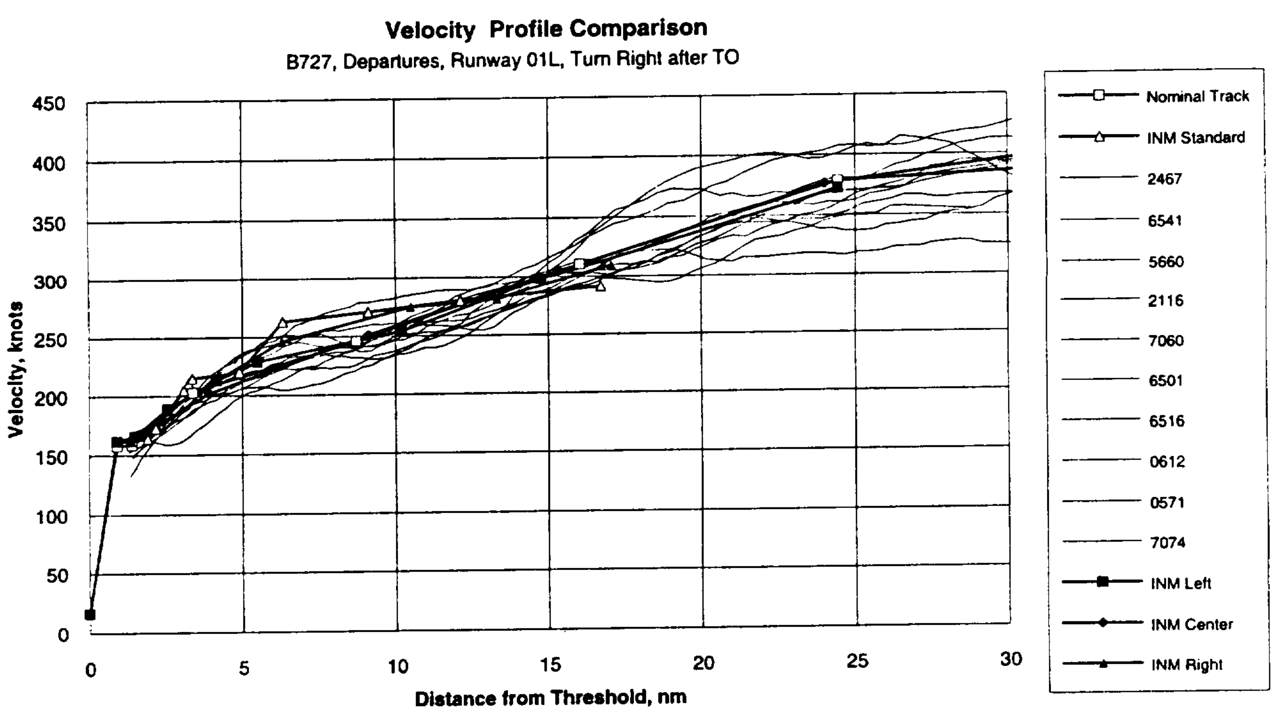


Figure 5-12. B-727 Velocity Profile, Departures.

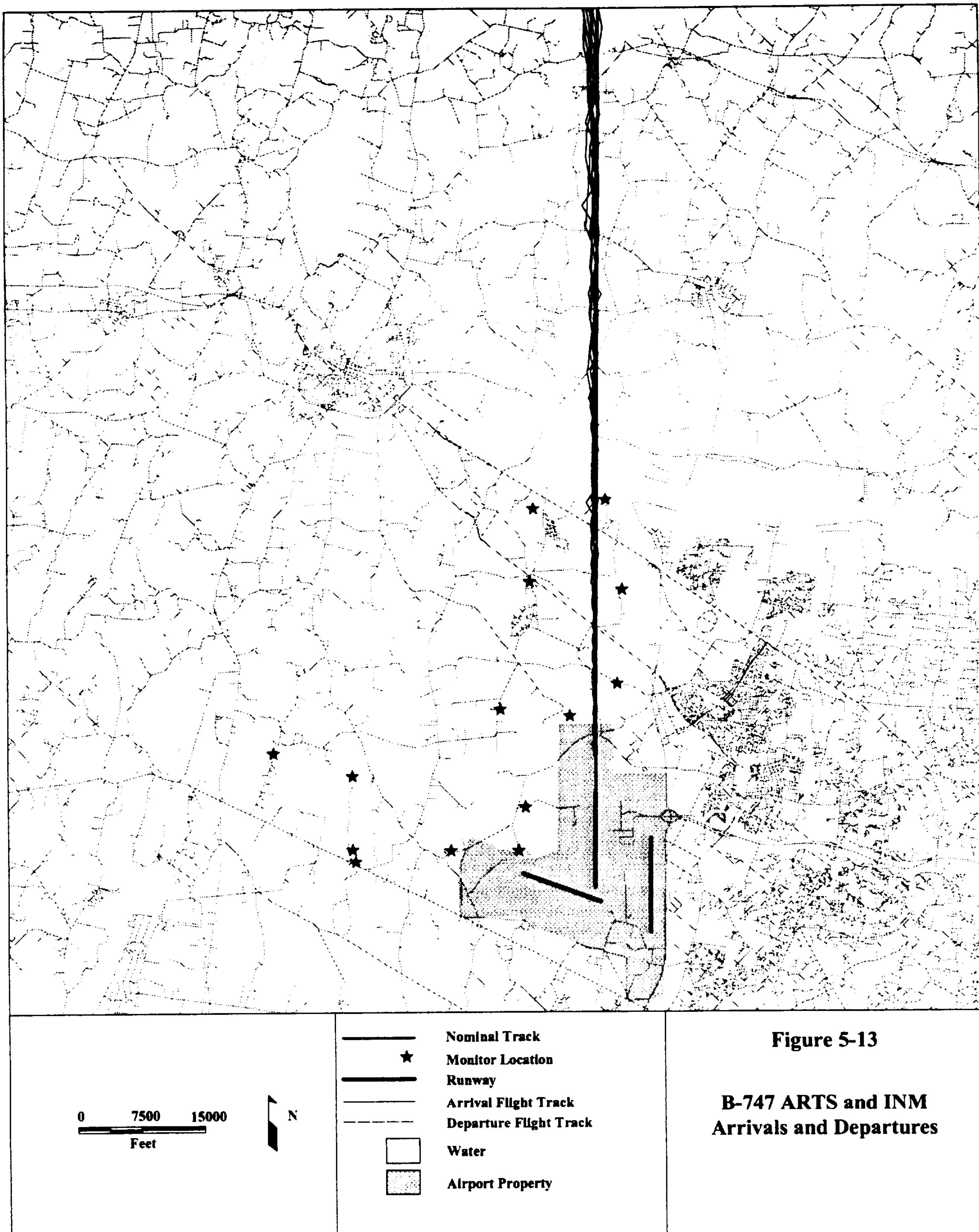


Figure 5-13

B-747 ARTS and INM Arrivals and Departures

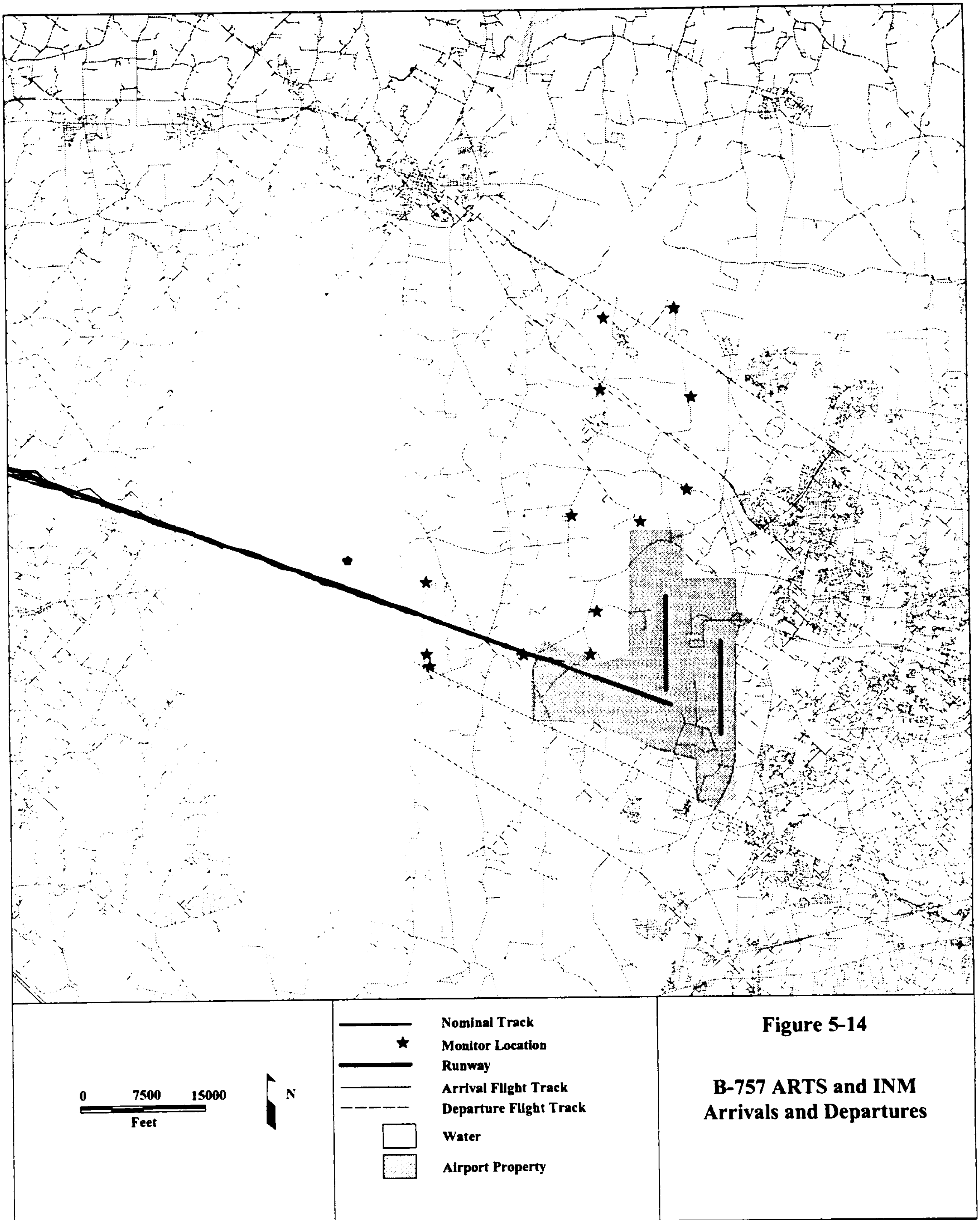


Figure 5-14

B-757 ARTS and INM Arrivals and Departures

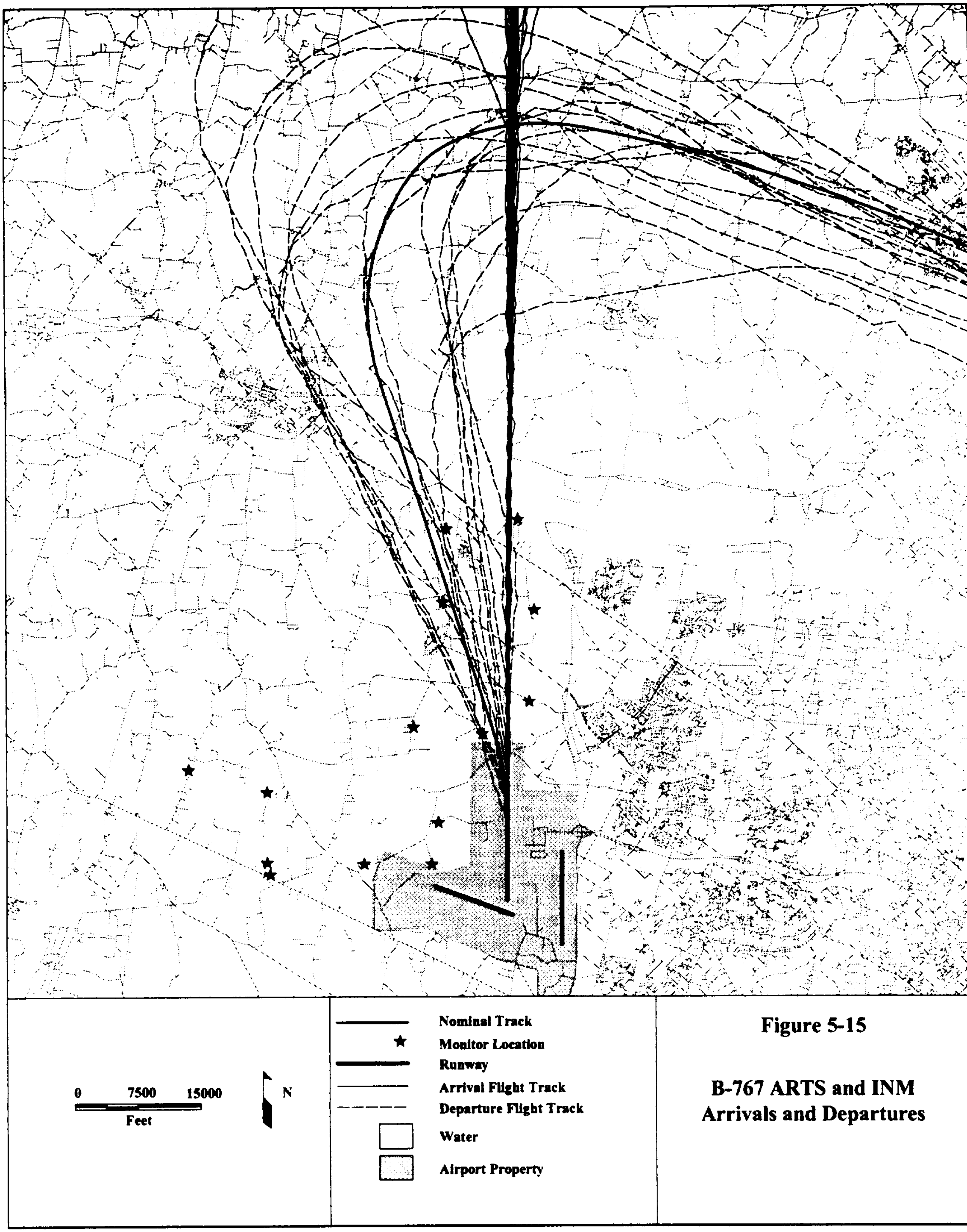


Figure 5-15

B-767 ARTS and INM Arrivals and Departures

Table 5-7

B-767 Approach Modeling Sensitivity:
Actual Versus Nominal, Site #1

Squawk	INM Actual SEL, dB	INM Nominal SEL, dB
7336	76.6	76.0
2416	76.1	76.0
7204	74.9	76.0
2556	76.1	76.0
6735	75.1	76.0
6761	75.3	76.0
0743	76.1	76.0
2367	74.4	76.0
0750	75.8	76.0
Mean	75.7	76.0
Acoust. Mean	75.7	76.0
Std. Dev.	0.7	0

Based on these first nine tracks, a standard deviation of less than 1 dB and a difference between the mean of the actual and the nominal track/profile of less than 0.5 dB, the nominal track and profile were used for the remaining 19 aircraft. The results of this modeling technique can be seen in Appendix B. Similar procedures were used in the development of altitude, velocity, and power profiles, both individual and nominal.

B-767 departures were also modeled both separately and as one nominal track/profile. Appendix B gives the results of both modeling approaches. The nominal track was created within the DISARTS[12] portion of NDADS by creating gates at various distances downtrack and calculating the mean gate penetration. The nominal track was then drawn by visually aligning the various straight and curved segments within one standard deviation of the mean penetration location. Mean track penetrations were considered both in the creation of the nominal tracks as well as the flight profile.

5.4.5 DC-9 INM Modeling Technique

Given the fleet mix of DC-9s with correlated noise measurements, aircraft #40 (DC9-30 with JT8D-9 engines) was used in INM. Appendix A describes the fleet mix used to arrive at this conclusion in more detail. DC-9 departures were modeled independently, whereas DC-9 arrivals were treated as one nominal case. Figure 5-16 shows the ARTS IIIA radar tracks, with the INM nominal tracks superimposed. The standard deviation of the individually modeled SEL prediction at

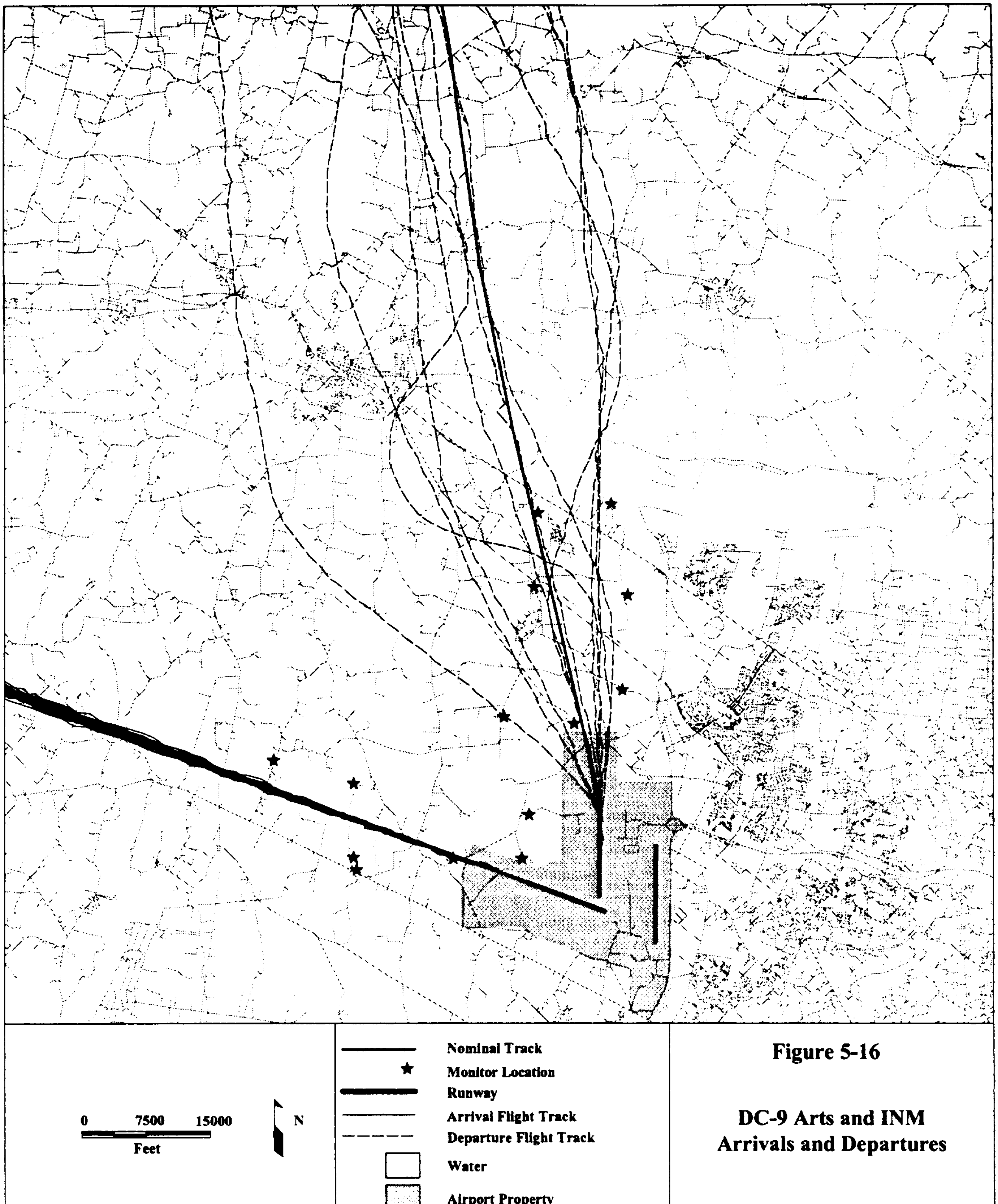


Figure 5-16

DC-9 Arts and INM Arrivals and Departures

site #5 was 2.8 dB. This small deviation indicated that the amount of track dispersion was perhaps small enough that departures could have been modeled as the single nominal track. It is interesting to note that although the acoustical mean value of the individual tracks, 91.5 dB SEL, was closer to the acoustical mean value of the measured exceedances, 90.2 dB SEL, than was that of the nominal track at 93.8 dB SEL, given a difference less than 3 dB the nominal track model would be justified in this case.

