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ACOUSTIC AND FUEL CONSUMPTION EFFECTS RESULTING FROM THE INSTALLATION OF SPIROID WINGLETS ON AIRCRAFT

Final Report
September 2011

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13. ABSTRACT (Maximum 200 words)

The Volpe National Transportation System Center's Environmental Measurement and Modeling Division (Volpe Center), is supporting the FAA in implementing its Next Generation Air Transportation System (NextGen) Program. The objective of the NextGen Program is to design and implement an air transportation system capable of accommodating an expected tripling in required capacity over the next 25 years. As part of this initiative, the Volpe Center participated in a study to determine the potential fuel saving and noise reduction benefits of installing experimental spiroid winglets on an aircraft.

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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS – WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup ©	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F	=	y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS – WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

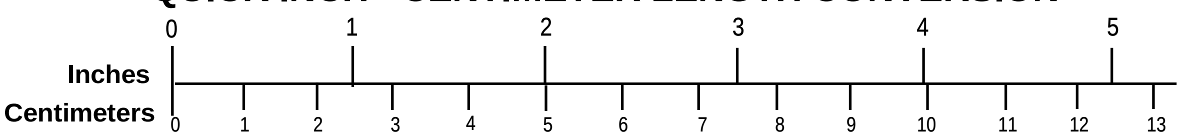
VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

[(9/5) y + 32] °C	=	x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



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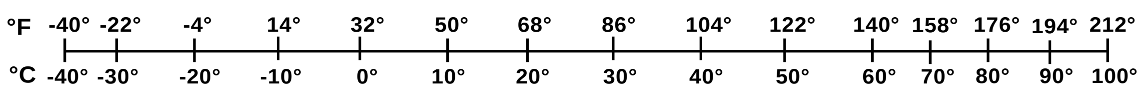

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. SD Catalog No. C13 10286

Acknowledgements

The authors of this report wish to express their sincere gratitude to all who helped make this a successful study, including API employees Hank Thompson and Mike Williams, AeroTEC employee Doug MacSparran,. The staff at Needles and Port Angeles International Airport was also instrumental in the successful completion of this study. In particular, the efforts of Terry Stover, Needles Airport Manager, Doug Sandau, Port Angeles Airport and Marina Manager, and Jeff Williams, Fairchild Airport Maintenance, were invaluable.

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1 INTRODUCTION

1.1 Background and Objectives

Aviation Partners, Inc. (API) implemented their second-generation, experimental spiroid winglets on a Dassault Falcon 50 test aircraft. The winglets are composed of hollow, machined parts and resemble large ribbon-shaped winglets that are attached to each wingtip of the aircraft (see Figure 1). API claims the spiroid winglets cut fuel burn of any aircraft by between 6% and 10% in cruise flight*, relative to standard wing configurations.

Figure 1. Aviation Partners' Spiroid Winglets Installed on a Falcon 50 Aircraft

The Volpe National Transportation System Center's Environmental Measurement and Modeling Division (Volpe Center), is supporting the Federal Aviation Administration (FAA) in implementing its Next Generation Air Transportation System (NextGen) program. The objective of NextGen is to design and implement an air transportation system capable of accommodating an expected tripling in required capacity over the next 25 years. As part of this initiative, the Volpe Center conducted a study to determine the potential fuel saving and noise reduction benefits of installing experimental spiroid winglets on an aircraft.

In March and August of 2010, the Volpe Center with the support of Aerospace Testing, Engineering, and Certification (AeroTEC) Corporation of Seattle, conducted field measurement studies to quantify the effects of the spiroid winglets installed on a Dassault Falcon 50. From this point on this aircraft will be referred to as the "test aircraft". The first objective of the measurements was to determine if the installation of spiroid winglets resulted in a reduction of fuel consumption. The second objective was to identify changes, if any, in the noise signature of the test aircraft, as a result of installing the spiroid winglets. This was completed by a joint study

* As stated from API's website, http://www.aviationpartners.com/future.html

between the Volpe Center, whom conducted the noise measurements, and AeroTEC whom collected data on fuel burn.

The measurement study consisted of two phases. Phase I, completed in March 2010, was the baseline measurement. The baseline phase involved the measurement and data collection of the fuel consumption and noise signature of the test aircraft prior to installation of the spiroid winglets. After the baseline measurements were conducted, API installed the spiroid winglets on the test aircraft. Phase II of the measurement study, which was conducted in August 2010, consisted of measurements done with the same measurement methodology as Phase I, but with the spiroid winglets installed on the test aircraft. This “before and after” type measurement study was designed to quantify the installation effects of the spiroid winglets on the test aircraft.

2 TEST AIRCRAFT

2.1 Dassault Falcon 50

The test aircraft is a Dassault Aviation Mystere Falcon 50. It is a mid-sized, long-range corporate jet powered by three AlliedSignal TFE731-3-1C turbofan engines. This aircraft is designed to carry 2 crew members and 8 to 9 passengers. Table 1 lists further characteristics of the test aircraft. Figure 2 and 3 show the actual test aircraft pre- and post-installation of the spiroid winglets, respectively. No other modifications relevant to fuel burn and noise were made to the aircraft between the Phase I and II measurements.

Table 1. Characteristics of a Dassault Falcon 50

Aircraft Manufacturer	Dassault Aviation
Aircraft Model	Falcon 50
Registration Number	N789JC
Aircraft Type	Turbo Jet
Aircraft Wingspan (ft)	61.875
Maximum Gross Takeoff Weight (lb)	40,780
Number and Type of Engine(s)	(3) AlliedSignal TFE731-3-1C
Number of Passengers	8-9

Figure 2. Test Aircraft Before Installation of Spiroid Winglets

Figure 3. Test Aircraft with Spiroid Winglets Installed

3 MEASUREMENT DATES AND TEST SITES

The Phase I baseline measurements were conducted on March 8, 2010 in Needles, CA. The Phase II measurements were conducted on August 3, 2010 in Port Angeles, WA.

3.1 Test Site Selection Methodology

Acoustical considerations in selecting aircraft flight test sites include the following:

- To minimize the effect of altitude on aircraft performance, the elevation of the measurement site should be at or below approximately 2,000 feet above mean sea level (MSL);
- To lessen the risk of external acoustic contamination, a measurement site should have a relatively quiet ambient environment, including minimal aircraft operations; and
- To eliminate the need of acoustic corrections due to terrain undulations, the measurement site should have a long stretch of flat terrain near the measurement site, where a microphone array is expected to be placed.

Non-acoustical considerations include weather conditions at the measurement site. In order to lessen the risk of test flight delays, an ideal measurement site should have suitable weather conditions (see Table 4 in Section 4.5) during the planned measurement period. Selection of a measurement site is made considering the aforementioned factors, as well as the proximity of the test aircraft location. This minimizes both the fuel and time costs of the test aircraft.

3.2 Phase I Test Site

During March 2010, the test aircraft was located in San Bernardino International Airport (FAA identifier: SBD), CA for installation of the fuel burn flight test instrumentation. Because the test aircraft was located at SBD, it was initially considered a measurement site candidate for acoustics tests. However, a review of the airport using aerial photography identified nearby highways, neighborhoods, and an Air Force Base - any of which can be potential sources of noise contamination. It was also noted that the airport has an average daily air traffic volume that is high enough to significantly increase the risk of noise contamination from non-test aircraft. As a result of the review, San Bernardino International Airport has been deemed unsuitable for noise measurements since it did not meet all of the acoustical criteria mentioned above.

In January of 2007, the Volpe Center performed unrelated aircraft source data measurements at Needles Airport (FAA identifier: EED, elevation: 983 ft) located in Needles, California. It was determined that EED was a nearly ideal airport for noise measurements, meeting all the acoustical considerations for a measurement site. EED is located 159 miles east of SBD, the test aircraft's location. Because EED met all acoustics considerations for a measurement site, is in close proximity of the test aircraft, and was the site of past successful measurements, it was selected as the measurement site for the Phase I baseline measurements.