5.4.6 <u>DC-10 INM Modeling Technique</u>

Appendix A contains the individual fleet mix which yielded the decision to model correlated DC-10 tracks as INM aircraft #19 (DC10-10 with CF660 engines). Arrivals, with minimal track dispersion, were handled as one nominal track, shown in Figure 5-17.

Departures were grouped into two subsets entitled "over" and "left". These two tracks as well as the overall nominal track can also be seen in Figure 5-17. Appendix B quantifies the statistical differences between the two modeling approaches. In summary, considering site #9 as an example, the difference in the acoustical mean between the two-track and the nominal track versus the measurement was 0.5 dB SEL versus 2.0 dB SEL, respectively. Given the difference of only 0.5 dB SEL between the two-track method predicted and measured data, no further detailed track modeling was justified.

5.5 Profile Modeling

Based on ARTS IIIA radar data, altitude profiles were viewed within NDADS. Both actual and nominal profiles were developed for each data subset (Table 5-4). Standard power profiles, as provided by INM, were used to guide development of power profiles for each data subset. A table of power versus distance was obtained by comparing the nominal flight altitude with the standard altitude and applying the standard power setting for that attitude, at the nominal distance. This had the physical effect of applying a power setting which yields a similar climb rate with differences in weight affecting the level acceleration altitude, rather than the power setting. This approach was justified because altitude data was available, whereas performance maps and actual power settings were not. Recent studies indicate that errors in power of up to 20 percent (which is substantial) result in only a 2 to 3 dB error in noise level.[17]

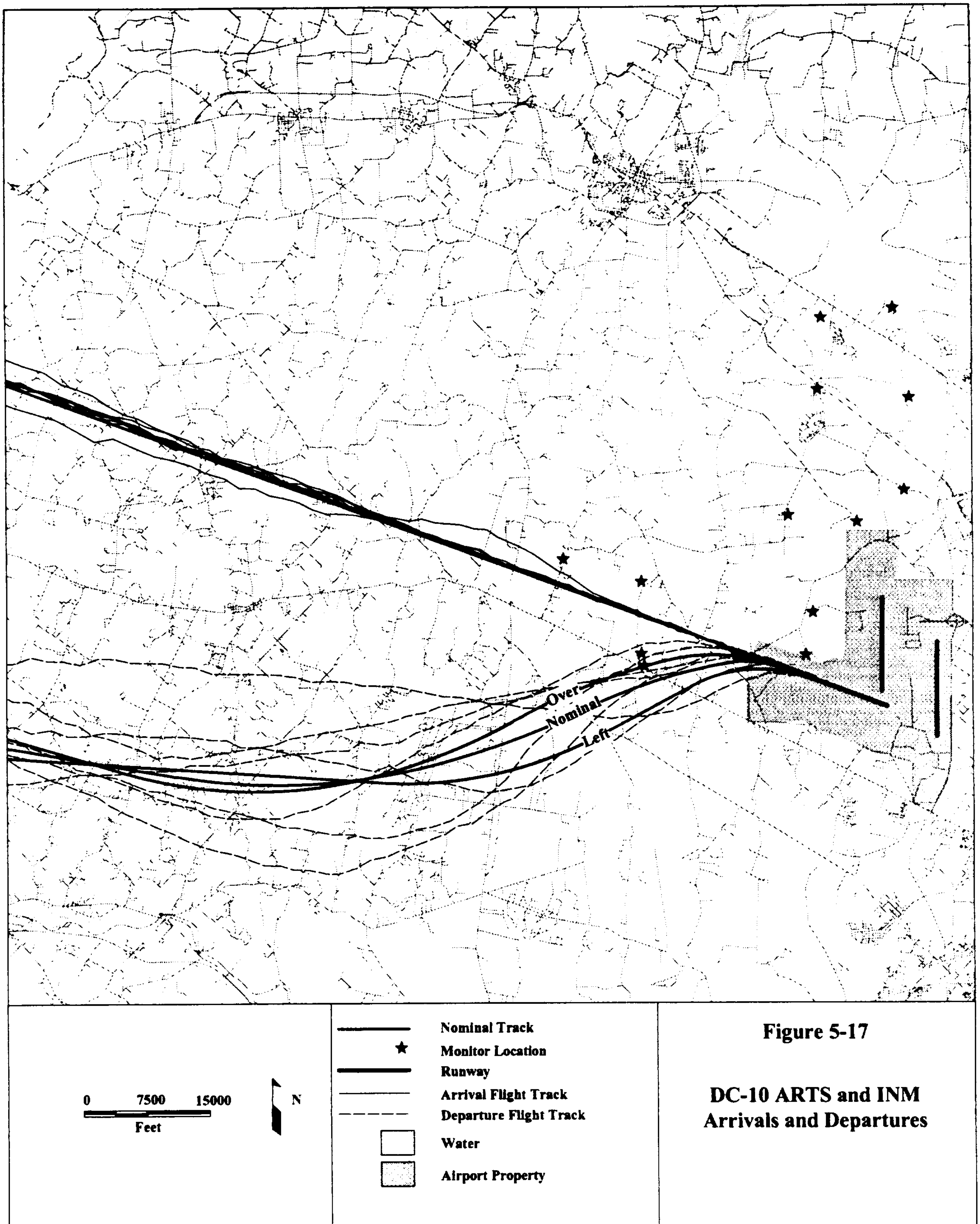


Figure 5-17

DC-10 ARTS and INM Arrivals and Departures

5.6 Statistical Analysis of Correlated Noise Events

A statistical analysis of the correlated noise events was carried out in order to determine if the difference between the SELs that were computed from the INM and those that were measured was a function of the position of the aircraft's flight path. To accomplish this, linear regressions of the form

$$y = a + bx$$

were calculated for the entire 342-element data set, where y, the dependent variable, is $SEL_{INM} - SEL_{meas}$ and x, the independent variable, is a measure of the position of the closest point of approach of the aircraft's flight track to the measurement position. In particular, analyses were done for the following independent variables:

- Altitude of the point of closest approach in kilofeet,
- Slant range of the point of closest approach in kilofeet, and
- Elevation angle of the point of closest approach in degrees.

In addition, two additional linear regressions were computed in which the independent variables were:

- Aircraft speed in miles per hour and
- Site distance from start of takeoff roll in kilofeet.

The results of these regression calculations are shown in Table 5-8.

Table 5-8

Linear Regressions of the Form:

$SEL_{INM} - SEL_{meas} = a + b^*$ (Independent Variable)

Independent Variable	Parameter a					Parameter b				
	Value	Std.Error	t-value*	95% Conf. Limits		Value	Std.Error	t-value*	95% Conf. Limits	
Altitude	1.257	0.424	2.964	0.423	2.091	-0.468	-0.176	-2.656	-0.815	-0.121
Slant Range	0.826	0.399	2.071	0.042	1.610	-0.142	0.089	-1.594	-0.318	0.033
Elevation Angle	1.046	0.500	2.093	0.063	2.030	-0.017	0.010	-1.668	-0.038	0.003
Aircraft Speed	3.226	1.132	2.849	0.999	5.453	-0.016	0.006	-2.633	-0.028	-0.004
Site Distance	1.762	0.461	3.819	0.855	2.669	-0.062	0.017	-3.615	-0.096	-0.028

* $t_{critical} = 1.970$

In all cases the dependence on the independent variable is small. In fact, a comparison of the calculated t-value with the critical t-value for 340 degrees of freedom shows that the difference in SELs is independent of slant range and elevation angle at the 95 percent level of confidence. Further, the regression does not vary by more than ±2 dB over the entire measurement range of each independent variable.

6.0 SENSITIVITY STUDY

INM analysis was conducted for 342 individual aircraft operations where ARTS IIIA radar data were correlated with noise measurements. A database (Appendix B) was created which contains predictions versus measurements for these correlated noise events. Sensitivity studies were performed in order to evaluate the effect of INM prediction accuracy on physical parameters. Figure 6-1 compares field measurements with INM predictions. The amount of data scatter, while unnerving at first sight, is consistent with that seen in earlier studies.[17] Deviations of ±10 dB are not uncommon.

A comparison of the Predicted—Measured SEL levels with the altitude of the closest point of approach to the noise monitor shows a slight sensitivity with altitude (Figure 6-2). Considering first a linear fit, INM underpredicts the individual event SEL for aircraft above 2,500 feet. Looking at the energy-average fit, however, INM appears to underpredict individual SEL levels across the entire range. The energy fit was obtained by performing a linear fit to the sound exposures (SE), where:

$$SE = 10^{\frac{SEL}{10}} \times (20\ \mu Pa)^2 - sec$$

SE fits were converted to decibels for comparison with SEL data and linear fits. Based on the energy fit, a trend of INM underprediction with increasing altitude is apparent when considering data scatter; however, these trends are only very slight.

INM prediction accuracy, based on a linear fit in the SEL domain, also seems to decrease with increasing slant range (Figure 6-3). Slant range is defined as the minimum straight-line distance between the monitoring site and the aircraft's position. However, based on fitting the data in the energy domain, this conclusion cannot be drawn.

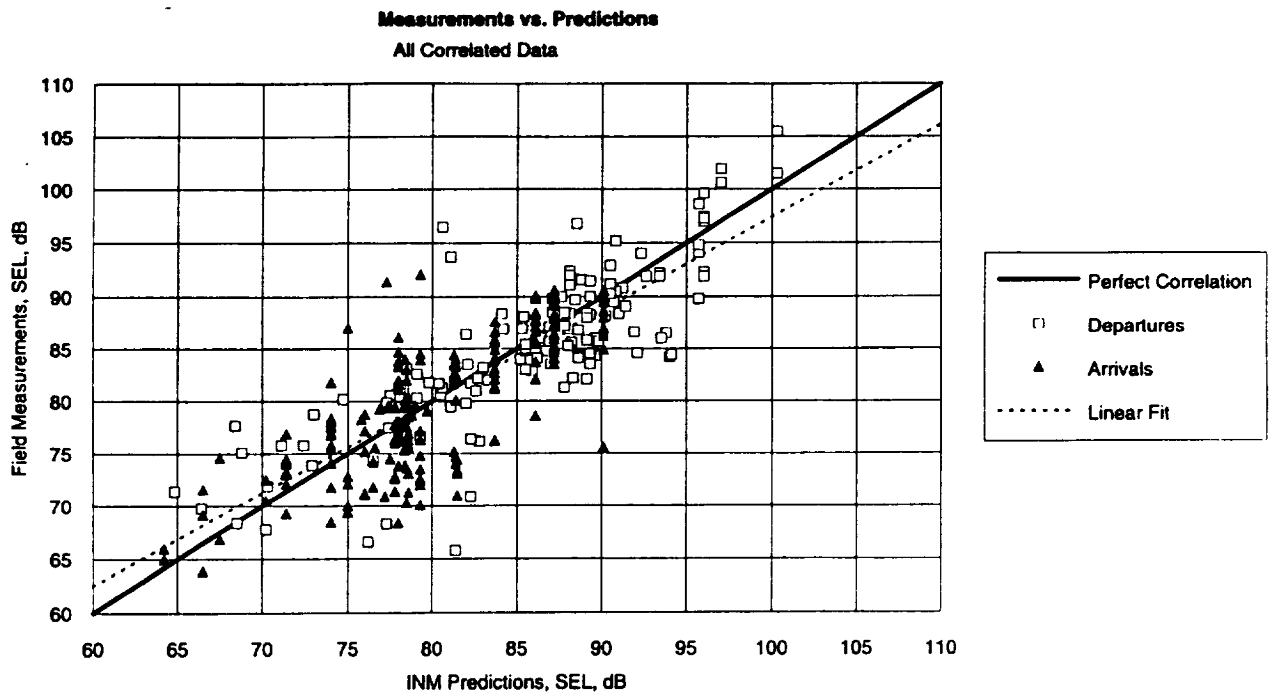


Figure 6-1. INM Predictions Compared With Field Measurements, All Correlated Data.

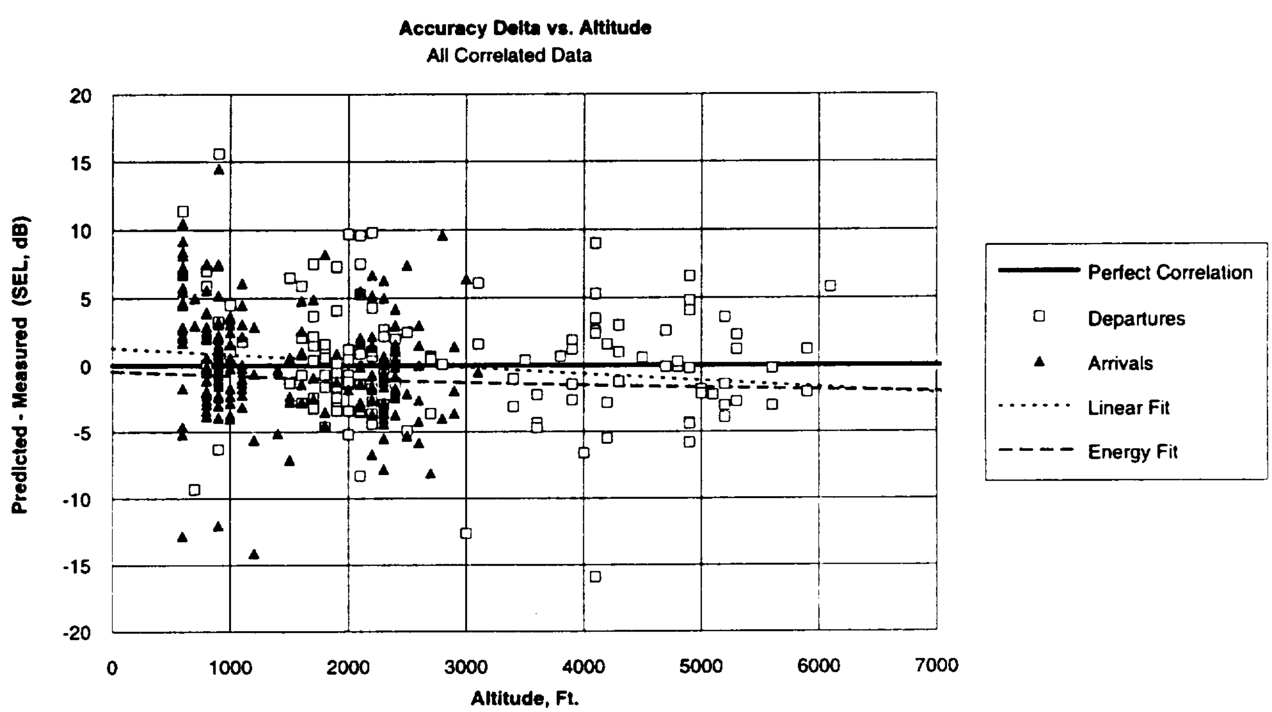


Figure 6-2. Accuracy Versus Aircraft Altitude at Point of Closest Approach, All Correlated Data.

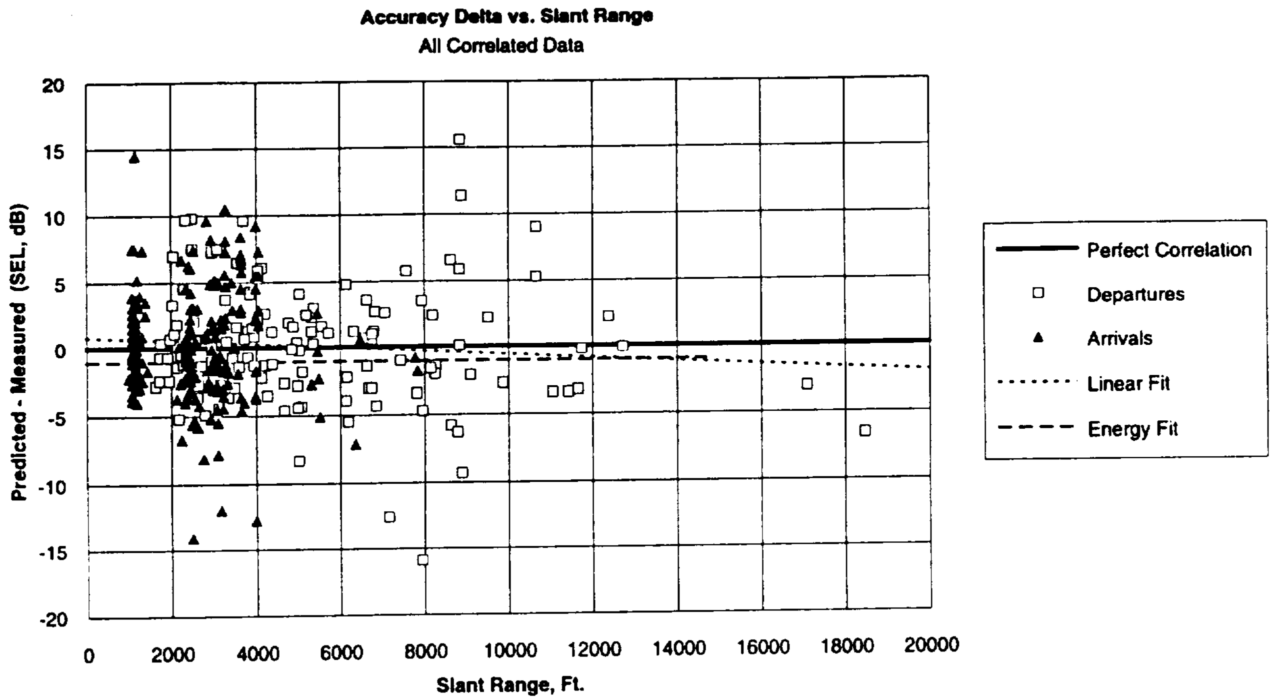


Figure 6-3. Accuracy Versus Slant Range at Point of Closest Approach, All Correlated Data.

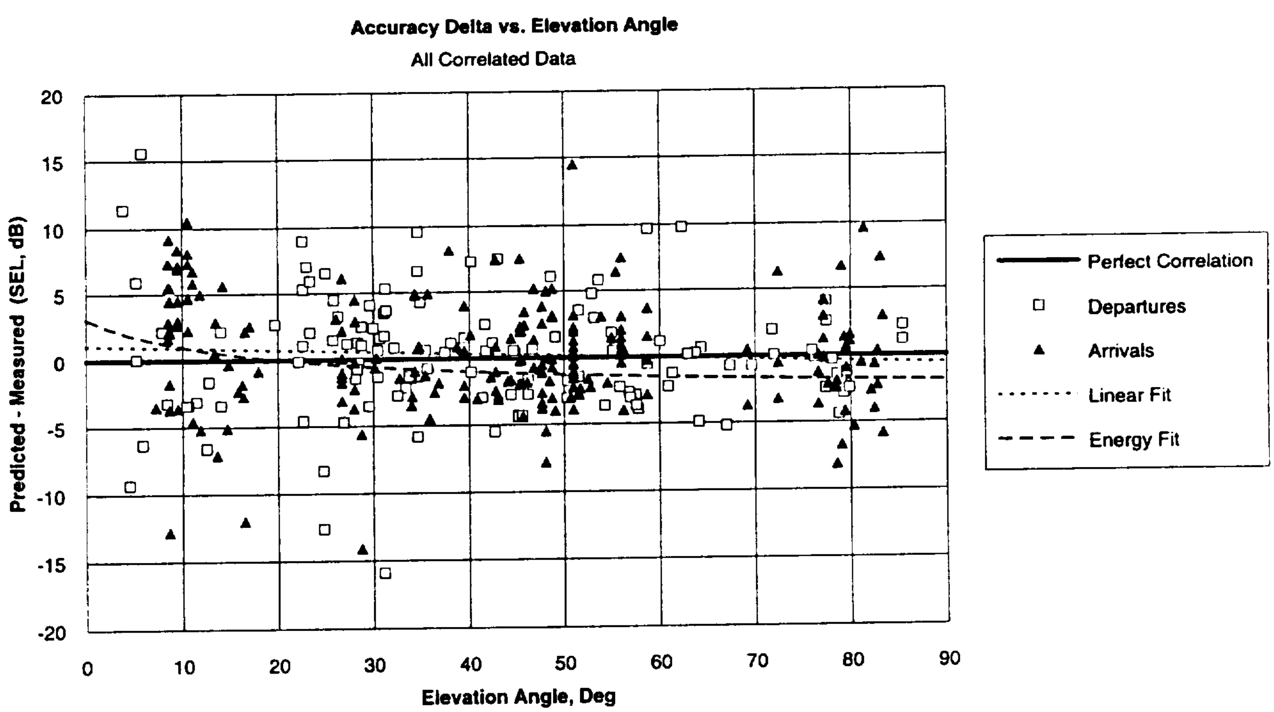


Figure 6-4. Accuracy Versus Elevation Angle at Point of Closest Approach, All Correlated Data.

Elevation angle – the angle between the horizon, the monitoring site, and the aircraft's point of closest approach to the monitor – does not seem to influence the prediction accuracy (Figure 6-4). Both linear fits in the SEL and SE domain indicate only slight dependence on elevation angle. Measurement scatter increases somewhat for elevation angles below about 30 degrees, most likely due to ground impedance and micrometeorological effects at grazing angles.

A consideration of aircraft speed was also undertaken. Figure 6-5 shows the sensitivity of INM prediction accuracy with aircraft speed. Although both the linear fit in the SEL as well as the SE domain show a slight sensitivity with aircraft speed, given the amount of data scatter, no concrete conclusions can be made.

Several factors entering into this analysis which required assusmptions to be made in the predictions include the following:

- Exact identification of the airframe/engine type.
- Availability of INM noise curves for all airframe/engine combinations.
- Resolution limits within the radar tracking data.
- No as-flown power setting data was available.

The first two points can primarily be thought of as a function of fleet age. As aircraft get re-engined, upgraded, and sold between aircraft carriers, equipment changes take place, specifically engine modifications. For the older aircraft, such as DC-9s and B-727s, an incomplete matrix of airframe/engine noise is available within INM. Identification of the equipment tracked by the radar data is also difficult. The *OAG*[14,15,16] and FedEx[11] were consulted to obtain "likely" candidates; however, given the absence of detailed equipment usage in the IF messages, uncertainty occurs. A comparison of the INM accuracy as a function of the average fleet age is given in Figure 6-6. The fleet ages were determined by averaging the delivery dates for these equipment/carrier combinations contained within each of the data subsets. Appendix A contains more detailed information on the data subsets.

In order to understand the sensitivity of INM with modeling technique, a brief comparison between a straight segment and a curved segment with an "infinite" radius (actually 999,999 feet) was made. The effect of using the large radius is to divide the track into multiple segments, thus providing a test of the noise fraction algorithm.

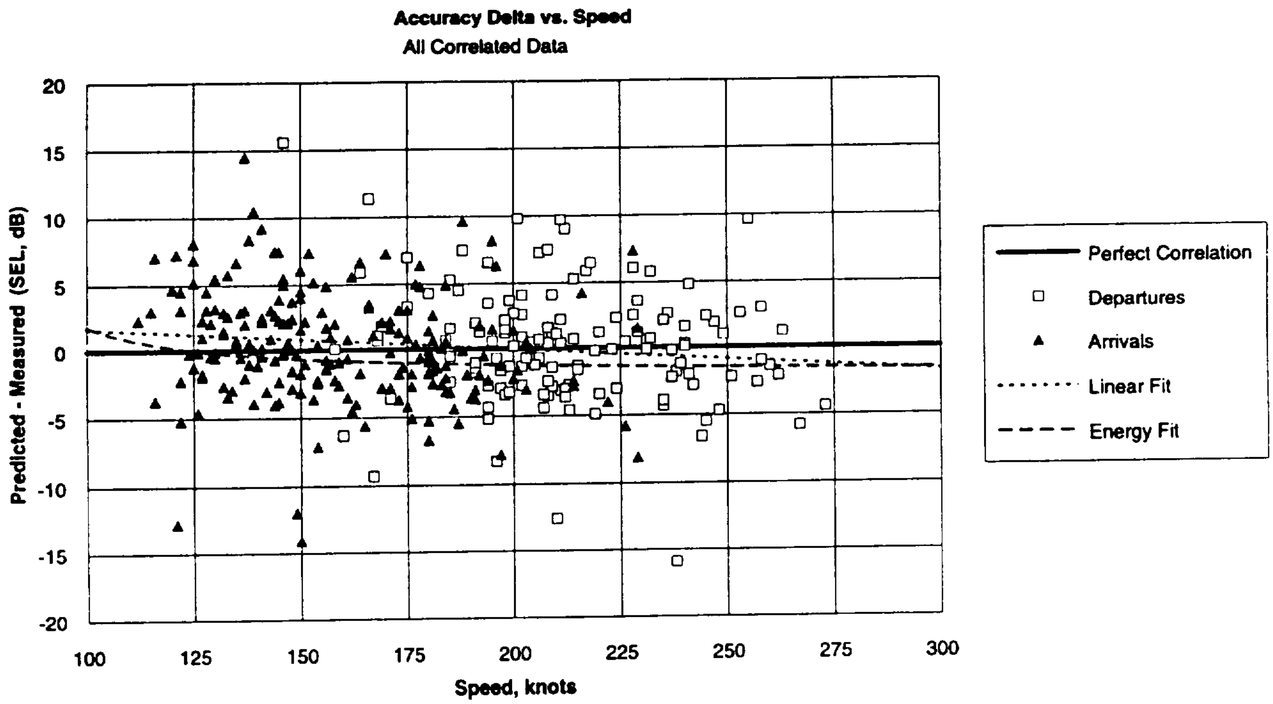


Figure 6-5. Accuracy Versus Aircraft Speed at Point of Closest Approach, All Correlated Data.

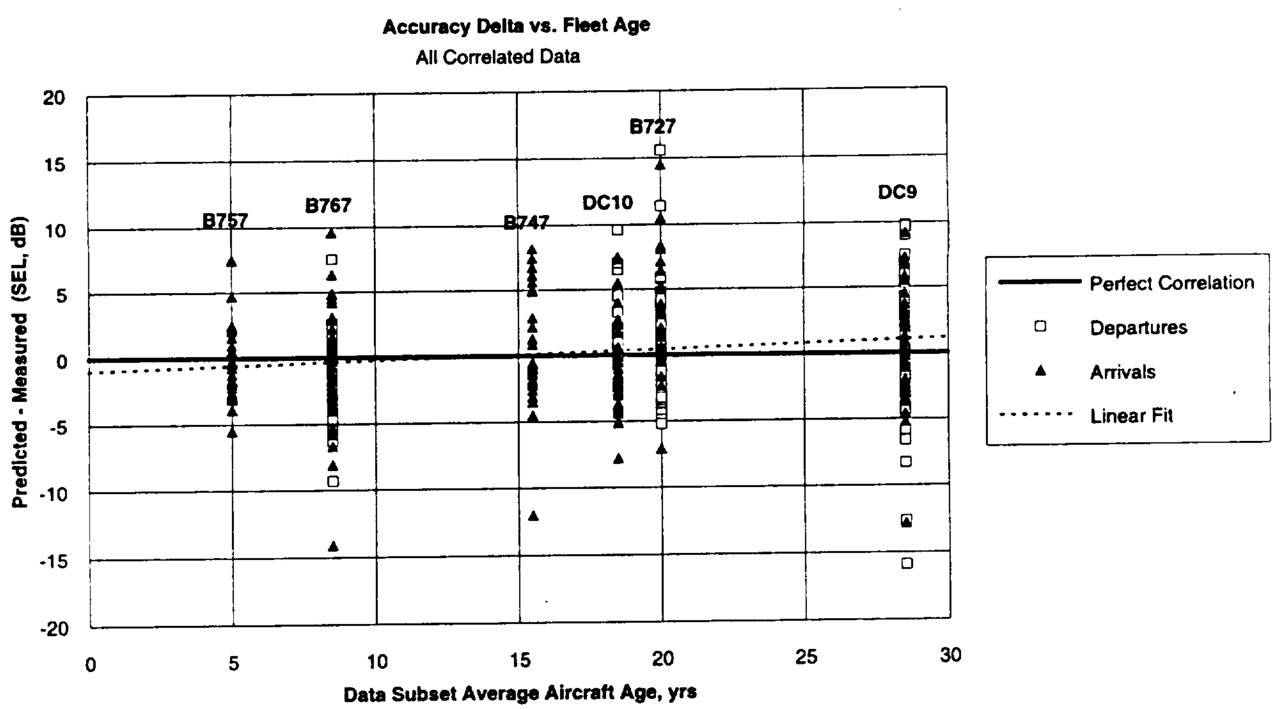


Figure 6-6. Accuracy Versus Average Fleet Age For Correlated Noise Events.

A DC9-10, stage length 1, departure was used. A lateral array of grid points at -15,000 ft, -5,000 ft, 0 ft, +5,000 ft, and +15,000 ft was set up at 10,000 ft, 20,000 ft, 50,000 ft, and 100,000 ft downtrack. Up to 50,000 feet, both forms agree. At a track distance of 100,000 feet, differences of up to 2.8 dB occur, indicating inadequacy of the current noise fraction algorithm at larger distances.

Table 6-1

Sample Analysis, North/South Runway
(Grid Aligned on Runway (0,0))

y	x	x	x	x	x
10,000 Ft	-15,000 Ft	-5,000 Ft	0 Ft	+5,000 Ft	+15,000 Ft
Straight	16.5	34.6	51.3	34.6	16.8
Curved	16.9	34.6	51.3	34.6	16.8
Difference	0.4	0	0	0	0
20,000 Ft					
Straight	17.9	34.0	43.5	34.0	17.9
Curved	18.0	34.1	43.5	33.9	17.8
Difference	0.1	0.1	0	-0.1	-0.1
50,000 Ft					
Straight	18.8	30.3	33.4	30.3	18.8
Curved	19.5	31.1	33.4	29.7	18.2
Difference	0.7	0.8	0	-0.6	-0.6
100,000 Ft					
Straight	17.2	24.6	26.0	24.6	17.2
Curved	19.8	25.7	25.2	22.3	14.4
Difference	2.6	1.1	-0.8	-2.3	-2.8

Another analysis was made using B-747s in order to quantify the sensitivity of INM predictions with airframe/engine combination. Four combinations, B747-100 with JT9D-7QN engines, B747-200 with JT9D-7 engines, B747-400 with PW 4056 engines, and B747-200 with JT9D-7A engines were considered. Table 6-2 shows the rsults of these predictions using the nominal track, as used in the sensitivity studies with the "as-flown" altitude, velocity, and power profiles.

Table 6-2

Sensitivity of INM Predictions With B-747 Airframe/Engine Combinations for Arrivals on Runway 19R

Monitoring Site No.	B-747-100 JT9D-7QN	B747-200 JT9D-7	B-747-400 PW 4056	B-747-200 JT9D-7A	Spread
1	78.5	78.5	81.1	82.5	4.0
2	64.3	64.2	67.9	68.9	4.7
3	81.5	81.4	84.4	85.9	4.5
4	81.3	81.3	83.7	85.2	3.9
5	75.0	75.0	77.5	79.0	4.0
6	54.3	54.3	58.8	59.0	4.3
7	32.9	32.6	43.0	39.0	10.1
8	34.8	34.8	44.6	40.9	9.8
9	41.1	41.1	48.0	46.2	6.9
10	29.9	29.9	41.6	36.7	11.7
11	54.6	54.6	57.8	38.5	19.3
12	49.0	49.0	53.1	53.1	4.1
13	62.4	62.4	65.9	66.9	4.5
14	32.7	32.7	42.8	38.8	10.1

7.0 CONCLUSIONS

INM and similar semi-empirical airport noise modeling tools were originally developed for use in areas in the vicinity of airports, at distances which encompass an L_{dn} of 65 dB or higher. There is increasing interest in noise at larger distances, including en-route noise.

A measurement program was conducted to examine the accuracy of noise models at distances encompassing areas exposed to an L_{dn} of 55 dB. This represents distances two to three times as large as those associated with 65 dB. Measurements were conducted at 14 sites around a major air carrier airport over a two-month period. ARTS radar tracking data, which provides actual flight paths and positive identification of aircraft, were obtained for 25 days in that period. Fifteen of the ARTS-available days corresponded to days with good weather and low wind. Three hundred and forty-two (342) specific aircraft operations were selected for detailed analysis. This selection was sampled by aircraft type, stage length, straight versus curved flight tracks, runway, and arrival versus departure. Single-event noise, quantified by sound exposure level (SEL), was computed via INM and compared with measured SEL. The INM modeling used flight paths derived from ARTS data.

Once this significant volume of field data and corresponding INM calculations was collected, a comprehensive statistical analysis was performed. Differences between measured and predicted SEL were correlated with altitude, slant range, elevation angle, aircraft speed, and distance of the measurement site from the airport. Linear regressions of the average differences were bounded by ±2 dB over the range of each independent variable. For practical noise modeling purposes this is not significant, so the validity of INM for average noise predictions is within acceptable tolerance. Further, the average SEL difference was found to be statistically independent (at the 95 percent level of confidence) of slant range and elevation angle, so this finding is supported in a statistical as well as practical sense. It is concluded that (within the bounds of the current study) INM predictions do not deteriorate with increasing distance from the airport.

In addition to the linear analysis, regressions were also performed on an energy-averaging basis. Noise impact calculated from INM is most often represented by the day-night average sound level, L_{dn}, which represents a summation of acoustical energy. The energy averaging analysis is appropriate for assessing the validity of the model for prediction of L_{dn}. These correlations showed similar characteristics to the linear analysis. It is therefore concluded that INM and similar models can be applied to regions exposed to an L_{dn} of 55 dB, with reliability comparable to that associated with application to an L_{dn} of 65 dB and higher.

While the average results were very consistent, and therefore support L_{dn} analysis, there was large variation in individual events. The individual overflight SEL data was characterized by spreads of 10 dB or more. This spread was found to be independent of most of the independent variables considered, including distance. There was a correlation between spread and aircraft fleet age, and between spread and elevation angle. Spread increased with increasing age, and with decreasing elevation angle. The correlation with fleet age is reasonable because of the increasing variety of configuration as aircraft types age. The correlation with elevation angle is also consistent with the approximate nature of the lateral attenuation algorithms employed in current noise models.