Figure 4 provides an aerial view of EED with the test runway indicated. EED has two runways (11-29 and 02-20). It was determined in the January 2007 measurements that 02-20 was the best test runway because of the space available to place a microphone array. As such, the test aircraft flew alongside Runway 02-20, from North to South, during measurements. A Notice-To-Airmen (NOTAM) informing non-test aircraft to use runway 11-29 for departures and approaches was issued for day of the test.

Figure 4. Aerial View of EED with Test Runway Identified

3.3 Phase II Test Site

In August 2010, the test aircraft returned to its base of operations at Boeing Field in Seattle, WA with the spiroid winglets fully installed. Because of the new location of the test aircraft and the fact that average daily temperatures at EED during August regularly exceed 105 degrees Fahrenheit, which is above the aircraft's engine break-point temperature, a review of the acoustical considerations for airports near Boeing Field was conducted. The test airport selected was William Fairchild International Airport (FAA identifier: CLM, elevation: 291 ft) located in Port Angeles, WA. Figure 5 provides an aerial view of Fairchild Airport with the test runway identified. Fairchild Airport maintains two asphalt paved runways (08-26 and 13-31). Runway 08-26 was chosen as the test runway because of the space available to safely place a microphone array. As such, the test aircraft flew alongside Runway 08-26, from Southwest to Northeast, during measurements. The average daily traffic at CLM is 3 aircraft per day. Therefore, a NOTAM was not considered necessary for the tests.

Figure 5. Aerial Photo of Fairchild International Airport

4 INSTRUMENTATION DESCRIPTIONS

This section presents a description of the instrumentation used during the Spiroid Phase I and Phase II measurements.

4.1 Acoustic System

Each acoustic system consisted of a Brüel and Kjær (B&K) Model 4189 ½-inch electret microphone powered by a B&K Model 2671 preamplifier. A B&K Model UA0207 3.5-inch windscreen was used to reduce wind-generated noise on the microphone diaphragm. The microphone, preamplifier, and windscreen were installed on top of a tripod with the microphone diaphragm set at 4 feet above ground level (AGL). The primary recording device was a Larson Davis Model 824 (LD824) sound level meter/real-time spectral analyzer. Data were also recorded simultaneously with a backup Sound Devices Model 744T (SD744T) digital audio recorder. A GPS time-code generator, Masterclock model GPS200A, was used to provide the backup recording device with an accurate time base. The primary recording device time was also synched manually to the GPS time-code generator.

The acoustic instrumentation setup is presented in Figure 6. Table 2 shows the settings used for the LD824 during data collection.

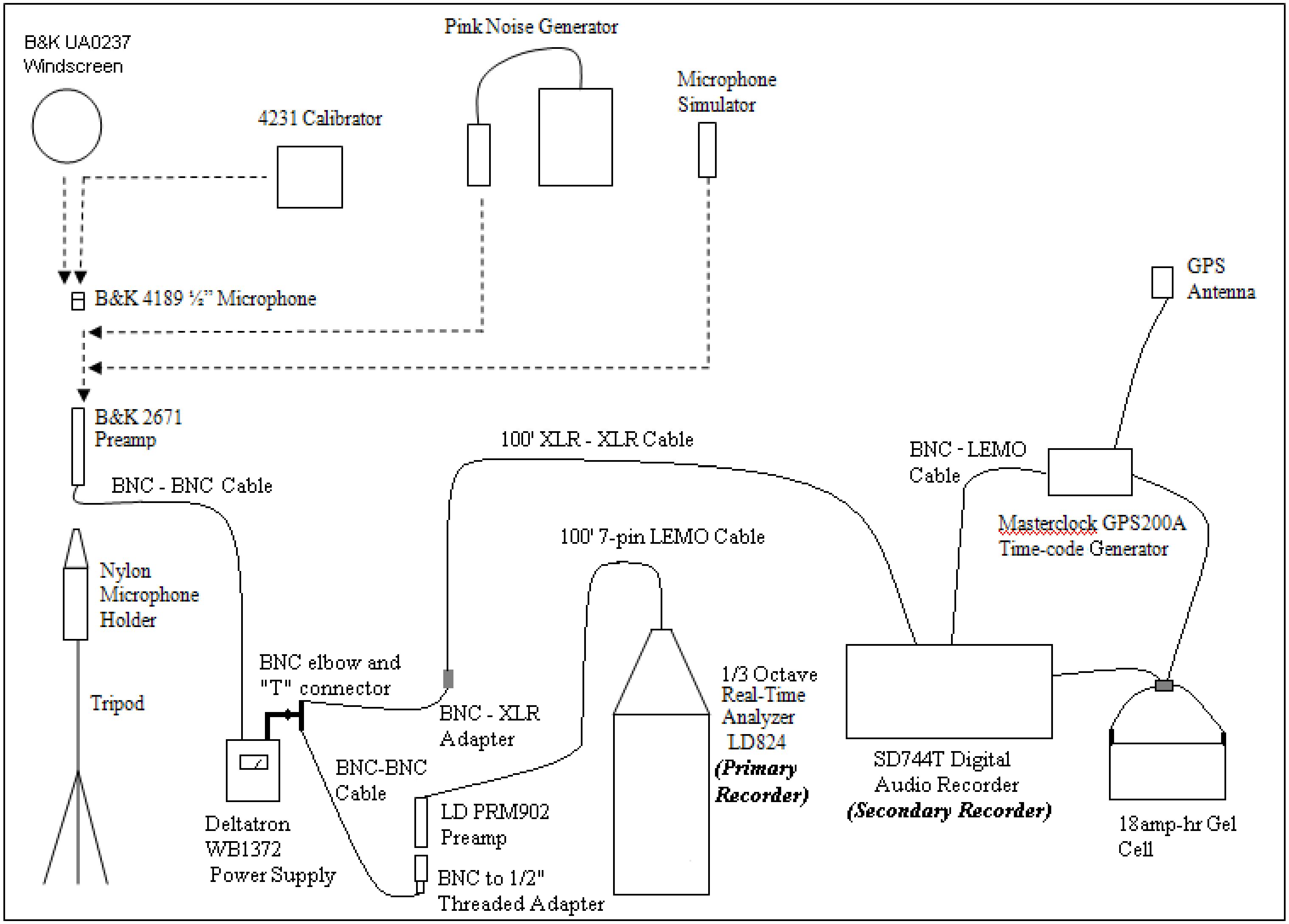

Figure 6. Acoustic Instrumentation Setup

Table 2. LD824 Collection Settings

Parameter	Setting
Detector	Slow
Broadband Frequency Weighting	A
Spectra Bandwidth	$^{1}/_{3}$ Octave Band
Spectra Frequency Weighting	Flat
Time History Interval	½ Second

4.2 Fuel Burn System

A data acquisition system was installed on the test aircraft and operated by AeroTEC. The acquisition system recorded streaming data from the test aircraft's systems and temporary flight test installations such as pressure transducers, accelerometers, and position sensors. For the purpose of this report, the data of interest from this system is fuel consumption. The fuel consumption data for the test aircraft are collected in 10 pound increments for each engine. The data from the acquisition system was recorded via an onboard PC-based system. A complete description of the AeroTEC data acquisition system and individual parts can be found in report ATEC-09107[1].