The event-to-event variation is larger than can be explained by any single mechanism. Differences due to choices in modeling of tracks, nominal power settings, etc., can only account for differences of 2 to 3 dB. Aircraft position, type, weight (as predicted from stage or trip length and associated fuel load), and nominal meteorological conditions (analysis limited to good-weather days) were controlled in the analysis. There were unknowns of actual power settings and variations, actual engine types (rather than fleet nominal), turbulence, and surface micrometeorology.

Aircraft operations at larger distances from airports are characterized by geographical dispersion, with the result that a given distant location is exposed to fewer aircraft noise events than a near location. Statistically reliable predictions of average levels in such situations requires a better understanding of the variability observed in the current study.

It is therefore logical to continue the current research in two directions:

1. Similar measurements at increasingly larger distances. ARTS tracking data, key to monitoring aircraft location, is available at distances several times larger than utilized here. Lower noise levels at farther distances may pose signal-to-noise difficulties, but this can be overcome by use of manned sites rather than (or supplementing) automatic sites.

2. More detailed measurements at distances studied here. This would include obtaining actual configuration and power profiles for some measured aircraft, tape recordings to examine spectra as well as levels, and more detailed analysis of meteorological conditions. Surface layer conditions should be measured at the noise measurement sites, and estimates of turbulent conditions (practical from surface layer and standard weather data) should be made.

These two directions should be conducted simultaneously, so that the within-55 dB detailed measurements can serve as a reference for the measurements at larger distances, just as the within-65 dB measurements in the current study served as a reference for the near-55 dB measurements.

REFERENCES

1. "Integrated Noise Model (INM) Version 5.0 User's Guide", FAA-AEE-95-01, August 1995.

2. "Integrated Noise Model (INM) Version 4.11 User's Guide - Supplement", DOT/FAA/EE/93-03, December 1993.

3. "Procedure for the Calculation of Airplane Noise in the Vicinity of Airports", SAE AIR 1845, March 1986.

4. Moulton, C.L., "Air Force Procedure for Predicting Aircraft Noise Around Airbases: Noise Exposure Model (NOISEMAP) User's Manual", Wyle Research Report WR 89-20, also AAMRL-TR-90-011, February 1990.

5. Burn, M., Stusnick, E., and Ehrlich, G., "A Comparison of Different Aircraft Noise Metrics for Large, Medium, and Small Airports", Paper 2pNS8, 129th Meeting of the Acoustical Society of America, 30 May–3 June 1995.

6. Wesler, J.E., "Effects of the Expanded East Coast Air Traffic Plan on Noise Over Northern New Jersey", Wyle Research Report WR 89-2, March 1989.

7. "Noise Standards: Aircraft Type and Airworthiness Certification", Part 36 of the Federal Aviation Regulations.

8. Mohlman, H.T., "Computer Programs for Producing Single-Event Aircraft Noise Data for Specific Engine Power and Meteorological Conditions for Use With USAF Community Noise Model (NOISEMAP)", AFAMRL-TR-83-020, April 1983.

9 FAR Part 150 Noise Compatibility Program, Washington Dulles International Airport, KMPG Peat Marwick, 1993.

10. "National Airspace System Automated Radar Terminal System III (ARTS III)", Department of Transportation, FAA Aeronautical Center, N-9, March 1973.

11. "Commercial Jet Fleets", Federal Express Aviation Services, Inc., Vol. II, July 1994.

12. "Preliminary DISARTS (NDADS) User's Guide", Wyle Research Report WR 95-15, October 1995.

13. "INM – Integrated Noise Model, Version 3, User's Guide – Revision 1", DOT/FAA/EE-92/02, June 1992.

14. *Official Airline Guide*, October 1994.

15. *Official Airline Guide*, November 1994.

16. *Official Airline Guide*, December 1994.

17. Gulding, J. Private communication, February 1996.

18. Lucas, M.J., "Noise Calculation Procedures Contained in the MOA Range NOISEMAP (MRNMAP) Computer Program", Wyle Research Report WR 95-18, March 1995.

APPENDIX A

Detailed Descriptions of Data Subsets Used in Sensitivity Analysis

#1

Aircraft Type:	727			
Operation Description:	Straight-In arrival on 12			
Airlines:	United Airlines, American Airlines			
Fleet mix:	UAL	18	B-727-222	JT8D-7
		74	B-727-222	JT8D-15
	AAL	69	B-727-223	JT8D-9
		15	B-727-227	JT8D-9A
		22	B-727-223	JT8D-15A
Year of delivery:	1968–1980			
Average Age:	20 yrs			
INM Info:	727D15			
Aircraft No.:	26			
Stage:	Arrival			
Weight:	152100			
OAG:	727	Boeing 727 Passenger (All Series)		

#2

Aircraft Type:	727			
Operation Description:	01L Departure North then East			
Airlines:	American Airlines, United Airlines			
Fleet mix:	UAL	18	B-727-222	JT8D-7
		74	B-727-222	JT8D-15
	AAL	69	B-727-223	JT8D-9
		15	B-727-227	JT8D-9A
		22	B-727-223	JT8D-15A
Year of delivery:	1968–1980			
Average Age:	20 yrs			
INM Info:	727D15			
Aircraft No.:	26			
Stage:	1			
Weight:	156000			
OAG:	727	Boeing 727 Passenger (All Series)		

#3

Aircraft Type:	747			
Operation Description:	Straight-In arrival on 19R			
Airlines:	United Airlines, British Airways, SWR			
Fleet Mix:	UAL	9	B-747SP	JT9D-7A
		18	B-747-123	JT9D-7A
		9	B-747-200	JT9D-7R4G2
				JT9D-7F
		23	B-747-400	PW2040
	BAW	13	B-747-200B	RB211-524D4
		3	B-747-200B Combi	RB211-524D4
		28	B-747-400	RB211-524G
Year of Delivery:	1969–1993			
Average Age:	15.5 yrs			
INM Info:	747200/JT9D-7			
Aircraft No.:	2			
Stage:	Arrival			
Weight:	507600			
OAG:	747	Boeing 747 Passenger (All Series)		

#4

Aircraft Type:	757			
Operation Description:	Arrival on 12		Straight-In	
Airlines:	United Airlines			
Fleet mix:	UAL	75	757-200	PW2040
		13	757-200	PW2037
Year of delivery:	1989–1993			
Average Age:	5 yrs			
INM Info:	757PW			
Aircraft No.:	52			
Stage:	arrival			
Weight:	178200			
OAG :	757	Boeing 757-200 Passenger		

#5

Aircraft Type:	767			
Operation Description:	Straight-In Arrival on 19R			
Airlines:	United Airlines			
Fleet mix:	UAL	19	767-200	JT9D-7R4D
		23	767-300	PW4060
Year of Delivery:	1981–1993			
Average Age:	8.5 yrs			
INM Info:	767JT9			
Aircraft No.:	33			
Stage:	arrival			
Weight:	243000			
OAG:	767	Boeing 767 (All Series)		

#6

Aircraft Type:	767			
Operation Description:	Departure 01L North then east			
Airlines:	United Airlines			
Fleet mix:	UAL	19	767-200	JT9D-7R4D
		23	767-300	PW4060
Year of Delivery:	1981–1993			
Average Age :	8.5 yrs			
INM Info:	767JT9			
Aircraft No.:	33			
Stage:	5			
Weight:	284600			
OAG:	767	Boeing 767 (All Series)		

#7

Aircraft Type:	DC9			
Operation Description:	Straight-In arrival on 12			
Airlines:	NorthWest Airlines, Transworld Airlines, USAir, ABX			
Fleet mix:	NWA	22	DC9-10/15	JT8D-7B
Year of Delivery:	1965–1975			
Average Age:	28.5 yrs			
INM Info:	DC910			
Aircraft No.:	40			
Stage:	arrival			
Weight:	91800			
OAG:	DC9	McDonnell Douglas DC-9 (All 10&20 Series)		

#8

Aircraft Type:	DC9			
Operation Description:	Straight-Out Departure on 01L			
Airlines:	NorthWest Airlines, Transworld Airlines, USAir			
Fleet mix:	NWA	22	DC9-10/15	JT8D-7B
Year of Delivery:	1965–1975			
Average Age:	28.5 yrs			
INM Info:	DC910			
Aircraft No.:	40			
Stage:	1			
Weight:				
OAG:	DC9	McDonnell Douglas DC-9 (All 10&20 Series)		

#9

Aircraft Type:	DC10			
Operation Description:	Straight-In arrivals on 12			
Airlines:	United Airlines			
Fleet mix:	UAL	44	DC1010	CF6-6D
		4	DC1030	CF6-50C2B
		4	DC1030CF/F	CF6-50C1
Year of Delivery:	1975–1980			
Average Age:	18.5 yrs			
INM Info:	DC1010			
Aircraft No.:	19			
Stage:	arrival			
Weight:	390000			
OAG:	D10	McDonnell Douglas DC10 (All Series)		

#10

Aircraft Type:	DC10			
Operation Description	Departure on 30 with bank left then right			
Airlines:	United airlines			
Fleet mix:	UAL	44	DC1010	CF6-6D
		4	DC1030	CF6-50C2B
		4	DC1030CF/F	CF6-50C1
Year of Delivery:	1975–1980			
Average Age:	18.5 yrs			
INM Info:	DC1010			
Aircraft No.:	19			
Stage:	4			
Weight:	390000			
OAG:	D10	McDonnell Douglas (All Series)		

APPENDIX B

Correlation Data, Organized by Aircraft Type, Operation Type, and Monitoring Site Location

Correlation Data
B-727, Departures

B-727, Departure, 01L, Right Turn after Take-off										
					Nominal Track Measurement:			87.6		
Site #1	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2467	90.7	n/a			0.83	4500	6753	41.7	211	
6541	90.7	n/a			0.70	3600	5567	40.2	219	
5660	90.7	90.0	0.7	1.008	0.88	3800	6553	35.4	206	
2116	90.7	n/a			0.95	2600	6323	24.2	249	
7060	90.7	89.5	1.2	1.013	0.82	3900	6321	38.1	220	
6501	90.7	n/a			0.70	3400	5440	38.6	243	
6516	80.7	n/a			1.53	3300	9852	19.5	233	
0612	80.7	n/a			1.63	3800	10594	21.0	221	
0571	94.5	n/a			0.27	3600	3955	65.5	248	
7074	94.5	n/a			0.16	3500	3632	74.5	227	
	89.5				0.85	3600	6499	39.9	227.7	Mean
	90.7	89.8	1.0	1.0	0.9	3850.0	6437.3	36.7	213.0	Mean w/o n/a
	4.9				0.46	485	2232	17.9	15.1	Std. Dev.
	0.0	0.4	0.4	0.0	0.0	70.7	163.9	1.9	9.9	Std. Dev w/o n/a
	91.1									Acou. Mean
	90.7	89.8	1.0							Ac. Mean w/o n/a

Correlation Data
B-727, Departures

B-727, Departure, 01L, Right Turn after Take-off										
					Nominal Track Measurement:			91.1		
Site #2	INM	Measured	Delta	Acc Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P M	nm	Ft	Ft	Deg	knots	
2467	88.1	86.9	1.2	[illegible]	[illegible]	[illegible]	[illegible]	60.0	229	
6541	88.1	92.4	-4.3	[illegible]	[illegible]	[illegible]	6854	45.6	235	
5660	88.1	91.1	-3.0	[illegible]	[illegible]	5600	6679	56.9	212	
2116	88.1	n/a			0.48	4300	5193	55.9	249	
7060	88.1	92.0	-3.9	0.958	0.54	5200	6146	57.7	235	
6501	88.1	n/a			0.73	4900	6605	47.8	241	
6516	88.1	n/a			0.65	4700	6135	50.0	255	
0612	88.1	91.1	-3.0	0.967	0.71	5200	6752	50.3	224	
0571	80.2	n/a			1.36	4600	9447	29.1	271	
7074	80.2	n/a			1.67	4600	11127	24.4	237	
	86.5				0.81	4990	7175	47.8	238.8	Mean
	88.1	90.7	-2.6	1.0	0.6	5360.0	6648.0	54.1	227.0	Mean w/o n/a
	3.3				0.39	491	1759	12.1	16.6	Std. Dev.
	0.0	2.2	2.2	0.0	0.1	391.2	288.2	6.0	9.6	Std. Dev w/o n/a
	87.3									Acou. Mean
	88.1	91.1	-2.1							Ac. Mean w/o n/a

Correlation Data
B-727, Departures

B-727, Departure, 01L, Right Turn after Take-off										
					Nominal Track Measurement:			86.5		
Site #3	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2467	89.3	83.5	5.8	1.069	0.74	6100	7574	53.6	232	
6541	89.3	91.5	-2.2	0.976	0.57	5100	6162	55.8	237	
5660	89.3	n/a			0.63	5900	7030	57.0	218	
2116	89.3	88.3	1.0	1.011	0.86	4300	6761	39.5	249	
7060	89.3	n/a			0.81	5500	7376	48.2	233	
6501	89.3	84.5	4.8	1.057	0.61	4900	6141	52.9	241	
6516	77.4	n/a			1.96	4500	12714	20.7	254	
0612	77.4	77.5	-0.1	0.999	1.94	4800	12711	22.2	223	
0571	90.8	95.2	-4.4	0.954	0.16	4900	4995	78.8	273	
7074	90.8	90.5	0.3	1.003	0.39	4800	5352	63.7	240	
	87.2				**0.87**	**5080**	**7682**	**49.2**	**240.0**	**Mean**
	88.0	**87.3**	**0.7**	**1.0**	**0.8**	**4985.7**	**7099.4**	**52.3**	**242.1**	**Mean w/o n/a**
	5.2				**0.61**	**583**	**2776**	**17.8**	**15.9**	**Std. Dev.**
	4.7	**5.9**	**3.6**	**0.0**	**0.6**	**549.0**	**2617.6**	**17.9**	**15.8**	**Std. Dev w/o n/a**
	88.8									**Acou. Mean**
	89.2	**90.1**	**2.0**							**Ac. Mean w/o n/a**

Correlation Data
B-727, Departures

B-727, Departure, 01L, Right Turn after Take-off										
						Nominal Track Measurement:		94.0		
Site #4	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2467	95.7	94.1	1.6	1.017	0.62	3100	4874	39.5	185	
6541	95.7	98.6	-2.9	0.971	0.43	2300	3478	41.4	197	
5660	95.7	94.8	0.9	1.009	0.55	2100	3943	32.1	202	
2116	95.7	89.8	5.9	1.066	0.61	1600	4032	23.3	217	
7060	95.7	n/a			0.50	2100	3689	34.7	208	
6501	95.7	n/a			0.37	2200	3143	44.4	222	
6516	88.0	86.9	1.1	1.013	0.87	2200	5718	22.6	210	
0612	88.0	85.3	2.7	1.032	1.06	2300	6830	19.7	200	
0571	97.0	101.9	-4.9	0.952	0.20	2500	2779	64.1	219	
7074	97.0	100.6	-3.6	0.964	0.23	2200	2605	57.6	212	
	94.4				0.54	2260	4109	37.9	207.2	Mean
	94.1	94.0	0.1	1.0	0.6	2287.5	4282.4	37.5	205.3	Mean w/o n/a
	3.4				0.27	375	1340	14.7	11.4	Std. Dev.
	3.8	6.2	3.6	0.0	0.3	419.0	1454.1	16.5	11.4	Std. Dev w/o n/a
	95.3									Acou. Mean
	95.1	97.2	1.4							Ac. Mean w/o n/a

B-727, Departure, 01L, Right Turn after Take-off										
					Nominal Track Measurement:			95.8		
Site #5	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2467	96.0	99.6	-3.6	0.964	0.32	2700	3326	54.2	171	
6541	96.0	97.4	-1.4	0.986	0.49	2000	3583	33.9	191	
5660	96.0	97.0	-1.0	0.990	0.37	1900	2941	40.2	191	
2116	96.0	97.3	-1.3	0.987	0.37	1500	2700	33.7	202	
7060	96.0	92.3	3.7	1.040	0.46	1700	3268	31.3	199	
6501	96.0	91.9	4.1	1.045	0.55	1900	3840	29.6	209	
6516	100.3	101.5	-1.2	0.988	0.18	2000	2279	61.3	205	
0612	100.3	105.5	-5.2	0.951	0.14	2000	2173	67.0	194	
0571	93.4	92.2	1.2	1.013	0.64	2000	4368	27.2	198	
7074	93.4	91.9	1.5	1.016	0.58	1700	3908	25.8	198	
	96.3				0.41	1940	3238	40.4	195.8	Mean
	96.3	96.7	-0.3	1.0	0.41	1940.0	3238.4	40.4	195.8	Mean w/o n/a
	2.3				0.17	317	719	14.9	10.4	Std. Dev.
	2.3	4.7	3.0	0.0	0.17	316.9	718.6	14.9	10.4	Std. Dev w/o n/a
	97.0									Acou. Mean
	97.0	99.1	0.6							Ac. Mean w/o n/a

Correlation Data
B-727, Departures

B-727, Departure, 01L, Right Turn after Take-off										
					Nominal Track Measurement:			78.6		
Site #6	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2467	78.1	n/a			1.77	2700	11073	14.1	171	
6541	78.1	n/a			1.91	2100	11777	10.3	195	
5660	78.1	81.5	-3.4	0.958	1.79	2000	11043	10.4	198	
2116	78.1	n/a			1.79	1500	10963	7.9	211	
7060	78.1	81.3	-3.2	0.961	1.90	1700	11652	8.4	199	
6501	78.1	n/a			1.98	2000	12178	9.4	216	
6516	82.0	79.8	2.2	1.028	1.52	2300	9504	14.0	211	
0612	82.0	n/a			1.34	2500	8505	17.1	202	
0571	76.5	n/a			2.08	2000	12777	9.0	198	
7074	76.5	74.3	2.2	1.030	2.02	1700	12373	7.9	198	
	78.6				1.81	2050	11184	10.8	199.9	Mean
	78.7	79.2	-0.6	1.0	1.8	1925.0	11142.9	10.2	201.5	Mean w/o n/a
	1.9				0.23	372	1316	3.1	12.4	Std. Dev.
	2.3	3.4	3.2	0.0	0.21	287.2	1220.2	2.8	6.4	Std. Dev w/o n/a
	79.0									Acou. Mean
	79.2	80.0	0.3							Ac. Mean w/o n/a

B-727, Departure, 01L, Right Turn after Take-off										
					Nominal Track Measurement:			83.0		
Site #11	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2467	82.3	n/a			1.38	1300	8473	8.8	162	
6541	82.3	n/a			1.45	800	8833	5.2	158	
5660	82.3	70.9	11.4	1.161	1.46	600	8878	3.9	166	
2116	82.3	n/a			1.46	700	8885	4.5	154	
7060	82.3	76.4	5.9	1.077	1.45	800	8833	5.2	164	
6501	82.3	n/a			1.50	1200	9179	7.5	159	
6516	92.6	n/a			1.50	800	9136	5.0	166	
0612	82.6	n/a			1.40	1200	8578	8.0	172	
0571	81.4	n/a			1.46	600	8878	3.9	172	
7074	81.4	65.8	15.6	1.237	1.45	900	8843	5.8	146	
	83.2				1.45	890	8852	5.8	161.9	Mean
	82.0	71.0	11.0	1.2	1.45	766.7	8851.5	5.0	158.7	Mean w/o n/a
	3.3				0.04	256	213	1.7	8.0	Std. Dev.
	0.5	5.3	4.9	0.1	0.01	152.8	23.5	1.0	11.0	Std. Dev w/o n/a
	85.2									Acou. Mean
	82.0	73.0	12.6							Ac. Mean w/o n/a

Correlation Data
B-727 Arrivals

B-727, Runway 12, Arrivals, Straight In										
					Nominal Track Measurement:			70.2		
Site #7	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2702	70.2	72.5	-2.3	0.968	0.87	1500	5487	15.8	194	
3535	70.2	n/a			0.88	1400	5519	14.7	166	
6061	70.2	n/a			0.84	1800	5405	19.4	151	
0536	70.2	70.5	-0.3	0.996	0.87	1400	5461	14.8	149	
0640	70.2	n/a			0.86	1500	5429	16.0	135	
0531	70.2	n/a			0.87	1400	5461	14.8	129	
4122	70.2	n/a			0.88	1500	5546	15.7	163	
3602	70.2	n/a			0.87	1500	5487	15.8	154	
7407	70.2	n/a			0.89	1800	5692	18.4	141	
2260	70.2	n/a			0.88	1400	5519	14.7	170	
1424	70.2	n/a			0.87	1700	5545	17.8	208	
2712	70.2	n/a			0.86	1400	5402	15.0	144	
	70.2				0.87	1525	5496	16.1	158.7	Mean
	70.2	71.5	-1.3	0.982	0.87	1450	5474	15.3	171.5	Mean w/o n/a
	0.0				0.01	154	79	1.6	23.4	Standard Deviation
	0.0	1.4	1.4	0.019	0.00	71	19	0.7	31.8	Std. Dev w/o n/a
	70.2									Acoustical Mean
	70.2	71.6	-1.2							Acoustical Mean w/o n/a

Correlation Data
B-727 Arrivals

B-727, Runway 12, Arrivals, Straight In										
					Nominal Track Measurement:			90.1		
Site #9	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2702	90.1	90.6	-0.5	0.994	0.12	800	1082	47.7	136	
3535	90.1	89.9	0.2	1.002	0.10	900	1085	56.0	141	
6061	90.1	86.9	3.2	1.037	0.13	900	1197	48.7	130	
0536	90.1	86.2	3.9	1.045	0.12	800	1082	47.7	145	
0640	90.1	90.5	-0.4	0.996	0.12	900	1158	51.0	141	
0531	90.1	87.0	3.1	1.036	0.13	900	1197	48.7	122	
4122	90.1	88.0	2.1	1.024	0.10	900	1085	56.0	146	
3602	90.1	75.6	14.5	1.192	0.12	900	1158	51.0	137	
7407	90.1	84.9	5.2	1.061	0.13	900	1197	48.7	125	
2260	90.1	89.5	0.6	1.007	0.16	800	1258	39.5	147	
1424	90.1	86.6	3.5	1.040	0.16	1000	1394	45.8	166	
2712	90.1	88.6	1.5	1.017	0.10	900	1085	56.0	132	
	90.1				0.12	883	1165	49.7	139.0	Mean
	90.1	87.0	3.1	1.038	0.12	883	1165	49.7	139.0	Mean w/o n/a
	0.0				0.02	58	94	4.8	11.7	Standard Deviation
	0.0	4.0	4.0	0.053	0.02	58	94	4.8	11.7	Std. Dev w/o n/a
	90.1									Acoustical Mean
	90.1	88.1	6.0							Acoustical Mean w/o n/a

Correlation Data
B-727 Arrivals

B-727, Runway 12, Arrivals, Straight In										
					Nominal Track Measurement:			77.8		
Site #10	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2702	77.8	76.3	1.5	1.020	0.37	2200	3143	44.4	229	
3535	77.8	n/a			0.34	2100	2944	45.5	198	
6061	77.8	71.4	6.4	1.090	0.34	3000	3641	55.4	178	
0536	77.8	76.0	1.8	1.024	0.41	2100	3255	40.1	192	
0640	77.8	72.6	5.2	1.072	0.34	2200	3016	46.8	153	
0531	77.8	72.8	5.0	1.069	0.34	2300	3090	48.1	177	
4122	77.8	77.8	0.0	1.000	0.38	2600	3475	48.4	204	
3602	77.8	79.4	-1.6	0.980	0.29	2300	2896	52.5	181	
7407	77.8	76.3	1.5	1.020	0.30	2600	3174	55.0	195	
2260	77.8	n/a			0.38	2300	3257	44.9	208	
1424	77.8	n/a			0.55	2800	4356	40.0	232	
2712	77.8	76.4	1.4	1.018	0.34	2200	3016	46.8	180	
	77.8				**0.37**	**2392**	**3272**	**47**	**194**	**Mean**
	77.8	**75.4**	**2.4**	**1.0**	**0.3**	**2388.9**	**3189.4**	**48.6**	**187.7**	**Mean w/o n/a**
	0.0				**0.07**	**291**	**404**	**5**	**23**	**Standard Deviation**
	0.0	**2.6**	**2.6**	**0.0**	**0.0**	**289.2**	**236.8**	**5.0**	**21.1**	**Std. Dev w/o n/a**
	77.8									**Acoustical Mean**
	77.8	**76.1**	**3.1**							**Acoustical Mean w/o n/a**

B-727, Runway 12, Arrivals, Straight In										
					Nominal Track Measurement:			81.5		
Site #12	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2702	81.5	n/a			0.59	600	3629	9.5	121	
3535	81.5	73.1	8.4	1.115	0.59	600	3629	9.5	138	
6061	81.5	73.4	8.1	1.110	0.53	600	3271	10.6	125	
0536	81.5	71.0	10.5	1.148	0.53	600	3271	10.6	139	
0640	81.5	n/a			0.53	600	3271	10.6	152	
0531	81.5	74.4	7.1	1.095	0.59	600	3629	9.5	116	
4122	81.5	n/a			0.65	700	4005	10.1	133	
3602	81.5	n/a			0.59	500	3614	7.9	127	
7407	81.5	n/a			0.59	700	3647	11.0	126	
2260	81.5	n/a			0.66	600	4049	8.5	138	
1424	81.5	n/a			0.65	700	4005	10.1	138	
2712	81.5	85.6	-4.1	0.952	0.65	600	3989	8.6	137	
	81.5				0.60	616.67	3667.61	9.70	132.50	Mean
	81.5	75.5	6.0	1.1	0.6	600.0	3558.0	9.8	131.0	Mean w/o n/a
	0.0				0.05	57.74	294.81	0.95	9.85	Standard Deviation
	0.0	5.8	5.8	0.1	0.1	0.0	300.3	0.8	10.1	Std. Dev w/o n/a
	81.5									Acoustical Mean
	81.5	79.5	7.8							Acoustical Mean w/o n/a

Correlation Data
B-727 Arrivals

B-727, Runway 12, Arrivals, Straight In										
					Nominal Track Measurement:			67.5		
Site #14	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2702	67.5	n/a			1.04	1400	6463	12.5	188	
3535	67.5	n/a			1.04	1400	6463	12.5	166	
6061	67.5	n/a			1.01	1800	6387	16.3	151	
0536	67.5	n/a			1.02	1400	6345	12.7	149	
0640	67.5	66.9	0.6	1.009	1.04	1500	6486	13.4	135	
0531	67.5	n/a			1.02	1400	6345	12.7	129	
4122	67.5	n/a			1.04	1500	6486	13.4	163	
3602	67.5	74.6	-7.1	0.905	1.02	1500	6368	13.6	154	
7407	67.5	n/a			1.06	1500	6604	13.1	140	
2260	67.5	n/a			1.04	1400	6463	12.5	170	
1424	67.5	n/a			1.02	1700	6418	15.3	208	
2712	67.5	n/a			1.04	1400	6463	12.5	142	
	67.5				1.03	1491.67	6440.70	13.38	157.92	Mean
	67.5	70.8	-3.3	1.0	1.0	1500.0	6426.5	13.5	144.5	Mean w/o n/a
	0.0				0.01	131.14	73.74	1.23	22.82	Standard Deviation
	0.0	5.4	5.4	0.1	0.0	0.0	83.4	0.2	13.4	Std. Dev w/o n/a
	67.5									Acoustical Mean
	67.5	72.3	-1.7							Acoustical Mean w/o n/a

Correlation Data
B-747 Arrivals

B747, Arrivals on Runway 19R, Straight In Arrivals										
					Nominal Track Measurement:			81.3		
Site #4	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
3111	81.3	75.2	6.1	1.081	0.36	1100	2445	26.7	150	
2545	81.3	84.4	-3.1	0.963	0.36	1100	2445	26.7	150	
2563	81.3	n/a			0.34	1200	2386	30.2	144	
0740	81.3	82.3	-1.0	0.988	0.36	1100	2445	26.7	157	
0562	81.3	81.9	-0.6	0.993	0.34	1200	2386	30.2	161	
3062	81.3	83.5	-2.2	0.974	0.34	1100	2338	28.0	154	
3131	81.3	81.9			0.36	1100	2445	26.7	145	
6711	81.3	83.3			0.34	1100	2338	28.0	165	
3112	81.3	80.1			0.34	1200	2386	30.2	152	
7332	81.3	74.0			0.34	1100	2338	28.0	166	
1753	81.3	84.0			0.34	1000	2292	25.8	140	
0705	81.3	82.6	-1.3	0.984	0.36	1100	2445	26.7	156	
	81.3				**0.35**	**1117**	**2391**	**27.8**	**153.3**	**Mean**
	81.3	**81.7**	**-0.4**	**1.0**	**0.4**	**1116.7**	**2417.7**	**27.5**	**154.7**	**Mean w/o n/a**
	0.0				**0.01**	**58**	**55**	**1.6**	**8.2**	**Standard Deviation**
	0.0	**3.3**	**3.3**	**0.0**	**0.0**	**40.8**	**45.7**	**1.4**	**4.3**	**Std. Dev w/o n/a**
	81.3									**Acoustical Mean**
	81.3	**82.4**	**1.0**							**Acoustical Mean w/o n/a**

B747, Arrivals on Runway 19R, Straight In Arrivals										
						Nominal Track Measurement:		81.4		
Site #3	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
3111	81.4	n/a			0.09	2900	2951	79.3	210	
2545	81.4	n/a			0.09	2700	2755	78.6	160	
2563	81.4	74.7	6.7	1.090	0.07	2200	2241	79.1	164	
0740	81.4	82.3	-0.9	0.989	0.07	2300	2339	79.5	180	
0562	81.4	81.9	-0.5	0.994	0.12	2300	2412	72.4	180	
3062	81.4	83.5	-2.1	0.975	0.09	2500	2559	77.7	184	
3131	81.4	81.9	-0.5	0.994	0.08	3100	3138	81.1	193	
6711	81.4	83.3	-1.9	0.977	0.08	2400	2449	78.6	189	
3112	81.4	80.1	1.3	1.016	0.09	2400	2461	77.2	173	
7332	81.4	74.0	7.4	1.100	0.05	2500	2518	83.1	228	
1753	81.4	84.0	-2.6	0.969	0.05	2200	2221	82.1	159	
0705	81.4	82.6	-1.2	0.985	0.09	2300	2364	76.6	197	
	81.4				0.08	2483	2534	78.8	184.8	Mean
	81.4	80.8	0.6	1.0	0.1	2420.0	2470.2	78.7	184.7	Mean w/o n/a
	0.0				0.02	282	281	2.8	20.5	Standard Deviation
	0.0	3.6	3.6	0.0	0.0	261.6	258.9	3.1	19.4	Std. Dev w/o n/a
	81.4									Acoustical Mean
	81.4	81.8	2.2							Acoustical Mean w/o n/a

Correlation Data
B-747 Arrivals

B747, Arrivals on Runway 19R, Straight In Arrivals										
					Nominal Track Measurement:			78.5		
Site #1	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
3111	78.5	n/a			0.44	2100	3396	38.1	182	
2545	78.5	n/a			0.41	1700	3013	34.3	145	
2563	78.5	n/a			0.41	1700	3013	34.3	150	
0740	78.5	82.0	-3.5	0.957	0.44	1800	3220	34.0	161	
0562	78.5	77.6	0.9	1.012	0.39	1900	3035	38.7	175	
3062	78.5	79.4	-0.9	0.989	0.41	1700	3013	34.3	159	
3131	78.5	80.3	-1.8	0.978	0.44	2000	3336	36.8	173	
6711	78.5	n/a			0.38	1700	2864	36.4	172	
3112	78.5	83.0	-4.5	0.946	0.41	1800	3070	35.9	162	
7332	78.5	70.3	8.2	1.117	0.38	1800	2925	37.9	195	
1753	78.5	79.9	-1.4	0.982	0.41	1600	2958	32.7	156	
0705	78.5	73.6	4.9	1.067	0.39	1700	2914	35.7	184	
	78.5				0.41	1792	3063	35.8	167.8	Mean
	78.5	78.3	0.2	1.0	0.4	1787.5	3058.6	35.7	170.6	Mean w/o n/a
	0.0				0.02	144	168	1.9	14.9	Standard Deviation
	0.0	4.3	4.3	0.1	0.0	124.6	148.6	2.0	13.7	Std. Dev w/o n/a
	78.5									Acoustical Mean
	78.5	79.7	2.4							Acoustical Mean w/o n/a

Correlation Data
B-747 Arrivals

B747, Arrivals on Runway 19R, Straight In Arrivals										
					Nominal Track Measurement:			75.0		
Site #5	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
3111	75.0	n/a			0.56	1000	3542	16.4	146	
2545	75.0	n/a			0.55	900	3456	15.1	141	
2563	75.0	n/a			0.50	900	3164	16.5	144	
0740	75.0	n/a			0.55	900	3456	15.1	146	
0562	75.0	72.8	2.2	1.030	0.50	900	3164	16.5	151	
3062	75.0	n/a			0.56	900	3515	14.8	153	
3131	75.0	n/a			0.52	900	3281	15.9	146	
6711	75.0	69.4	5.6	1.081	0.52	800	3255	14.2	162	
3112	75.0	87.0	-12.0	0.862	0.50	900	3164	16.5	149	
7332	75.0	n/a			0.55	900	3456	15.1	158	
1753	75.0	70.0	5.0	1.071	0.55	700	3409	11.8	146	
0705	75.0	72.1	2.9	1.040	0.55	800	3431	13.5	155	
	75.0				0.53	875	3358	15.1	149.8	Mean
	75.0	74.3	0.7	1.0	0.5	820.0	3284.8	14.5	152.6	Mean w/o n/a
	0.0				0.02	75	143	1.4	6.2	Standard Deviation
	0.0	7.3	7.3	0.1	0.0	83.7	129.5	2.0	6.2	Std. Dev w/o n/a
	75.0									Acoustical Mean
	75.0	80.5	3.2							Acoustical Mean w/o n/a

B747, Arrivals on Runway 19R, Straight In Arrivals										
					Nominal Track Measurement:			64.2		
Site #2	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
3111	64.2	n/a			1.24	2800	8027	20.4	207	
2545	64.2	n/a			1.22	2600	7845	19.3	158	
2563	64.2	n/a			1.23	2100	7752	15.7	161	
0740	64.2	66.0	-1.8	0.973	1.24	2200	7838	16.3	176	
0562	64.2	n/a			1.25	2200	7896	16.2	178	
3062	64.2	65.0	-0.8	0.988	1.22	2400	7781	17.9	181	
3131	64.2	n/a			1.25	2800	8084	20.2	188	
6711	64.2	n/a			1.25	2200	7896	16.2	175	
3112	64.2	n/a			1.22	2300	7751	17.2	190	
7332	64.2	n/a			1.10	2500	7127	20.5	226	
1753	64.2	n/a			1.23	2100	7752	15.7	159	
0705	64.2	n/a			1.27	2200	8013	15.9	199	
	64.2				1.23	2367	7814	17.6	183.2	Mean
	64.2	65.5	-1.3	1.0	1.2	2300.0	7809.6	17.1	178.5	Mean w/o n/a
	0.0				0.04	253	245	2.0	20.4	Standard Deviation
	0.0	0.7	0.7	0.0	0.0	141.4	40.3	1.2	3.5	Std. Dev w/o n/a
	64.2									Acoustical Mean
	64.2	65.5	-1.3							Acoustical Mean w/o n/a

Correlation Data

B-757 Arrivals

B-757, Runway 12, Arrivals										
					Nominal Track Measurement:			83.7		
Site #9	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
6644	83.7	84.9	-1.2	0.986	0.12	900	1158	51.0	125	
7204	83.7	85.6	-1.9	0.978	0.13	800	1123	45.4	127	
1417	83.7	85.9	-2.2	0.974	0.12	900	1158	51.0	122	
2773	83.7	86.6	-2.9	0.967	0.16	800	1258	39.5	134	
6006	83.7	87.6	-3.9	0.955	0.12	900	1158	51.0	139	
6640	83.7	76.2	7.5	1.098	0.10	900	1085	56.0	144	
1464	83.7	82.1	1.6	1.019	0.10	1000	1170	58.7	150	
2766	83.7	82.7	1.0	1.012	0.10	900	1085	56.0	127	
1442	83.7	81.4	2.3	1.028	0.12	900	1158	51.0	141	
7475	83.7	83.1	0.6	1.007	0.10	900	1085	56.0	138	
0504	83.7	83.9	-0.2	0.998	0.13	800	1123	45.4	146	
1401	83.7	76.3	7.4	1.097	0.16	900	1324	42.8	152	
7363	83.7	81.2	2.5	1.031	0.16	1000	1394	45.8	141	
0631	83.7	84.1	-0.4	0.995	0.10	900	1085	56.0	129	
	83.7				0.12	893	1169	50.4	136.8	Mean
	83.7	83.0	0.7	1.010	0.12	893	1169	50.4	136.8	Mean w/o n/a
	0.0				0.02	62	94	5.8	9.6	Standard Deviation
	0.0	3.4	3.4	0.043	0.02	62	94	5.8	9.6	Std. Dev w/o n/a
	83.7									Acoustical Mean
	83.7	83.7	3.6							Acoustical Mean w/o n/a