4.3 Aircraft Tracking System

A differential Global Positioning System (DGPS) was used as the primary aircraft guidance and tracking system during measurements. The specific system was the Time-Space-Position-Information (TSPI) System Version 6.1, a DGPS designed by the Volpe Center for use in transportation environmental measurements (refer to Volpe Center Time-Space-Position-Information System User's Guide[2] for more information). The Volpe Center TSPI system is configured to track vehicles in motion and survey stationary points to within ± 20 centimeter accuracy, while recording time-stamped X-Y-Z-coordinate position data at a rate of twice per second and velocity data once every two seconds. In addition to obtaining TSPI for test aircraft during measurements, the Volpe Center TSPI system serves additional purposes:

1. To conduct a site survey of the measurement site to establish a local coordinate system and determine instrumentation locations; and
2. To provide real-time guidance and position information of the aircraft to the pilot and Test Director.

The Volpe Center TSPI system consists of a base station and a rover unit, each of which receives GPS satellite signals via a receiver and transmits or receives differential corrections via a transceiver.

- **<u>Base Station</u>** - The DGPS base station consists of a NovAtel PROPAK-V3-RT2 receiver, GLB Model SNTR150 transceiver tuned to a frequency of 136.325 MHz, GPS antenna, radio antenna, and supporting cabling; See Figure 7 for a diagram of this portion of the system.

- **Rover Unit** - The DGPS rover unit, which is usually installed onboard the test aircraft, consists of a NovAtel PROPAK-V3-RT2 receiver, GLB Model SNTR150 transceiver, a laptop installed with Volpe Center's TSPI software, and supporting cabling. Figure 8 depicts a typical Rover Unit setup onboard a test aircraft.

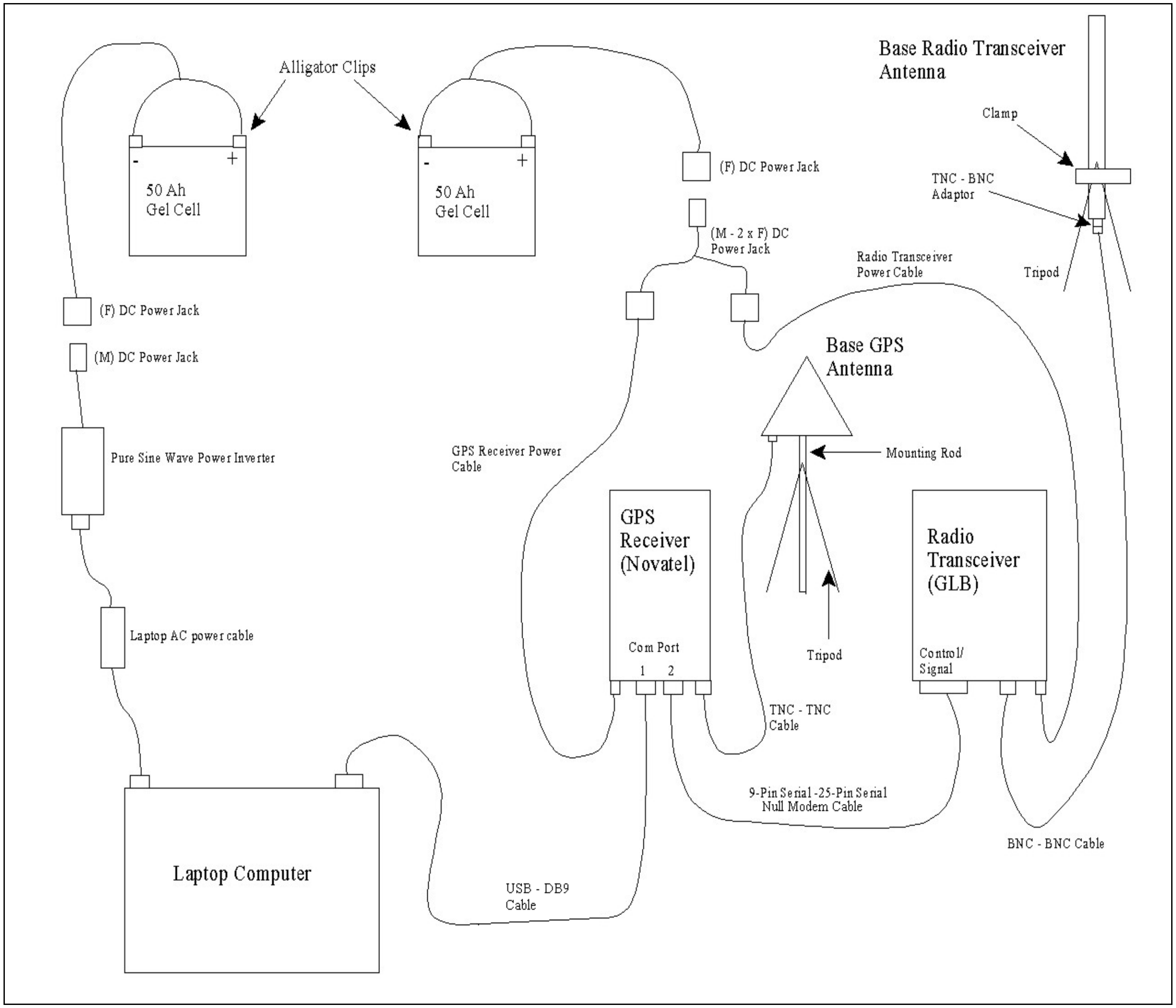

Figure 7. TSPI DGPS Base Station Setup

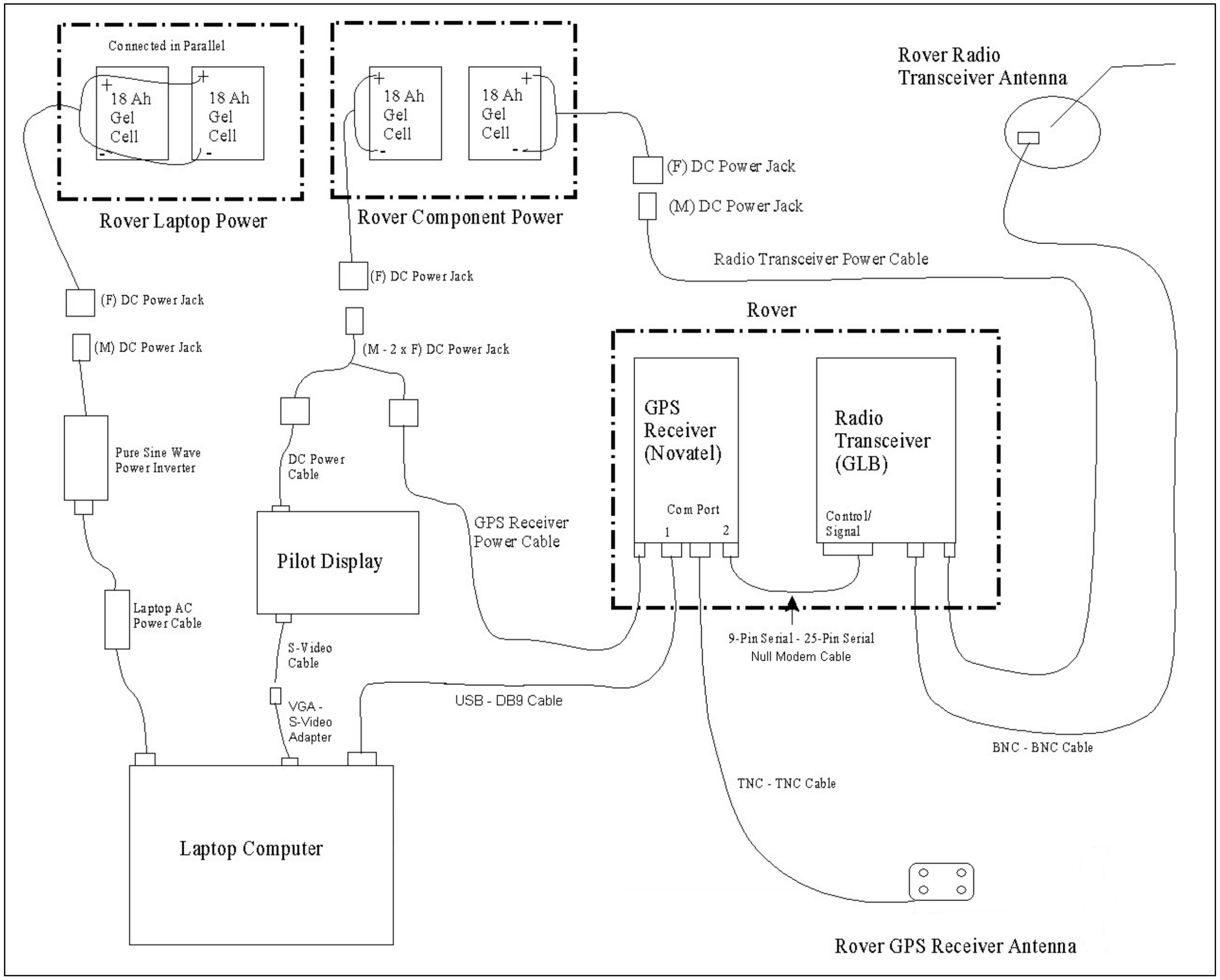

Figure 8. TSPI DGPS Rover Unit Setup

4.4 Onboard Aviation Instrumentation

The test aircraft was outfitted with high resolution instruments that tracked altitude, flight path, and speed of the aircraft. The TSPI Rover Operator was also equipped with a ContourHD helmet video camera in order to record live video of the aircraft's instrument gauges. In the event the TSPI system was unavailable, a digital photo scaling method was planned to be used in conjunction with readings recorded aboard the aircraft by the Rover Operator as a backup method of aircraft tracking. During both Phase I and Phase II measurements, the TSPI system was available during the entire measurement period and the backup method was not needed.

4.5 Meteorological System

Two Qualimetrics Transportable Automated Meteorological Stations (TAMS) were used to measure surface wind speed and direction, relative humidity, air temperature, and barometric pressure at one-second intervals throughout all testing periods. Each of the TAMS units were positioned so that the sensors were at a height of 4 feet AGL to match the height of the microphone receivers.

One TAMS unit was set up near the centerline microphone station as the primary data collection unit. An additional TAMS unit was set up at the Test Director's location to obtain a real-time display of the meteorological data to determine if the meteorological conditions were within tolerances during each measurement run. The meteorological instrumentation setup is illustrated in Figure 9. Table 3 provides information on the TAMS system specifications and measurement tolerances[*].

[*] Meteorological tolerances were based on Appendix B, Noise Requirements for Large Transports and Jet Engines, of the Federal Aviation Regulations Part 36 and Chapter 8 of ICAO Annex 16 (FAR 36 / Annex 16).

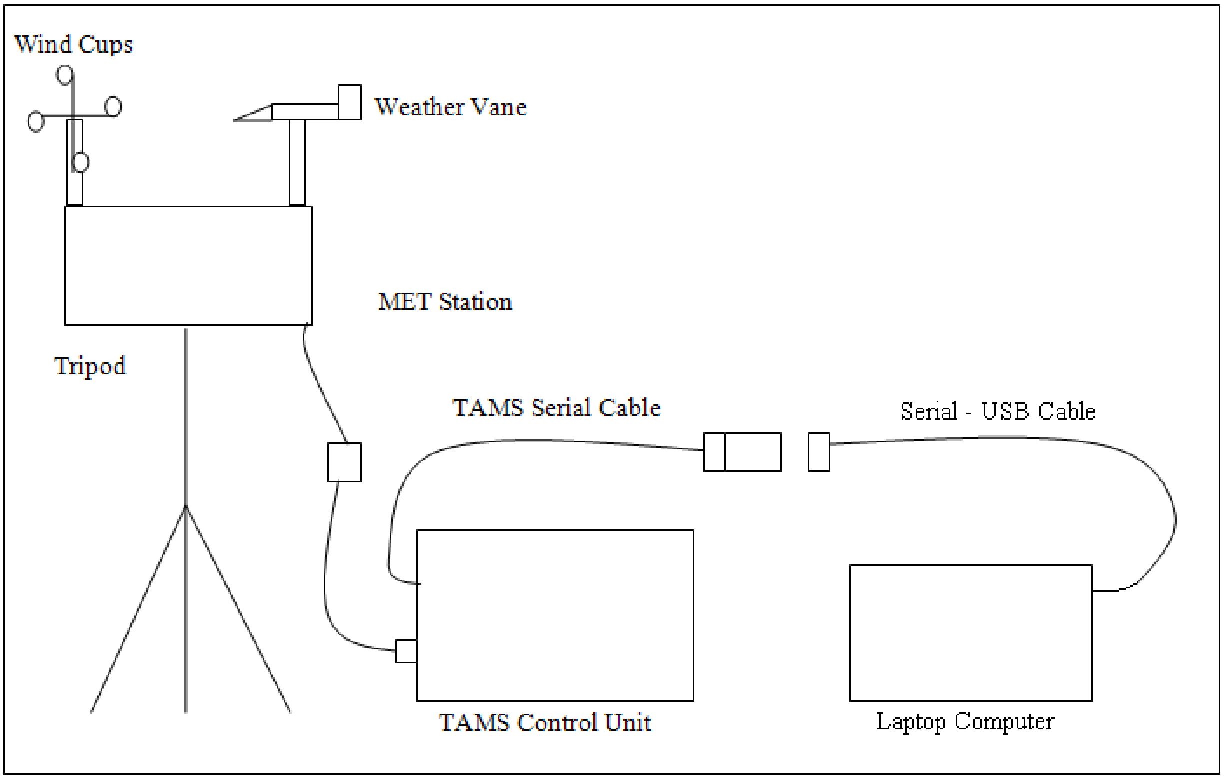

Figure 9. Meteorological Instrumentation Setup

Table 3. TAMS System Specifications and Measurement Tolerances

Data	Range	Resolution	Accuracy	FAR 36 Measurement Limit
Temperature (^{0}F)	-40 to +130	1	±1	14 to 95
Relative Humidity (%)	0 to 100	1	±3	20 to 95
Wind Speed (kts)	2 to 48	1	±1 or ±5%, whichever is greater	12 (average)* 7 (average crosswind)* 15 (gust)
Wind Direction (^{0})	0 to 360	10	±5 RMSE	N/A
Precipitation (in)	N/A	N/A	N/A	0

* The average velocity is determined using a 30-second averaging period spanning the 10 dB sound level rise and fall time interval.

5 MEASUREMENT SETUP

5.1 Phase I at Needles Airport

Two acoustic stations were set up during noise measurements: a centerline microphone and a sideline microphone station. During the Phase I baseline measurements at EED in Needles, CA the microphone stations were located to the east of Runway 02-20. To avoid potential noise contamination from traffic on runway 11-29, the centerline microphone station was located as far north as possible (towards the beginning of Runway 20). This was deemed practical without experiencing significant changes in terrain elevation. The sideline microphone was placed 500 feet from the centerline microphone. A Test Director was stationed in a central location with a full view of the flight path and instrumentation, but far enough away from the acoustic systems to avoid contamination of the acoustic data. The Test Director was responsible for announcing events, monitoring DGPS and meteorological data, communicating with the aircraft and field technicians, and ensuring the quality of all measurement events. The approximate locations of the microphone stations and Test Director at EED are overlaid on an aerial photograph in Figure 10. A staging area where the TSPI Rover unit was installed onboard the test aircraft is also shown in this figure.