Correlation Data
B-757 Arrivals

B-757, Runway 12, Arrivals										
					Nominal Track Measurement:			71.4		
Site #10	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
6644	71.4	n/a			0.30	2500	3092	53.9	165	
7204	71.4	n/a			0.29	2600	3139	55.9	198	
1417	71.4	n/a			0.34	2200	3016	46.8	163	
2773	71.4	74.5	-3.1	0.958	0.37	2100	3074	43.0	184	
6006	71.4	74.2	-2.8	0.962	0.37	2100	3074	43.0	171	
6640	71.4	73.1	-1.7	0.977	0.35	2400	3205	48.5	180	
1464	71.4	73.0	-1.6	0.978	0.37	2200	3143	44.4	201	
2766	71.4	72.1	-0.7	0.990	0.34	2200	3016	46.8	156	
1442	71.4	n/a			0.34	2200	3016	46.8	190	
7475	71.4	69.3	2.1	1.030	0.34	2100	2944	45.5	169	
0504	71.4	74.0	-2.6	0.965	0.34	2600	3319	51.5	183	
1401	71.4	73.3	-1.9	0.974	0.34	2900	3559	54.5	192	
7363	71.4	n/a			0.37	2800	3589	51.2	182	
0631	71.4	76.9	-5.5	0.928	0.34	2300	3090	48.1	187	
	71.4				0.3	2371.4	3162.4	48.6	180.1	Mean
	71.4	73.4	-2.0	1.0	0.4	2322.2	3158.0	47.3	180.3	Mean w/o n/a
	0.0				0.0	267.3	197.0	4.2	13.5	Standard Deviation
	0.0	2.0	2.0	0.0	0.0	272.8	185.0	3.9	13.4	Std. Dev w/o n/a
	71.4									Acoustical Mean
	71.4	73.8	-1.5							Acoustical Mean w/o n/a

Correlation Data
B-757 Arrivals

B-757, Runway 12, Arrivals										
					Nominal Track Measurement:			76.5		
Site #12	INM-JT9	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
6644	76.5	74.2	2.3	1.031	0.65	600	3989	8.6	112	
7204	76.5	n/a			0.72	600	4409	7.8	104	
1417	76.5	71.8	4.7	1.065	0.53	600	3271	10.6	120	
2773	76.5	n/a			0.59	600	3629	9.5	124	
6006	76.5	n/a			0.59	600	3629	9.5	136	
6640	76.5	n/a			0.65	600	3989	8.6	142	
1464	76.5	n/a			0.65	600	3989	8.6	128	
2766	76.5	n/a			0.53	500	3254	8.8	123	
1442	76.5	n/a			0.59	600	3629	9.5	133	
7475	76.5	n/a			0.65	600	3989	8.6	129	
0504	76.5	n/a			0.65	600	3989	8.6	152	
1401	76.5	n/a			0.59	600	3629	9.5	141	
7363	76.5	n/a			0.53	700	3291	12.3	128	
0631	76.5	n/a			0.66	600	4049	8.5	131	
	76.5				0.6	600.0	3766.9	9.2	128.8	Mean
	76.5	73.0	3.5	1.0	0.6	600.0	3630.0	9.6	116.0	Mean w/o n/a
	0.0				0.1	39.2	345.3	1.1	12.3	Standard Deviation
	0.0	1.7	1.7	0.0	0.1	0.0	507.6	1.4	5.7	Std. Dev w/o n/a
	76.5									Acoustical Mean
	76.5	73.2	3.7							Acoustical Mean w/o n/a

Correlation Data

B-767 Departures

B-767, Runway 1L, Takeoffs, North then Sharp Right Turn										
					Nominal Track Measurement:			85.1		
Site #5	INM-JT9	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2111	87.5	86.8	0.7	1.008	0.25	2200	2672	55.4	184	
0636	88.1	88.4	-0.3	0.997	0.08	2300	2351	78.1	185	
2462	83.3	82.0	1.3	1.016	0.55	1800	3791	28.3	192	
7011	80.6	81.3	-0.7	0.991	0.55	1800	3791	28.3	206	
2145	80.4	81.7	-1.3	0.984	0.56	2000	3942	30.4	199	
2436	87.1	89.8	-2.7	0.970	0.37	2200	3143	44.4	202	
0655	87.1	88.5	-1.4	0.984	0.07	2100	2143	78.6	209	
2423	88.8	91.6	-2.8	0.969	0.05	1600	1629	79.2	209	
2452	87.6	90.0	-2.4	0.973	0.05	1700	1727	79.9	208	
2425	91.2	90.8	0.4	1.004	0.07	1700	1752	76.0	211	
2140	85.3	86.9	-1.6	0.982	0.30	1900	2631	46.2	197	
6573	82.6	81.0	1.6	1.020	0.50	1800	3527	30.6	208	
2445	82.7	82.2	0.5	1.006	0.43	2000	3287	37.4	204	
2413	92.1	84.6	7.5	1.089	0.30	1700	2491	43.0	208	
	86.0				**0.30**	**1914**	**2777**	**52.6**	**201.6**	**Mean**
	86.0	**86.1**	**-0.1**	**1.0**	**0.3**	**1914.3**	**2777.0**	**52.6**	**201.6**	**Mean w/o n/a**
	3.7				**0.21**	**221**	**839**	**22.0**	**9.2**	**Standard Deviation**
	3.7	**3.9**	**2.6**	**0.0**	**0.2**	**221.4**	**810.7**	**21.3**	**9.0**	**Std. Dev w/o n/a**
	87.4									**Acoustical Mean**
	87.4	**85.9**	**0.1**							**Acoustical Mean w/o n/a**

Correlation Data
B-767 Departures

B-767, Runway 1L, Takeoffs, North then Sharp Right Turn										
					Nominal Track Measurement:			80.6		
Site #2	INM-JT9	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2111	79.3	76.7	2.6	1.034	0.87	4700	7068	41.6	236	
0636	80.5	80.6	-0.1	0.999	0.19	4700	4839	76.2	231	
2462	77.9	n/a			0.62	4500	5865	50.1	248	
7011	71.1	75.8	-4.7	0.938	1.17	3600	7959	26.9	248	
2145	74.7	80.2	-5.5	0.931	0.75	4200	6192	42.7	245	
2436	81.1	79.5	1.6	1.020	0.60	4200	5558	49.0	240	
0655	81.1	n/a			0.15	4100	4200	77.5	263	
2423	70.2	67.8	2.4	1.035	1.17	4100	8197	30.0	245	
2452	72.9	73.9	-1.0	0.986	1.09	3400	7436	27.2	258	
2425	70.4	n/a			1.23	4300	8613	29.9	246	
2140	78.3	81.1	-2.8	0.965	0.44	4200	4977	57.5	242	
6573	77.3	79.9	-2.6	0.967	0.42	3900	4659	56.8	257	
2445	79.1	80.3	-1.2	0.985	0.13	4300	4372	79.6	239	
2413	89.1	n/a			0.22	3400	3653	68.5	256	
	77.4				0.65	4114	5970	51.0	246.7	Mean
	76.5	77.6	-1.1	1.0	0.7	4130.0	6125.6	48.7	244.1	Mean w/o n/a
	5.2				0.40	377	1548	19.2	9.1	Standard Deviation
	4.0	4.2	2.8	0.0	0.4	416.5	1444.8	18.9	8.6	Std. Dev w/o n/a
	80.6									Acoustical Mean
	77.8	78.8	-0.3							Acoustical Mean w/o n/a

Correlation Data
B-767 Departures

B-767, Runway 1L, Takeoffs, North then Sharp Right Turn										
					Nominal Track Measurement:			66.5		
Site #6	INM-JT9	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2111	69.2	n/a			1.66	2300	10331	12.8	190	
0636	70.3	n/a			1.51	2300	9445	14.1	185	
2462	66.5	n/a			1.98	1800	12147	8.5	192	
7011	63.8	n/a			1.99	1800	12207	8.5	206	
2145	64.6	n/a			1.99	1900	12222	8.9	193	
2436	69.0	n/a			1.81	2200	11199	11.3	202	
0655	69.0	n/a			1.35	2100	8455	14.4	215	
2423	70.3	71.9	-1.6	0.978	1.31	1800	8149	12.7	215	
2452	70.0	n/a			1.32	1900	8231	13.3	225	
2425	72.4	75.8	-3.4	0.955	1.25	1900	7818	14.0	220	
2140	66.4	n/a			1.74	1900	10726	10.2	197	
6573	65.0	n/a			1.92	1900	11803	9.3	212	
2445	66.4	69.8	-3.4	0.951	1.85	2100	11419	10.6	207	
2413	68.6	n/a			1.69	1900	10428	10.5	217	
	68.0				1.67	1986	10327	11.4	205.4	Mean
	69.7	72.5	-2.8	1.0	1.5	1933.3	9128.6	12.5	214.0	Mean w/o n/a
	2.5				0.29	185	1694	2.2	12.5	Standard Deviation
	3.0	3.0	1.0	0.0	0.3	152.8	1990.2	1.7	6.6	Std. Dev w/o n/a
	68.6									Acoustical Mean
	70.3	73.2	-2.7							Acoustical Mean w/o n/a

Correlation Data
B-767 Departures

B-767, Runway 1L, Takeoffs, North then Sharp Right Turn										
					Nominal Track Measurement:			68.6		
Site #11	INM-JT9	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2111	68.8	75.1	-6.3	0.916	1.44	900	8783	5.9	160	
0636	70.9	n/a			1.44	1300	8833	8.5	158	
2462	69.8	n/a			1.45	900	8843	5.8	148	
7011	68.3	n/a			1.45	800	8833	5.2	171	
2145	69.0	n/a			1.47	700	8946	4.5	165	
2436	70.0	n/a			1.46	700	8885	4.5	180	
0655	70.0	n/a			1.39	1400	8549	9.4	169	
2423	68.4	n/a			1.45	700	8825	4.5	179	
2452	68.4	n/a			1.45	600	8818	3.9	177	
2425	69.6	n/a			1.45	700	8825	4.5	178	
2140	68.5	68.4	0.1	1.001	1.45	800	8833	5.2	158	
6573	68.4	77.7	-9.3	0.880	1.46	700	8885	4.5	167	
2445	68.3	n/a			1.46	900	8903	5.8	157	
2413	69.1	n/a			1.50	1000	9155	6.3	174	
	69.1				1.45	864	8851	5.6	167.2	Mean
	68.6	73.7	-5.2	0.9	1.5	800.0	8833.9	5.2	161.7	Mean w/o n/a
	0.8				0.02	240	94	1.6	10.1	Standard Deviation
	0.2	4.8	4.8	0.1	0.0	100.0	51.4	0.7	4.7	Std. Dev w/o n/a
	69.2									Acoustical Mean
	68.6	75.1	-3.4							Acoustical Mean w/o n/a

Correlation Data
B-767 Departures

B-767, Runway 1L, Takeoffs, North then Sharp Right Turn										
					Nominal Track Measurement:			76.5		
Site #4	INM-JT9	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2111	75.9	n/a			0.74	2400	5091	28.1	197	
0636	76.5	n/a			0.86	2500	5786	25.6	197	
2462	86.9	85.7	1.2	1.014	0.36	2000	2961	42.4	209	
7011	84.2	86.9	-2.7	0.969	0.30	1900	2631	46.2	213	
2145	82.0	86.4	-4.4	0.949	0.36	2200	3100	45.2	207	
2436	73.4	n/a			0.56	2400	4160	35.2	207	
0655	73.4	n/a			1.00	2200	6454	19.9	221	
2423	71.9	n/a			1.07	1700	6711	14.7	211	
2452	72.5	n/a			1.05	1900	6648	16.6	219	
2425	74.1	n/a			1.14	1800	7147	14.6	216	
2140	79.1	82.6	-3.5	0.958	0.61	2100	4255	29.5	208	
6573	81.2	n/a			0.49	2000	3583	33.9	217	
2445	78.6	n/a			0.56	2200	4048	32.9	211	
2413	78.5	83.1	-4.6	0.945	0.71	1800	4669	22.6	213	
	77.7				0.7	2078.6	4803.0	29.1	210.4	Mean
	82.1	84.9	-2.8	1.0	0.5	2000.0	3523.3	37.2	210.0	Mean w/o n/a
	4.6				0.3	248.6	1521.8	10.8	7.2	Standard Deviation
	3.5	2.0	2.4	0.0	0.2	158.1	885.7	10.5	2.8	Std. Dev w/o n/a
	80.2									Acoustical Mean
	83.3	85.3	-2.2							Acoustical Mean w/o n/a

Correlation Data
B-767 Arrivals

B-767, Runway 19R, Arrivals										
					Nominal Track Measurement:			76.0		
Site #1	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
7336	76.6	75.6	1.0	1.013	0.38	1600	2806	34.7	157	
2416	76.1	n/a			0.38	1700	2864	36.4	166	
7204	74.9	n/a			0.38	1900	2987	39.5	167	
2556	76.1	n/a			0.41	1600	2958	32.7	155	
6735	75.1	n/a			0.39	1700	2914	35.7	161	
6761	75.8	n/a			0.38	1700	2864	36.4	163	
0743	76.1	n/a			0.39	1700	2914	35.7	164	
2367	74.4	n/a			0.38	1700	2864	36.4	193	
0750	75.8	78.3	-2.5	0.968	0.38	1700	2864	36.4	181	
2574	76.0	n/a			0.41	1700	3013	34.3	178	
2526	76.0	n/a			0.44	2100	3396	38.1	187	
2504	76.0	n/a			0.45	1900	3326	34.8	169	
6713	76.0	n/a			0.45	1800	3270	33.4	202	
7246	76.0	n/a			0.44	1700	3165	32.5	163	
2551	76.0	n/a			0.41	1600	2958	32.7	130	
2574	76.0	71.2	4.8	1.067	0.41	1600	2958	32.7	167	
6750	76.0	n/a			0.45	1700	3216	31.9	164	
2361	76.0	n/a			0.39	1700	2914	35.7	173	
2652	76.0	71.1	4.9	1.069	0.41	1700	3013	34.3	156	
6726	76.0	n/a			0.39	2100	3164	41.5	178	
6760	76.0	n/a			0.44	1800	3220	34.0	194	
0710	76.0	77.2	-1.2	0.984	0.44	1900	3277	35.4	184	
7213	76.0	75.2	0.8	1.011	0.38	1600	2806	34.7	161	
2554	76.0	78.8	-2.8	0.964	0.39	1600	2856	34.0	169	
2307	76.0	n/a			0.41	2000	3192	38.8	197	
2303	76.0	n/a			0.44	1800	3220	34.0	160	
1010	76.0	n/a			0.39	1700	2914	35.7	167	
2401	76.0	n/a			0.45	2100	3444	37.5	191	
	75.9				0.4	1764.3	3048.4	35.3	171.3	Mean
	76.1	75.3	0.7	1.0	0.4	1671.4	2940.1	34.6	167.9	Mean w/o n/a
	0.4				0.0	156.9	190.9	2.3	15.7	Standard Deviation
	0.3	3.1	3.2	0.0	0.0	111.3	167.0	1.1	11.1	Std. Dev w/o n/a
	81.8									Acoustical Mean
	76.1	76.2	1.7							Acoustical Mean w/o n/a

Correlation Data
B-767 Arrivals

B-767, Runway 19R, Arrivals										
						Nominal Track Measurement:		78.0		
Site #3	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
7336	79.7	79.1	0.6	1.008	0.07	2300	2339	79.5	184	
2416	79.0	79.6	-0.6	0.992	0.05	2300	2320	82.5	178	
7204	77.5	74.5	3.0	1.040	0.05	2600	2618	83.3	175	
2556	78.8	78.7	0.1	1.001	0.09	2300	2364	76.6	183	
6735	77.2	70.9	6.3	1.089	0.12	2300	2412	72.4	196	
6761	77.9	76.3	1.6	1.021	0.07	2400	2437	80.0	171	
0743	78.6	75.6	3.0	1.040	0.09	2400	2461	77.2	173	
2367	76.9	79.3	-2.4	0.970	0.08	2400	2449	78.6	214	
0750	77.4	79.6	-2.2	0.972	0.05	2400	2419	82.8	200	
2574	78.0	77.5	0.5	1.006	0.15	2400	2567	69.2	203	
2526	78.0	n/a			0.05	3000	3015	84.2	210	
2504	78.0	n/a			0.15	2800	2944	72.0	181	
6713	78.0	83.8	-5.8	0.931	0.05	2600	2618	83.3	226	
7246	78.0	82.0	-4.0	0.951	0.05	2300	2320	82.5	163	
2551	78.0	n/a			0.07	2200	2241	79.1	152	
2574	78.0	77.3	0.7	1.009	0.07	2300	2339	79.5	181	
6750	78.0	77.6	0.4	1.005	0.05	2400	2419	82.8	177	
2361	78.0	78.1	-0.1	0.999	0.09	2400	2461	77.2	180	
2652	78.0	76.9	1.1	1.014	0.07	2400	2437	80.0	167	
6726	78.0	68.4	9.6	1.140	0.07	2800	2832	81.4	188	
6760	78.0	73.8	4.2	1.057	0.09	2400	2461	77.2	216	
0710	78.0	81.7	-3.7	0.955	0.15	2400	2567	69.2	191	
7213	78.0	84.7	-6.7	0.921	0.07	2200	2241	79.1	180	
2554	78.0	81.6	-3.6	0.956	0.09	2300	2364	76.6	190	
2307	78.0	86.1	-8.1	0.906	0.09	2700	2755	78.6	229	
2303	78.0	83.3	-5.3	0.936	0.07	2500	2536	80.3	180	
1010	78.0	81.2	-3.2	0.961	0.12	2300	2412	72.4	185	
2401	78.0	76.6	1.4	1.018	0.09	2900	2951	79.3	200	
	78.0				0.1	2453.6	2510.7	78.4	188.3	Mean
	78.0	78.6	-0.5	1.0	0.1	2428.0	2483.9	78.5	189.2	Mean w/o n/a
	0.5				0.02	97	88	3.5	14.5	Standard Deviation
	0.6	4.1	4.1	0.1	0.0	169.6	167.6	4.0	17.6	Std. Dev w/o n/a
	78.2									Acoustical Mean
	77.9	80.0	1.6							Acoustical Mean w/o n/a