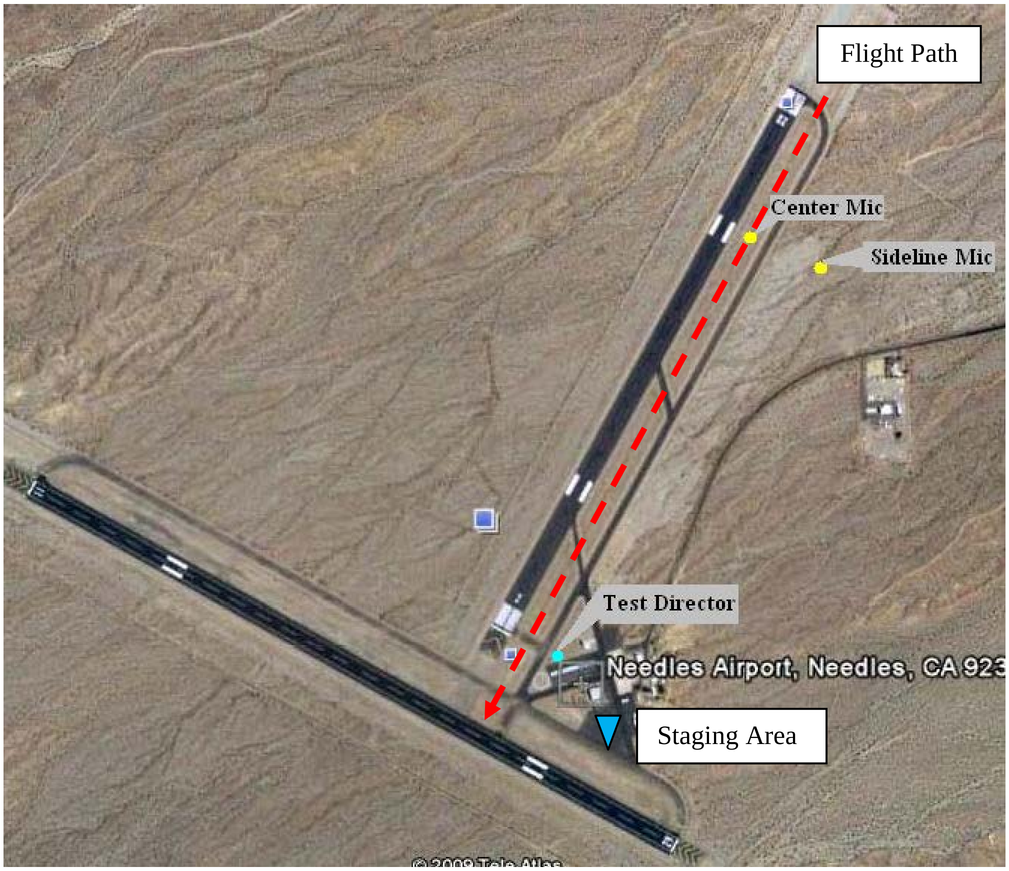

Figure 10. Acoustic Station and Test Director Locations During Phase I Measurements

5.2 Phase II at Port Angeles International Airport

During Phase II of the spiroid measurements at CLM, Port Angeles, WA, the centerline microphone station was set up at the northeast end of Runway 08-26. The lateral position of the sideline microphone was 500 feet from the centerline microphone. Similar to the Phase I measurements, a Test Director location and staging area for installing the TSPI Rover unit were selected. Figure 11 provides an aerial view of CLM with those key locations identified.

Figure 11. Acoustic Station and Test Director Locations during Phase II Measurements

At each microphone station, Volpe field technicians monitored and operated the acoustic recording instrumentation. The field technician and acoustic recording instrumentation were located at acoustic observer tables, approximately 100 ft from their respective microphones. This distance ensured field personnel did not contaminate the sound-level data. The placement of a field technician at each acoustic location also eliminated the need for long cables, which minimized the potential radio signal interference inherent to their use. Figure 12 shows an overhead schematic view of the acoustic observer tables relative to the microphones.

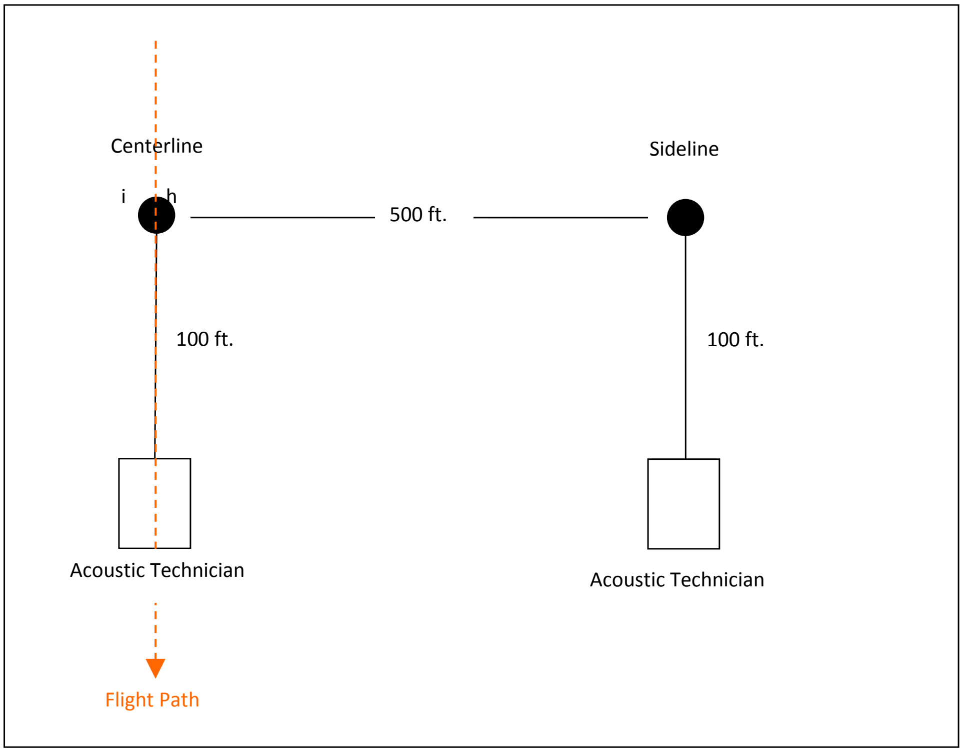

Figure 12. Overhead View of an Acoustic Station Setup

All the microphones were placed at 4 feet AGL and oriented nominally for grazing incidence i.e., diaphragm at 90 degrees relative to the anticipated direction of the noise source (centerline microphone) and at approximately 45 degrees for the sideline microphone. Table 4 summarizes this setup while Figure 13 illustrates a side view of a microphone configuration.

Table 4. Measurement Microphone Locations

Microphone	X-Coordinate (ft)	Y-Coordinate (ft)	Height (ft)	Angle (°)
Centerline	0	0	4	90
Sideline	0	500	4	45

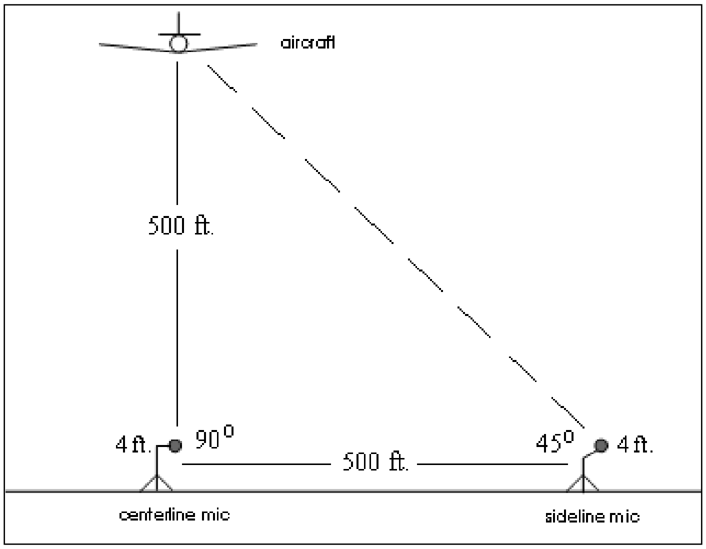

Figure 13. Side View of a Microphone Configuration

6 MEASUREMENT PROCEDURES

This section describes the daily procedures performed by Volpe technicians during both the Phase I and II Spiroid measurements.

6.1 Acoustic Technicians

6.1.1 Deployment

The acoustic systems were deployed at the locations as described in Section 5. The microphone tripods were anchored to the ground to avoid the risk of the tripod tipping over. A space blanket was secured to the operators table for rain contingency. All microphones were calibrated using the following standard procedure:

1. A B&K 4231 calibrator was mounted on the microphone and a sine wave signal of 114 decibels (dB) at 1 kHz was applied to the system. The LD824 was calibrated to this reference signal. One minute of calibration tone was recorded and levels indicated on the LD824 and 744T backup recorder were noted on log sheets.
2. The microphone was removed and a pink noise generator was applied to check the frequency response of the system. One minute of pink noise was recorded and levels indicated on the LD824 and 744T were noted on log sheets.
3. A microphone simulator was then applied to the system to measure the system noise floor and ensure no outside interference was present. At this point +20 dB gain was added to the LD824 to raise the lower range of the system to help identify any anomalous signals. One minute of the noise floor was recorded and levels indicated on the LD824 and 744T were noted on log sheets. The +20 dB gain was then removed from the LD824.
4. The microphone was replaced, and then the calibrator was reapplied to verify that the LD824 reads the same initial calibration reading performed in Step 1. Another minute of calibration tone was recorded and levels indicated on the LD824 and 744T were noted on log sheets.

6.1.2 During an Event

During an event, each acoustic technician performed the following:

- Recorded the maximum A-weighted slow-scale sound level (L_{ASmx}) observed on the LD824 on the log sheet. The observer also checked the L_{ASmx} for consistency and repeatability, i.e., the L_{ASmx} values for events in the same series should generally be similar in sound level.
- Confirmed and noted that the recording instrumentation indicated a minimum 20-dBA rise and fall during an event.
- Noted any audible external contamination.
- If possible, confirmed that the aircraft route was straight, at a constant speed with no anomalous flight characteristics, and over the centerline, as appropriate.
- Collected ambient measurements periodically throughout the measurement day.

- Performed a time synchronization using the Masterclock GPS200A throughout the measurement day.

At the end of each pass-by event, technicians at the sideline microphones signaled to the technician at the center position whether 20-dBA rise and fall was observed on their respective LD824. The technician at the center position then radioed to the Test Director if a 20-dBA rise and fall was attained at all microphone locations.

6.1.3 End of Measurement Day

At the end of the day a calibrator was reapplied to check for any drift that may have occurred during the day. Similar to during deployment, a minute of calibration tone was recorded and levels indicated on the LD824 and SD744T recorder were noted on log sheets. The systems were then broken down and removed from the site.

6.2 Fuel Burn System Operator

An AeroTEC technician operated the fuel burn data acquisition system onboard the test aircraft throughout the flight tests. Fuel consumption data were recorded and monitored from the moment the aircraft was powered on until the completion of the flight tests.

6.3 Test Director

6.3.1 Deployment

The TSPI tracking system base station and the primary meteorological system were deployed at the Test Director's location. While the field team deployed the acoustic, TAMS, and TSPI systems the Test Director, TSPI System Operator (see Section 6.4), and pilots conducted a Pilot Brief, including discussions regarding the test flight series to be flown, as well as communication protocols, local terrain features, and aircraft operations.

6.3.2 During an Event

During an event, the Test Director performed the following:

- Announced, via 2-way radio, the start of an event, including event number.
- Monitored the tracking data to verify the aircraft was within tolerances.
- Listened for potential external contamination.
- Monitored wind speed in real time via the TAMS meteorological system.
- Recorded the following in the log sheet:
    - Wind speed and direction;
    - Tracking information; and
    - Any external contamination.
- Announced, via 2-way radio, the end of event.

After the end of an event, the Test Director received an update from the acoustic technicians as to the event quality at their microphone locations. Based on their input, monitored wind speed and aircraft tracking data, and input from the pilot, a determination was made on the overall quality of the event; this was done to ensure that an adequate number of events were collected for each series. The Test Director then identified the next event series and number and announced it to the pilot and acoustic technicians.

6.3.3 End of Measurement Day

At the end of the day the Test Director, TSPI System Operator, and pilots conducted a Pilot Debrief. During this briefing the quality of individual events was discussed, and potential improvements for future implementation were identified.

6.4 TSPI System Operator

6.4.1 Deployment

The TSPI system rover unit was installed onboard the test aircraft prior to measurements at the staging area (see Sections 4.2 and 5). The Test Director, TSPI System Operator, and pilots conducted the Pilot Brief, while the field team deployed the acoustic, TAMS, and TSPI systems.

6.4.2 During an Event

During an event, the TSPI System Operator performed the following:

- Selected tolerances for the pilot guidance display.
- Verified the Test Director was receiving data from the rover station.
- Monitored the TSPI system to verify that the pilot flew within the assigned tolerances.
- Recorded actual flight parameters (Power, flaps, speed, and inlet turbine temperature) during the event.

The TSPI System Operator was also responsible for continued communication with the pilot throughout the events. This is important in general because pilots who do not regularly participate in noise measurement flight tests are not always aware of the ramifications of some decisions during flight. For this reason, the Volpe Center often deploys an acoustic technician who is also a certified pilot as the TSPI System Operator.

6.4.3 End of Measurement Day

At the end of the day the TSPI System Operator participated in the Pilot Debrief.

7 TEST SERIES DESCRIPTIONS

7.1 Series Definitions

The test series described in this section were designed to capture the test aircraft noise signature as a function of aircraft state. Typically, the state of the aircraft includes the aircraft operational mode (e.g. departure) and its power state, although flap state and speed are also important factors. Test series included level fly-over (LFO), approach (APP), and departure (DEP) flight configurations. The different test series were varied by:

- Flight configuration
    - Operational mode
    - Descent angle
    - Flap setting
- Reference altitude
- Reference speed
- Power settings

Individual events for each test series were flown to have reasonable confidence in the collected data. This typically meant three passes that were free from observable external contamination, track deviations outside of acceptable limits, and acceptable meteorological conditions, for each series. Descriptions of the specific test series for each aircraft measured at Needles and Port Angeles airports are provided in Table 5. Power settings, meteorological, and TSPI data for each of these test series are presented in Appendices A, C and D, respectively.

Table 5. Test Series Definitions

Test Series	Description
100	LFO: Normal Cruise @ 500 ft
300	DEP: Standard
400	DEP: Cruise Climb
500	APP: Flaps 20 Degrees, Gear Up
600	APP: Flaps 48 Degrees, Gear Down

7.2 Summary of Events Collected

A total of 44 passby events were recorded during both flight tests. The events varied in flight configuration, reference altitude, power and speed as described in the previous section. Of the 44 total measured events, 30 passed quality assurance (QA, see Section 9). Two of those events were then deemed unusable due to a temporary malfunction of a time code generator, resulting in a total of 28 good events. Only data from events that passed QA are included in the results and appendices of this report. Events were omitted on the following basis:

- *Contamination*, including an audible noise source from anything other than the test aircraft was detected during data recording by field personnel and/or identified later in the laboratory data analysis process (See Section 9.3); and
- *Incorrect aircraft settings*, including wrong power or flap setting, aircraft speed, or altitude and/or out-of-tolerance position;

8 DATA PROCESSING

This section describes the data reduction and analysis methodology undertaken to process the as-measured data. Comparisons of the Phase I and II noise results began with the production of Noise Power Distance (NPD) curves, which are series of noise metrics as a function of power and distance. The process of developing the NPD data is described in this section and the resultant data are summarized in Section 10. For completeness, a full set of NPD data for all good events is listed in Appendix C.