Correlation Data
B-767 Arrivals

B-767, Runway 19R, Arrivals										
						Nominal Track Measurement:		78.4		
Site #4	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
7336	78.7	n/a			0.31	1000	2130	28.0	142	
2416	78.7	n/a			0.36	1000	2402	24.6	159	
7204	77.3	91.4	-14.1	0.846	0.36	1200	2492	28.7	150	
2556	78.9	n/a			0.36	1000	2402	24.6	141	
6735	78.8	n/a			0.36	1000	2402	24.6	136	
6761	78.6	78.5	0.1	1.001	0.31	1100	2179	30.3	148	
0743	78.7	n/a			0.34	1100	2338	28.0	148	
2367	77.9	78.1	-0.2	0.997	0.34	1100	2338	28.0	171	
0750	79.1	n/a			0.30	1200	2180	33.4	139	
2574	78.4	75.5	2.9	1.038	0.37	1200	2545	28.1	136	
2526	78.4	76.2	2.2	1.029	0.36	1100	2445	26.7	171	
2504	78.4	78.3	0.1	1.001	0.36	1100	2445	26.7	139	
6713	78.4	84.0	-5.6	0.933	0.36	1200	2492	28.7	165	
7246	78.4	80.1	-1.7	0.979	0.36	1100	2445	26.7	127	
2551	78.4	75.3	3.1	1.041	0.37	1100	2500	26.1	128	
2574	78.4	n/a			0.31	1000	2130	28.0	143	
6750	78.4	n/a			0.30	1100	2127	31.1	142	
2361	78.4	n/a			0.36	1100	2445	26.7	151	
2652	78.4	n/a			0.36	1100	2445	26.7	142	
6726	78.4	n/a			0.36	1200	2492	28.7	162	
6760	78.4	79.7	-1.3	0.984	0.36	1100	2445	26.7	174	
0710	78.4	n/a			0.36	1100	2445	26.7	164	
7213	78.4	n/a			0.31	1100	2179	30.3	132	
2554	78.4	n/a			0.34	1100	2338	28.0	157	
2307	78.4	n/a			0.34	1400	2493	34.1	165	
2303	78.4	73.9	4.5	1.061	0.34	1100	2338	28.0	150	
1010	78.4	n/a			0.34	1100	2338	28.0	150	
2401	78.4	80.0	-1.6	0.980	0.31	1200	2231	32.5	165	
	78.4				0.3	1114.3	2363.7	28.2	149.9	Mean
	78.3	79.3	-1.0	1.0	0.4	1133.3	2408.0	28.1	152.0	Mean w/o n/a
	0.3				0.0	84.8	130.1	2.4	13.5	Standard Deviation
	0.3	4.7	4.9	0.1	0.0	49.2	113.1	1.8	17.0	Std. Dev w/o n/a
	78.4									Acoustical Mean
	78.3	82.8	0.6							Acoustical Mean w/o n/a

Correlation Data
DC-9 Departures

DC-9, Runway 1L, Takeoffs Straight North										
					Nominal Track Measurement:			78.2		
Site #1	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2163	78.1	79.5	-1.4	0.982	1.20	3900	8259	28.1	215	
2463	78.5	n/a			1.40	3400	9149	21.8	214	
7010	88.3	82.2	6.1	1.074	0.45	3100	4131	48.6	228	
7012	68.1	n/a			2.43	3000	15045	11.5	209	
7032	85.4	87.6	-2.2	0.975	0.33	3600	4119	60.9	251	
5604	86.7	84.8	1.9	1.022	0.45	3900	4761	55.0	247	
7072	84.1	88.4	-4.3	0.951	0.59	3600	5077	45.1	194	
2442	69.6	n/a			2.17	2800	13460	12.0	221	
2475	76.3	n/a			1.45	4600	9927	27.6	239	
2145	75.8	n/a			1.28	4100	8782	27.8	231	
2460	81.3	n/a			0.89	4400	6965	39.1	236	
5651	81.1	93.7	-12.6	0.866	1.07	3000	7151	24.8	210	
0634	86.4	86.0	0.4	1.005	0.58	3500	4963	44.8	208	
	80.0				1.10	3608	7830	34.4	223.3	Mean
	84.3	86.0	-1.7	1.0	0.7	3514.3	5494.4	43.9	221.9	Mean w/o n/a
	6.4				0.66	557	3474	15.8	17.0	Standard Deviation
	3.6	4.6	5.8	0.1	0.3	353.2	1588.2	13.2	21.1	Std. Dev w/o n/a
	83.1									Acoustical Mean
	85.3	88.1	0.8							Acoustical Mean w/o n/a

Correlation Data

DC-9 Departures

DC-9, Runway 1L, Takeoffs Straight North						Nominal Track Measurement		93.8		
Site #5	INM	Measured	Delta	Acc Ratio	Closest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P M	nm	ft	ft	Deg	knots	
2163	92.3	94.0	-1.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	191	
2463	94.0	84.2	9.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	201	
7010	88.5	96.8	-8.3	[illegible]	[illegible]	[illegible]	[illegible]	24.7	196	
7012	93.8	86.5	7.3	[illegible]	[illegible]	[illegible]	2941	40.2	206	
7032	85.5	83.0	2.5	1.030	0.75	2500	5192	28.7	228	
5604	89.6	84.3	5.3	1.063	0.57	2100	4046	31.2	214	
7072	88.6	84.3	4.3	1.051	0.52	2200	3846	34.8	180	
2442	94.1	84.4	9.7	1.115	0.20	2000	2339	58.7	211	
2475	92.6	91.9	0.7	1.008	0.19	2400	2662	64.3	232	
2145	90.2	88.2	2.0	1.023	0.13	2400	2526	71.8	191	
2460	88.4	89.7	-1.3	0.986	0.57	2400	4209	34.7	215	
5651	93.5	86.0	7.5	1.087	0.37	2100	3074	43.0	188	
0634	89.3	90.0	-0.7	0.992	0.46	2000	3433	35.6	196	
	90.8				**0.41**	**2192**	**3432**	**44.7**	**203.8**	**Mean**
	90.8	**87.9**	**2.9**	**1.0**	**0.4**	**2192.3**	**3432.3**	**44.7**	**203.8**	**Mean w/o n/a**
	2.8				**0.21**	**185**	**955**	**15.3**	**15.7**	**Standard Deviation**
	2.8	**4.3**	**5.2**	**0.1**	**0.2**	**184.7**	**955.3**	**15.3**	**15.7**	**Std. Dev w/o n/a**
	91.5									**Acoustical Mean**
	91.5	**90.2**	**5.2**							**Acoustical Mean w/o n/a**

Correlation Data
DC-9 Departures

DC-9, Runway 1L, Takeoffs Straight North										
					Nominal Track Measurement:			76.7		
Site #3	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2163	77.3	n/a			1.37	5300	9858	32.5	238	
2463	85.9	82.9	3.0	1.036	0.53	4300	5369	53.2	258	
7010	88.2	85.6	2.6	1.030	0.15	4100	4200	77.5	253	
7012	64.8	71.4	-6.6	0.908	2.97	4000	18458	12.5	244	
7032	82.1	83.5	-1.4	0.983	0.68	5200	6638	51.5	260	
5604	85.2	84.0	1.2	1.014	0.07	5300	5317	85.4	263	
7072	77.3	68.3	9.0	1.132	1.62	4100	10649	22.6	212	
2442	66.7	n/a			2.76	3400	17087	11.5	223	
2475	73.8	n/a			1.70	5600	11736	28.5	257	
2145	73.0	78.8	-5.8	0.926	1.17	4900	8625	34.6	267	
2460	79.8	81.8	-2.0	0.976	0.95	5900	8248	45.6	241	
5651	80.6	96.5	-15.9	0.835	1.12	4100	7936	31.1	238	
0634	86.9	87.1	-0.2	0.998	0.18	4900	5020	77.4	219	
	78.6				**1.2**	**4700.0**	**9164.7**	**43.4**	**244.1**	**Mean**
	80.4	**82.0**	**-1.6**	**1.0**	**0.9**	**4680.0**	**8046.1**	**49.1**	**245.5**	**Mean w/o n/a**
	7.4				**0.92**	**748**	**4458**	**24.5**	**17.7**	**Standard Deviation**
	7.2	**7.9**	**6.7**	**0.1**	**0.9**	**654.6**	**4164.8**	**24.8**	**18.5**	**Std. Dev w/o n/a**
	82.7									**Acoustical Mean**
	83.7	**88.0**	**2.0**							**Acoustical Mean w/o n/a**

Correlation Data

DC-9 Departures

DC-9, Runway 1L, Takeoffs Straight North										
					Nominal Track Measurement:			84.0		
Site #4	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2163	85.4	88.1	-2.7	0.969	1.37	5300	9858	32.5	194	
2463	83.3	n/a			0.53	4300	5369	53.2	205	
7010	91.0	88.4	2.6	1.029	0.15	4100	4200	77.5	202	
7012	77.5	n/a			2.97	4000	18458	12.5	206	
7032	89.6	86.0	3.6	1.042	0.68	5200	6638	51.5	229	
5604	91.4	89.1	2.3	1.026	0.07	5300	5317	85.4	224	
7072	91.9	86.6	5.3	1.061	1.62	4100	10649	22.6	185	
2442	77.5	80.6	-3.1	0.962	2.76	3400	17087	11.5	211	
2475	83.0	83.2	-0.2	0.998	1.70	5600	11736	28.5	237	
2145	82.8	76.2	6.6	1.087	1.17	4900	8625	34.6	194	
2460	88.6	n/a			0.95	5900	8248	45.6	221	
5651	87.0	83.5	3.5	1.042	1.12	4100	7936	31.1	194	
0634	89.8	85.7	4.1	1.048	0.18	4900	5020	77.4	202	
	86.1				**1.17**	**4700**	**9165**	**43.4**	**208.0**	**Mean**
	86.9	**84.7**	**2.2**	**1.0**	**1.1**	**4690.0**	**8706.6**	**45.2**	**207.2**	**Mean w/o n/a**
	5.0				**0.92**	**748**	**4458**	**24.5**	**15.6**	**Standard Deviation**
	4.7	**4.0**	**3.2**	**0.0**	**0.8**	**717.2**	**3869.7**	**26.1**	**17.4**	**Std. Dev w/o n/a**
	88.1									**Acoustical Mean**
	88.7	**86.0**	**3.1**							**Acoustical Mean w/o n/a**

Correlation Data

DC-9 Departures

DC-9, Runway 1L, Takeoffs Straight North										
					Nominal Track Measurement:			86.6		
Site #2	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
2163	85.8	87.6	-1.8	0.979	0.16	5000	5093	79.0	238	
2463	82.5	n/a			0.64	3900	5503	45.1	249	
7010	77.6	n/a			1.22	3900	8366	27.7	250	
7012	74.4	n/a			1.64	4000	10724	21.9	244	
7032	84.5	n/a			0.60	5500	6596	56.5	261	
5604	77.3	79.4	-2.1	0.974	1.25	5000	9084	33.4	262	
7072	82.3	81.7	0.6	1.007	0.83	4500	6753	41.7	231	
2442	77.0	n/a			1.46	3700	9600	22.6	227	
2475	83.8	n/a			0.41	5600	6128	66.0	257	
2145	82.3	n/a			0.16	4900	4995	78.8	267	
2460	83.5	n/a			0.38	6200	6615	69.6	242	
5651	87.7	n/a			0.27	4100	4415	68.2	238	
0634	79.1	n/a			1.11	4700	8212	34.9	218	
	81.4				0.8	4692.3	7083.4	49.6	244.9	Mean
	81.8	82.9	-1.1	1.0	0.7	4833.3	6976.8	51.4	243.7	Mean w/o n/a
	3.9				0.5	768.6	1956.2	21.0	14.6	Standard Deviation
	4.3	4.2	1.5	0.0	0.5	288.7	2004.5	24.3	16.3	Std. Dev w/o n/a
	82.8									Acoustical Mean
	83.0	84.3	-0.9							Acoustical Mean w/o n/a

Correlation Data

DC-9 Arrivals

DC-9, Runway 12, Arrivals, Straight In										
					Nominal Track Measurement:			87.2		
Site #9	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
4054	87.2	87.4	-0.2	0.998	0.10	1000	1170	58.7	124	
1775	87.2	84.0	3.2	1.038	0.12	900	1158	51.0	166	
7021	87.2	87.3	-0.1	0.999	0.13	900	1197	48.7	126	
2173	87.2	87.3	-0.1	0.999	0.13	800	1123	45.4	130	
6026	87.2	83.5	3.7	1.044	0.10	1000	1170	58.7	148	
4162	87.2	90.6	-3.4	0.962	0.12	800	1082	47.7	133	
2534	87.2	85.2	2.0	1.023	0.13	800	1123	45.4	158	
4152	87.2	84.6	2.6	1.031	0.12	800	1082	47.7	133	
4162	87.2	87.1	0.1	1.001	0.12	900	1158	51.0	148	
5736	87.2	85.9	1.3	1.015	0.12	900	1158	51.0	132	
7460	87.2	86.4	0.8	1.009	0.12	900	1158	51.0	135	
0742	87.2	84.1	3.1	1.037	0.12	1000	1237	53.9	137	
3612	87.2	n/a			0.13	800	1123	45.4	152	
2645	87.2	89.8	-2.6	0.971	0.12	800	1082	47.7	132	
2516	87.2	n/a			0.13	800	1123	45.4	156	
3042	87.2	85.2	2.0	1.023	0.12	900	1158	51.0	137	
6023	87.2	89.5	-2.3	0.974	0.13	1000	1274	51.7	145	
7445	87.2	87.9	-0.7	0.992	0.13	900	1197	48.7	144	
7054	87.2	84.1	3.1	1.037	0.10	900	1085	56.0	143	
7423	87.2	85.1	2.1	1.025	0.13	800	1123	45.4	129	
4130	87.2	88.3	-1.1	0.988	0.12	800	1082	47.7	140	
3066	87.2	84.9	2.3	1.027	0.12	900	1158	51.0	145	
2523	87.2	86.3	0.9	1.010	0.16	900	1324	42.8	143	
7416	87.2	88.2	-1.0	0.989	0.12	900	1158	51.0	138	
7066	87.2	90.2	-3.0	0.967	0.13	900	1197	48.7	142	
7053	87.2	89.2	-2.0	0.978	0.16	800	1258	39.5	137	
7426	87.2	n/a			0.10	900	1085	56.0	152	
3636	87.2	90.0	-2.8	0.969	0.10	1000	1170	58.7	148	
	87.2				0.1	882.1	1157.5	49.9	141.2	**Mean**
	85.0	84.6	1.7	2.2	1.4	849.3	1117.6	48.9	135.1	**Mean w/o n/a**
	0.0				0.01	72	61	4.8	10.1	**Standard Deviation**
	0.0	2.2	2.2	0.0	0.0	71.1	63.0	4.8	9.8	**Std. Dev w/o n/a**
	87.2									**Acoustical Mean**
	86.9	86.9	0.3							**Acoustical Mean w/o n/a**

Correlation Data
DC-9 Arrivals

DC-9, Runway 12, Arrivals, Straight In										
						Nominal Track Measurement:		79.3		
Site #12	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation		
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg		
4054	79.3	74.8	4.5	1.060	0.59	600	3629	9.5	122	
1775	79.3	n/a			0.66	600	4049	8.5	132	
7021	79.3	76.4	2.9	1.038	0.59	600	3629	9.5	125	
2173	79.3	72.4	6.9	1.095	0.59	600	3629	9.5	115	
6026	79.3	76.3	3.0	1.039	0.59	700	3647	11.0	135	
4162	79.3	n/a			0.65	600	3989	8.6	128	
2534	79.3	n/a			0.65	600	3989	8.6	147	
4152	79.3	72.6	6.7	1.092	0.66	600	4049	8.5	121	
4162	79.3	74.8	4.5	1.060	0.65	600	3989	8.6	141	
5736	79.3	77.2	2.1	1.027	0.65	600	3989	8.6	121	
7460	79.3	n/a			0.59	700	3647	11.0	133	
0742	79.3	n/a			0.59	700	3647	11.0	126	
3612	79.3	n/a			0.65	500	3975	7.2	161	
2645	79.3	n/a			0.65	600	3989	8.6	130	
2516	79.3	n/a			0.59	600	3629	9.5	153	
3042	79.3	72.0	7.3	1.101	0.65	600	3989	8.6	116	
6023	79.3	n/a			0.65	600	3989	8.6	141	
7445	79.3	n/a			0.53	600	3271	10.6	125	
7054	79.3	n/a			0.65	600	3989	8.6	130	
7423	79.3	n/a			0.59	500	3614	7.9	120	
4130	79.3	70.1	9.2	1.131	0.53	600	3271	10.6	134	
3066	79.3	n/a			0.59	600	3629	9.5	120	
2523	79.3	92.1	-12.8	0.861	0.65	600	3989	8.6	138	
7416	79.3	73.5	5.8	1.079	0.59	600	3629	9.5	121	
7066	79.3	n/a			0.66	600	4049	8.5	139	
7053	79.3	83.9	-4.6	0.945	0.72	600	4409	7.8	124	
7426	79.3	n/a			0.65	600	3989	8.6	127	
3636	79.3	84.5	-5.2	0.938	0.47	600	2914	11.9	122	
	79.3				0.6	603.6	3793.2	9.2	130.3	Mean
	79.3	77.0	2.3	1.0	0.6	607.7	3751.1	9.4	125.8	Mean w/o n/a
	0.0				0.1	42.9	308.3	1.1	11.1	Standard Deviation
	0.0	6.2	6.2	0.1	0.1	27.7	381.8	1.1	8.4	Std. Dev w/o n/a
	79.3									Acoustical Mean
	76.0	79.4	1.4							Acoustical Mean w/o n/a