8.1 Noise Metrics

NPD data for measured events were generated for four different noise metrics: sound exposure level (SEL), denoted by the ANSI[3] symbol L_{AE}; maximum, slow time- and A-weighted sound level (MXSA), denoted by the ANSI symbol L_{ASmx}; effective perceived noise level (EPNL), denoted by the ANSI symbol L_{EPN}; and tone-adjusted, maximum, slow time-weighted, perceived noise level (MXSPNT), denoted by the ANSI symbol L_{PNTSmx}.

8.2 Data Development Methodology

The as-measured sound pressure level (SPL), meteorological, and tracking data were processed in accordance with the FAR 36[4] / Annex 16[5] methodology to generate a set of sound level metrics. Specifically, the sound level metrics were derived using the FAR 36 / Annex 16 simplified procedure. In the simplified process L_{AE}, L_{ASmx}, L_{EPN}, and L_{PNTSmx} metrics are generated using as-measured spectral and tracking data taken at the time of L_{ASmx}. NPD curves generated in the simplified method are considered Type 2 NPDs within the FAR 36 framework. These metrics were derived for both microphones for each aircraft event, representing the center and sideline noise characteristics of the test aircraft.

8.3 Volpe Center Data Processing Software

To expedite the processing of large amounts of data using a modified version of the FAR 36 / Annex 16 simplified method, the Volpe Center utilized two data processing software programs. The first, MiniFAR Version 2.05, combines all field data and outputs a text file with calculated test day noise metrics. MiniFAR also contains an easy method for visually screening events for obvious contamination and missing data parameters. LCorrect Version 2.2 was then used to take the test day noise metrics from MiniFAR and adjust them to the SAE-AIR-1845[6] reference day conditions which are commonly used for modeling purposes. LCorrect also generates the distance-based data needed to create NPD curves.

8.3.1 MiniFAR Version 2.05

MiniFAR requires the following as-measured data input parameters:

- Sound level time history;
- Aircraft TSPI data time history;
- Microphone locations (X, Y and Z, in local coordinates);
- Meteorological data time history;
- Corrections to be applied to the as-measured data, including microphone frequency response, windscreen insertion loss, and calibration drifts; and
- Observer logs that include event start and stop times, as well as notes on contamination (converted into comma delimited (.csv) files).

MiniFAR uses the above data and creates a single file containing event-based $L_{AE,}$ L_{ASmx}, L_{EPN}, L_{PNTSmx} data, along with the un-weighted, one-third octave spectra at the time of L_{ASmx}. MiniFAR also appends to this file supplemental data that may be easily referenced at a later time; these include slant dance, wind speed and direction, aircraft speed at time of max, etc. Figure 14 presents an overview of the MiniFAR process.

MiniFAR also allows the user to visually examine events as an initial screening for external contamination. The technician may use this capability to detect any missing input parameters that would affect the computation of the noise metrics. Figure 15 shows a screenshot of MiniFAR's user interface.

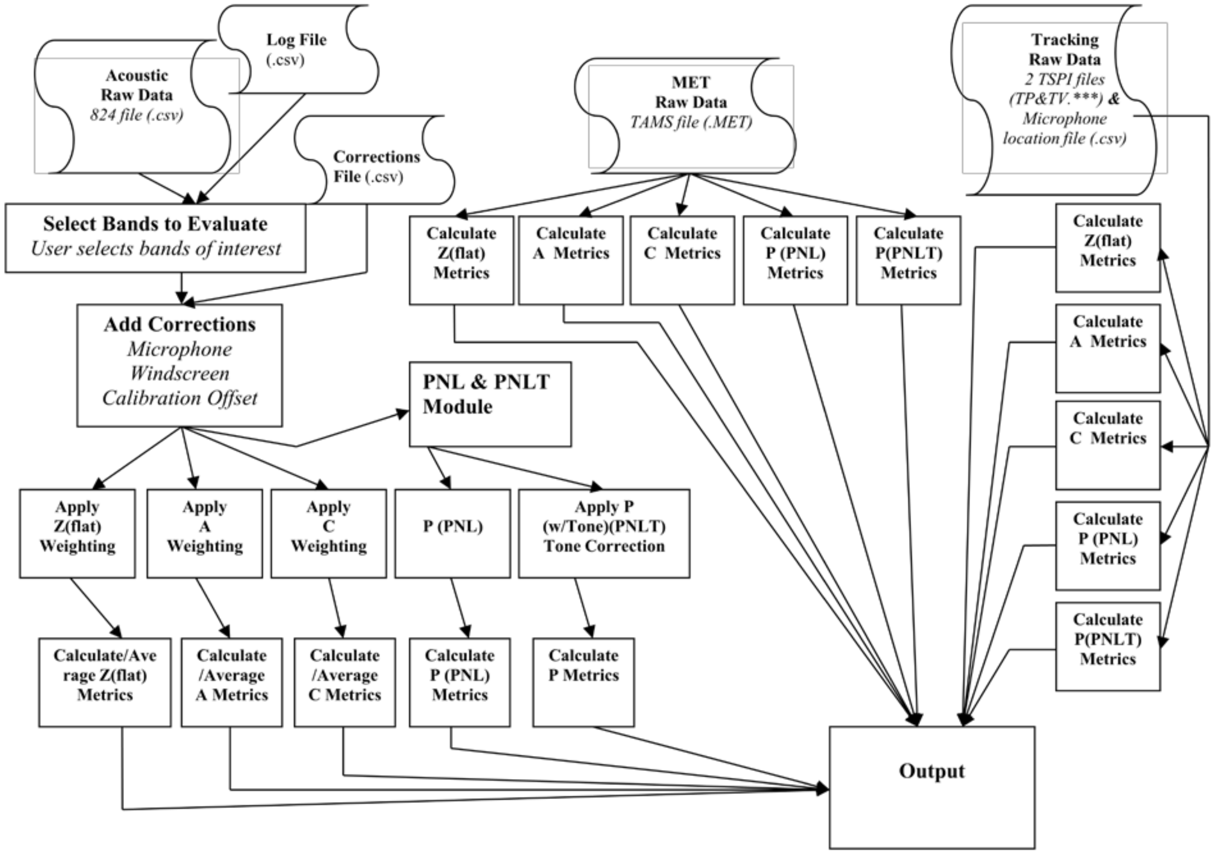

Figure 14. Overview of the MiniFAR Process

Figure 15. MiniFAR Graphical User Interface

MiniFAR averages the absolute- and cross-wind speeds for an event during data processing. These wind speeds were reviewed during processing. Typically, any events where the speeds exceeded the FAR 36 / Annex 16 absolute limit of 12 knots and/or the cross wind speed limit of 7 knots would be discarded. No events were discarded due to excessive wind speeds for either phase of measurements.

8.3.2 LCorrect

LCorrect uses the test day noise metrics, meteorological, aircraft speed, and slant distance results generated by MiniFAR to calculate noise metrics at 10 distances, ranging from 200 to 25,000 feet, with SAE-AIR-1845 reference day atmospheric conditions. LCorrect also takes the un-weighted spectrum at time of maximum sound level produced by MiniFAR and adjusts it to the 10 aforementioned distances. For the purpose of this measurement study, the spectrum adjusted to 1,000 feet was used. Figure 16 shows an overview of the LCorrect process.