Correlation Data
DC-9 Arrivals

DC-9, Runway 12, Arrivals, Straight In										
						Nominal Track Measurement:		74.0		
Site #10	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation		
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg		
4054	74.0	n/a			0.35	2400	3205	48.5	194	
1775	74.0	n/a			0.29	2100	2740	50.0	229	
7021	74.0	n/a			0.31	2200	2894	49.4	194	
2173	74.0	n/a			0.34	2200	3016	46.8	206	
6026	74.0	77.5	-3.5	0.955	0.38	2300	3257	44.9	182	
4162	74.0	68.5	5.5	1.080	0.31	2100	2819	48.1	183	
2534	74.0	n/a			0.39	2100	3164	41.5	233	
4152	74.0	n/a			0.23	2300	2690	58.7	201	
4162	74.0	n/a			0.39	2300	3300	44.1	243	
5736	74.0	n/a			0.34	2100	2944	45.5	227	
7460	74.0	n/a			0.40	2400	3413	44.6	222	
0742	74.0	77.6	-3.6	0.954	0.40	2900	3781	50.0	229	
3612	74.0	77.7	-3.7	0.952	0.40	2200	3276	42.2	188	
2645	74.0	n/a			0.35	2400	3205	48.5	187	
2516	74.0	n/a			0.40	2600	3557	46.9	220	
3042	74.0	n/a			0.40	2500	3484	45.8	172	
6023	74.0	n/a			0.34	2700	3398	52.6	179	
7445	74.0	n/a			0.34	2500	3241	50.4	221	
7054	74.0	n/a			0.34	2400	3165	49.3	178	
7423	74.0	n/a			0.34	2200	3016	46.8	168	
4130	74.0	n/a			0.30	2100	2779	49.0	225	
3066	74.0	n/a			0.37	2200	3143	44.4	186	
2523	74.0	n/a			0.35	2100	2986	44.6	200	
7416	74.0	n/a			0.41	2300	3388	42.7	210	
7066	74.0	n/a			0.38	2400	3328	46.1	178	
7053	74.0	n/a			0.37	2200	3143	44.4	218	
7426	74.0	71.8	2.2	1.031	0.40	2200	3276	42.2	232	
3636	74.0	79.4	-5.4	0.932	0.34	2400	3165	49.3	2002	
	74.0				0.36	2314	3170	47.0	268.1	Mean
	74.0	75.4	-1.4	1.0	0.4	2350.0	3262.1	46.1	502.7	Mean w/o n/a
	0.0				0.04	198	255	3.7	340.5	Standard Deviation
	0.0	4.3	4.3	0.1	0.0	288.1	308.5	3.5	734.9	Std. Dev w/o n/a
	74.0									Acoustical Mean
	67.3	70.0	-6.1							Acoustical Mean w/o n/a

Correlation Data

DC-10 Arrivals

DC-10, Runway 12, Arrivals, Straight In										
					Nominal Track Measurement:			66.5		
Site #7	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
3751	66.5	n/a			0.88	1400	5519	14.7	156	
3215	66.5	n/a			0.86	1400	5402	15.0	172	
3275	66.5	n/a			0.84	1600	5342	17.4	152	
7046	66.5	n/a			0.86	1800	5519	19.0	195	
7050	66.5	n/a			0.87	1400	5461	14.8	156	
7037	66.5	63.9	2.6	1.041	0.86	1600	5457	17.0	181	
7004	66.5	n/a			0.86	1400	5402	15.0	157	
6705	66.5	n/a			0.85	1600	5399	17.2	154	
3366	66.5	69.2	-2.7	0.961	0.84	1500	5312	16.4	176	
6555	66.5	n/a			0.87	1400	5461	14.8	148	
2762	66.5	71.6	-5.1	0.929	0.88	1400	5519	14.7	176	
1476	66.5	n/a			0.85	1600	5399	17.2	158	
4157	66.5	n/a			0.87	1400	5461	14.8	172	
3231	66.5	n/a			0.88	1500	5546	15.7	131	
	66.5				0.9	1500.0	5442.9	16.0	163.1	**Mean**
	66.5	68.2	-1.7	1.0	0.9	1500.0	5429.8	16.0	177.7	**Mean w/o n/a**
	0.0				0.0	124.0	70.0	1.4	16.3	**Standard Deviation**
	0.0	3.9	3.9	0.1	0.0	100.0	106.2	1.2	2.9	**Std. Dev w/o n/a**
	66.5									**Acoustical Mean**
	66.5	69.2	-0.5							**Acoustical Mean w/o n/a**

Correlation Data
DC-10 Arrivals

DC-10, Runway 12, Arrivals, Straight In										
					Nominal Track Measurement:			86.1		
Site #9	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
3751	86.1	78.6	7.5	1.095	0.13	800	1123	45.4	145	
3215	86.1	88.3	-2.2	0.975	0.10	800	1004	52.8	158	
3275	86.1	90.1	-4.0	0.956	0.11	1000	1202	56.2	144	
7046	86.1	87.8	-1.7	0.981	0.17	1000	1437	44.1	164	
7050	86.1	89.9	-3.8	0.958	0.12	800	1082	47.7	145	
7037	86.1	87.1	-1.0	0.989	0.16	900	1324	42.8	151	
7004	86.1	88.5	-2.4	0.973	0.16	900	1324	42.8	154	
6705	86.1	85.7	0.4	1.005	0.12	900	1158	51.0	154	
3366	86.1	89.8	-3.7	0.959	0.31	1000	2130	28.0	173	
6555	86.1	87.6	-1.5	0.983	0.12	900	1158	51.0	148	
2762	86.1	83.7	2.4	1.029	0.13	800	1123	45.4	148	
1476	86.1	86.6	-0.5	0.994	0.12	900	1158	51.0	130	
4157	86.1	82.1	4.0	1.049	0.16	800	1258	39.5	150	
3231	86.1	85.5	0.6	1.007	0.11	1000	1202	56.2	138	
	86.1				0.1	892.9	1263.0	46.7	150.1	**Mean**
	86.1	86.5	-0.4	1.0	0.1	892.9	1263.0	46.7	150.1	**Mean w/o n/a**
	0.0				0.1	82.9	273.0	7.4	10.6	**Standard Deviation**
	0.0	3.2	3.2	0.0	0.1	82.9	273.0	7.4	10.6	**Std. Dev w/o n/a**
	86.1									**Acoustical Mean**
	86.1	87.4	1.0							**Acoustical Mean w/o n/a**

Correlation Data
DC-10 Arrivals

DC-10, Runway 12, Arrivals, Straight In										
					Nominal Track Measurement:			74.0		
Site #10	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
3751	74.0	n/a			0.31	2300	2971	50.7	185	
3215	74.0	n/a			0.30	2200	2855	50.4	213	
3275	74.0	n/a			0.38	2300	3257	44.9	188	
7046	74.0	78.0	-4.0	0.949	0.40	2800	3705	49.0	222	
7050	74.0	77.0	-3.0	0.961	0.40	2100	3209	40.8	203	
7037	74.0	76.8	-2.8	0.964	0.30	2300	2933	51.6	214	
7004	74.0	78.2	-4.2	0.946	0.08	2600	2645	79.4	175	
6705	74.0	78.4	-4.4	0.944	0.37	2300	3214	45.7	186	
3366	74.0	77.0	-3.0	0.961	0.31	2300	2971	50.7	191	
6555	74.0	75.8	-1.8	0.976	0.38	2400	3328	46.1	180	
2762	74.0	74.1	-0.1	0.999	0.34	2100	2944	45.5	188	
1476	74.0	81.8	-7.8	0.905	0.34	2300	3090	48.1	197	
4157	74.0	75.4	-1.4	0.981	0.38	2100	3119	42.3	182	
3231	74.0	n/a			0.34	2400	3165	49.3	140	
	74.0				0.3	2321.4	3100.3	49.6	190.3	**Mean**
	74.0	77.3	-3.3	1.0	0.3	2330.0	3115.7	49.9	193.8	**Mean w/o n/a**
	0.0				0.1	192.9	251.9	9.2	20.2	**Standard Deviation**
	0.0	2.1	2.1	0.0	0.1	226.3	282.3	10.9	15.2	**Std. Dev w/o n/a**
	74.0									**Acoustical Mean**
	74.0	77.8	-2.8							**Acoustical Mean w/o n/a**

Correlation Data

DC-10 Arrivals

DC-10, Runway 12, Arrivals, Straight In										
					Nominal Track Measurement:			78.6		
Site #12	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Speed	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
3751	78.6	80.3	-1.7	0.979	0.65	600	3989	8.6	150	
3215	78.6	76.9	1.7	1.022	0.66	600	4049	8.5	156	
3275	78.6	n/a			0.65	700	4005	10.1	151	
7046	78.6	n/a			0.72	700	4424	9.1	144	
7050	78.6	73.1	5.5	1.075	0.66	600	4049	8.5	146	
7037	78.6	76.3	2.3	1.030	0.53	600	3271	10.6	127	
7004	78.6	75.9	2.7	1.036	0.59	600	3629	9.5	144	
6705	78.6	n/a			0.53	600	3271	10.6	141	
3366	78.6	71.3	7.3	1.102	0.53	600	3271	10.6	170	
6555	78.6	n/a			0.66	700	4065	9.9	141	
2762	78.6	n/a			0.65	600	3989	8.6	142	
1476	78.6	n/a			0.59	600	3629	9.5	130	
4157	78.6	n/a			0.66	600	4049	8.5	125	
3231	78.6	n/a			0.66	700	4065	9.9	135	
	78.6				0.6	628.6	3839.7	9.5	143.0	Mean
	78.6	75.6	3.0	1.0	0.6	600.0	3709.7	9.4	148.8	Mean w/o n/a
	0.0				0.1	46.9	362.1	0.8	11.9	Standard Deviation
	0.0	3.1	3.1	0.0	0.1	0.0	374.0	1.0	14.2	Std. Dev w/o n/a
	78.6									Acoustical Mean
	78.6	76.6	3.9							Acoustical Mean w/o n/a

DC10, Departure, 30, Left turn after take-off										
						Nominal Track Measurement:		82.3		
Site #7	INM	Measured	Delta	Acc. Ratio	Dnearest	Altitude	Slant Range	Elevation	Velocity	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
0626	85.5	84.8	0.7	1.008	0.42	2700	3713	46.6	214	
5664	85.5	85.0	0.5	1.006	0.31	2700	3290	55.1	226	
2461	85.5	85.4	0.1	1.001	0.15	2800	2944	72.0	240	
2112	85.5	n/a			0.21	2100	2456	58.7	235	
0561	73.7	n/a			1.16	2700	7538	21.0	256	
6503	73.7	n/a			1.14	2600	7389	20.6	212	
6502	73.7	n/a			0.50	2500	3931	39.5	229	
	80.4				0.56	2586	4466	44.8	230.3	Mean
	85.5	85.1	0.4	1.0	0.3	2733.3	3315.7	57.9	226.7	Mean w/o n/a
	6.3				0.42	234	2104	19.3	15.3	Standard Deviation
	0.0	0.3	0.3	0.0	0.1	57.7	384.8	12.9	13.0	Std. Dev w/o n/a
	83.3									Acoustical Mean
	85.5	85.1	0.4							Acoustical Mean w/o n/a

DC10, Departure, 30, Left turn after take-off										
						Nominal Track Measurement:		92.0		
Site #9	**INM**	**Measured**	**Delta**	**Acc. Ratio**	**Dnearest**	**Altitude**	**Slant Range**	**Elevation**	**Velocity**	
Squawk	**SEL, dB**	**SEL, dB**	**SEL, dB**	**P/M**	**nm**	**Ft**	**Ft**	**Deg**	**knots**	
0626	90.5	91.0	-0.5	0.995	0.19	1900	2222	58.7	185	
5664	90.5	92.9	-2.4	0.974	0.07	1900	1947	77.4	185	
2461	90.5	90.3	0.2	1.002	0.16	1900	2134	62.9	200	
2112	90.5	91.2	-0.7	0.992	0.11	1600	1734	67.3	203	
0561	87.8	81.3	6.5	1.080	0.53	1500	3548	25.0	218	
6503	87.8	87.2	0.6	1.007	0.30	1800	2560	44.6	195	
6502	87.8	88.5	-0.7	0.992	0.11	1800	1920	69.6	196	
	89.3				0.21	1771	2295	57.9	197.4	Mean
	89.3	88.9	0.4	1.0	0.21	1771	2295	57.9	197.4	Mean w/o n/a
	1.4				0.16	160	612	17.8	11.4	Standard Deviation
	1.4	3.8	2.8	0.03	0.16	160	612	17.8	11.4	Std. Dev w/o n/a
	89.5									Acoustical Mean
	89.5	90.0	1.5							Acoustical Mean w/o n/a

DC10, Departure, 30, Left turn after take-off										
						Nominal Track Measurement:		89.1		
Site #12	**INM**	**Measured**	**Delta**	**Acc. Ratio**	**Dnearest**	**Altitude**	**Slant Range**	**Elevation**	**Velocity**	
Squawk	**SEL, dB**	**SEL, dB**	**SEL, dB**	**P/M**	**nm**	**Ft**	**Ft**	**Deg**	**knots**	
0626	89.1	85.8	3.3	1.038	0.30	900	2030	26.3	175	
5664	89.1	82.1	7.0	1.085	0.31	800	2044	23.0	175	
2461	89.1	88.4	0.7	1.008	0.28	1000	1971	30.4	168	
2112	89.1	88.0	1.1	1.013	0.30	1000	2077	28.7	168	
0561	88.6	84.1	4.5	1.054	0.34	1000	2292	25.8	187	
6503	88.6	86.8	1.8	1.021	0.30	1100	2127	31.1	169	
6502	88.6	n/a			0.29	900	1976	27.1	168	
	88.9				**0.30**	**957**	**2074**	**27.5**	**172.9**	**Mean**
	88.9	**85.9**	**3.1**	**1.0**	**0.3**	**966.7**	**2090.2**	**27.6**	**173.7**	**Mean w/o n/a**
	0.3				**0.02**	**98**	**111**	**2.8**	**7.0**	**Standard Deviation**
	0.3	**2.4**	**2.4**	**0.0**	**0.0**	**103.3**	**111.6**	**3.1**	**7.3**	**Std. Dev w/o n/a**
	88.9									**Acoustical Mean**
	88.9	**86.4**	**3.7**							**Acoustical Mean w/o n/a**

Correlation Data
DC-10 Departures

DC10, Departure, 30, Left turn after take-off						Nominal Track Measurement		85.5		
Site #14	INM	Measured	Delta	Acc Ratio	Dnearest	Altitude	Slant Range	Elevation	Velocity	
Squawk	SEL, dB	SEL, dB	SEL, dB	P/M	nm	Ft	Ft	Deg	knots	
0626	86.2	n/a			0.62	3100	4874	39.5	214	
5664	86.2	n/a			0.43	2300	3478	41.4	226	
2461	86.2	n/a			0.55	2100	3943	32.1	246	
2112	86.2	84.1	2.1	1.025	0.61	1600	4032	23.3	235	
0561	76.2	66.6	9.6	1.144	0.50	2100	3689	34.7	255	
6503	76.2	n/a			0.37	2200	3143	44.4	216	
6502	76.2	n/a			0.87	2200	5718	22.6	229	
	81.9				0.56	2229	4125	34.0	231.6	Mean
	81.2	75.4	5.9	1.1	0.6	1850.0	3860.7	29.0	245.0	Mean w/o n/a
	5.3				0.16	446	886	8.6	15.0	Standard Deviation
	7.1	12.4	5.3	0.1	0.1	353.6	242.2	8.0	14.1	Std. Dev w/o n/a
	84.1									Acoustical Mean
	83.6	81.2	7.3							Acoustical Mean w/o n/a

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	June 1996	Contractor Report

4. TITLE AND SUBTITLE
Validation of Aircraft Noise Models at Lower Levels of Exposure

5. FUNDING NUMBERS
CNAS1-20103
TA 9
WU 538-03-15-01

6. AUTHORS
Juliet A. Page, Kenneth J. Plotkin, Jeffrey N. Carey, and Kevin A. Bradley

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
McDonnell Douglas Aerospace
2401 Wardlow Road
Long Beach, CA 90807-4418

Subcontractor:
Wyle Laboratories
2001 Jefferson Davis Highway
Arlington, VA 22202

8. PERFORMING ORGANIZATION REPORT NUMBER
Wyle Research Report WR 96-11
MDA Report CRAD-9310-TR-1757

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Langley Research Center
Hampton, VA 23681-0001

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
NASA CR-198315

11. SUPPLEMENTARY NOTES
This report was prepared by Wyle Laboratories under Subcontract RD-27031-C, Task 9, for McDonnell Douglas Aerospace under NASA Prime Contract No. NAS1-20103, Task 9.
Langley Technical Monitor: Kevin P. Shepherd

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Unclassified—Unlimited

Subject Category 71

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Noise levels around airports and airbases in the United States are computed via the FAA's Integrated Noise Model (INM) or the Air Force's NOISEMAP (NMAP) program. These models were originally developed for use in the vicinity of airports, at distances which encompass an L_{dn} of 65 dB or higher. There is increasing interest in aircraft noise at larger distances from the airport, including en-route noise. To evaluate the applicability of INM and NMAP at larger distances, a measurement program was conducted at a major air carrier airport with monitoring sites located in areas exposed to an L_{dn} of 55 dB and higher. ARTS radar tracking data were obtained to provide actual flight parameters and positive identification of aircraft. Flight operations were grouped according to aircraft type, stage length, straight versus curved flight tracks, and arrival versus departure. Sound exposure levels were computed at monitoring locations, using the INM, and compared with measured values. While individual overflight SEL data was characterized by a high variance, analysis performed on an energy-averaging basis indicates that INM and similar models can be applied to regions exposed to an L_{dn} of 55 dB with no loss of reliability.

14. SUBJECT TERMS
Aircraft Noise
Measurement Program
INM
NOISEMAP

15. NUMBER OF PAGES
114

16. PRICE CODE
A06

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified		

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102