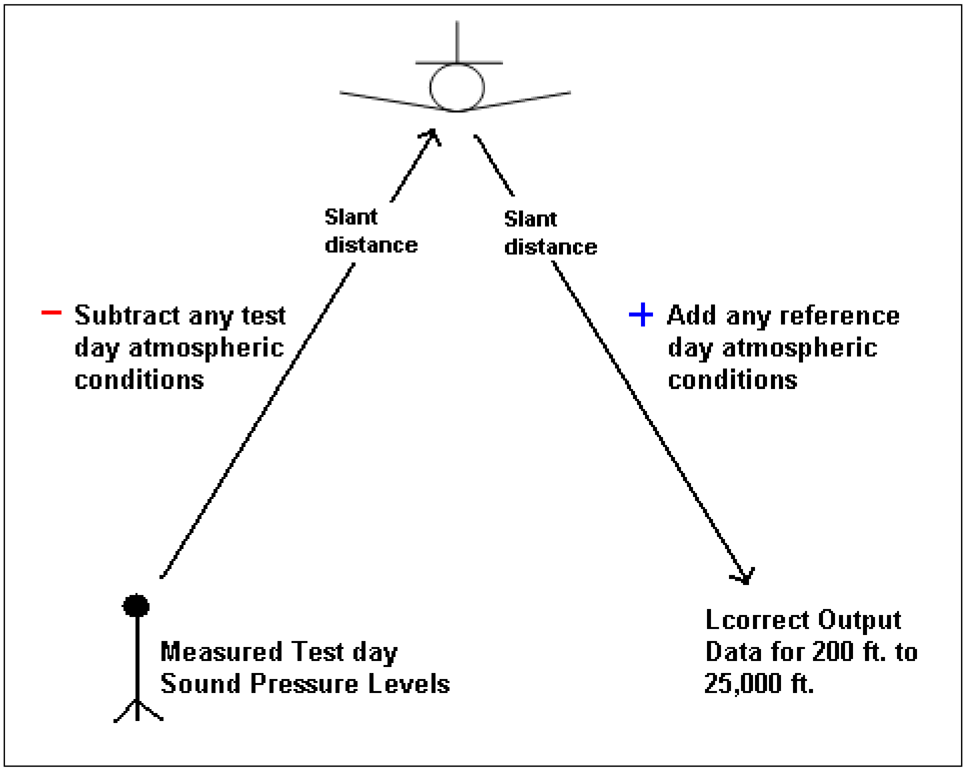

Figure 16. LCorrect Process

Consistent with SAE-AIR-1845, aircraft noise metrics were adjusted in LCorrect to a reference speed of 160 knots. LCorrect computes the reference speed adjustment by applying a duration adjustment to the aircraft NPD curves in order to account for the effect of time-varying aircraft speed. This duration adjustment is made using the following:

$$DUR_{ADJ} = 10 \log_{10}[160/AS_{seg}] \qquad \text{[Eq. 1]}$$

where:

AS_{seg} is the aircraft reference speed at the closest point of approach between the aircraft and the microphone.

The L_{AE} and L_{EPN} values in Appendix C of this report are adjusted to the reference speed using the above methodology. Since the L_{ASmx} and L_{PNTSmx} metrics are assumed to be independent of speed, no duration adjustment is applied to these metrics. Test day and reference speeds are found in the TSPI data tables in Appendix B.

8.4 Resulting NPD Curves

NPD curves for the center and sideline of the test aircraft for each event were generated with the software and method described in the previous section. The data for each event were then grouped by configuration and power setting (series), and arithmetically averaged together. The resulting NPD data are presented in Appendix C for the $L_{AE,}$ L_{ASmx}, L_{EPN}, and L_{PNTSmx} metrics. A comparison of these results for the two phases of the study is presented in Section 10.

9 QUALITY ASSURANCE

The quality of the measured and processed data is crucial since they will be used to determine any potential installation effects of the spiroid winglets. Special care was given to inspecting the data in the field, during data collection and in the lab during data processing.

9.1 Calibration

At the beginning of each measurement day, the acoustic systems were calibrated and integrity of the noise floor checked. A calibration was also done at the end of each measurement day to determine if a calibration drift existed during the measurement period. During Phase I and II measurements no calibration drifts occurred. If a calibration drift of up to 0.5 dB had occurred, then it would have been corrected for during data processing. The MiniFAR software (Section 8.3.1) is capable of correcting for calibration drifts during its calculation of noise metrics. If a calibration drift exceeded 0.5 dB, then the data would have been deemed invalid and not included in the data processing.

9.2 Time of Day

To ensure a uniform time source across all data acquisition systems, the Masterclock GPS200A time code generators were used as the “gold standard” time base during data collection. LD824 SLMs, which were the primary recording devices, were set to the time displayed on the time code generator. The GPS200A was used to provide the backup recording device with the precise GPS time. Field personnel also used the time code generator when transcribing notes onto field logs. Meteorological stations had their system time synched with the same GPS time code. The time displayed on the TSPI system was crosschecked with the GPS200A and fuel burn data acquisition system to ensure they were in uniform, therefore synchronizing the aircraft tracking acoustic, and fuel burn data. During processing, MiniFAR links the acoustic, field log, TSPI, and meteorological data together using this uniform time base.

9.3 External Contamination

During field measurements two acoustic observers, stationed approximately 100 feet from each microphone, noted in field logs the effects of any potentially contaminating noise sources. These field notes were displayed in the MiniFAR software. Accordingly, the user was able to view these notes in conjunction with a visual display of the event’s sound level time history to determine if the external noise contaminated the event. Events where contamination was seen in the time history by this initial screening process were discarded. During post-process inspection of the generated NPD curves and one-third octave spectral data, the field logs were referred to once again to help identify any external contamination to the data.

9.4 Test Aircraft TSPI

The TSPI System operator onboard the test aircraft monitored the TSPI in real time to ensure the position of the aircraft remained within tolerance during the event. Any events where the aircraft was out of tolerance were discarded and repeated. In addition, the Test Director on the ground monitored the test aircraft position with a real-time data feed from the TSPI System.

10 RESULTS

10.1 Fuel Burn Results

The fuel consumption data for the test aircraft were collected in 10 pound increments for each engine. Because the fuel consumption is reported in these 10 pound increments, the actual instantaneous fuel flow rate is unknown. For each of the procedures analyzed, it was considered that the fuel consumption rate from the beginning of the procedure until the end was constant.

Review of the data showed that the departure and level flyover flight test runs were too short to collect meaningful fuel consumption data – the aircraft were in a stable configuration (flaps 20) for these tests for less time than the engines took to consume enough fuel to have a large enough sample to be meaningful. During the approach noise tests, however, the aircraft needed to be stabilized well before the test, and so some fuel consumption data could be analyzed. For future similar studies, it is recommended to collect fuel consumption at shorter increments than 10 pounds in order to be able to more fully analyze the data.

Five approach events were conducted during the Phase I baseline measurements with the flaps/slats set to SF20 and the gear up and where the aircraft flew in a stable configuration. For two of these runs, the time during the stable part of the descent was too short to have reliable data. Table 6 below shows the results of the three individual events which were long enough to collect data.

Table 6. Phase I Approach Fuel Flows

Event	Average Weight (lb)	Flight Path Angle (degrees)	Fuel Flow (lb/hr)
510	34339	-1.4	1729
520	34123	-1.5	1665
570	29981	-1.9	1531

Three approach events were conducted during the Phase II measurements with the flaps/slats set to SF20 and the gear up and where the aircraft flew in a stable configuration. Table 7 below shows the results of these individual events.

Table 7. Phase II Approach Fuel Flows

Event	Average Weight (lb)	Flight Path Angle (degrees)	Fuel Flow (lb/hr)
510	31616	-3.4	1001
520	31349	-3.2	1063
530	31076	-3.0	1099

Note that the strongest indictor of fuel consumption for these descent conditions is the flight path angle; the steeper the descent angle, the less fuel consumed. The flight path angle and fuel consumption data presented in Table 6 and Table 7 above are presented in graphical form in Figure 17.

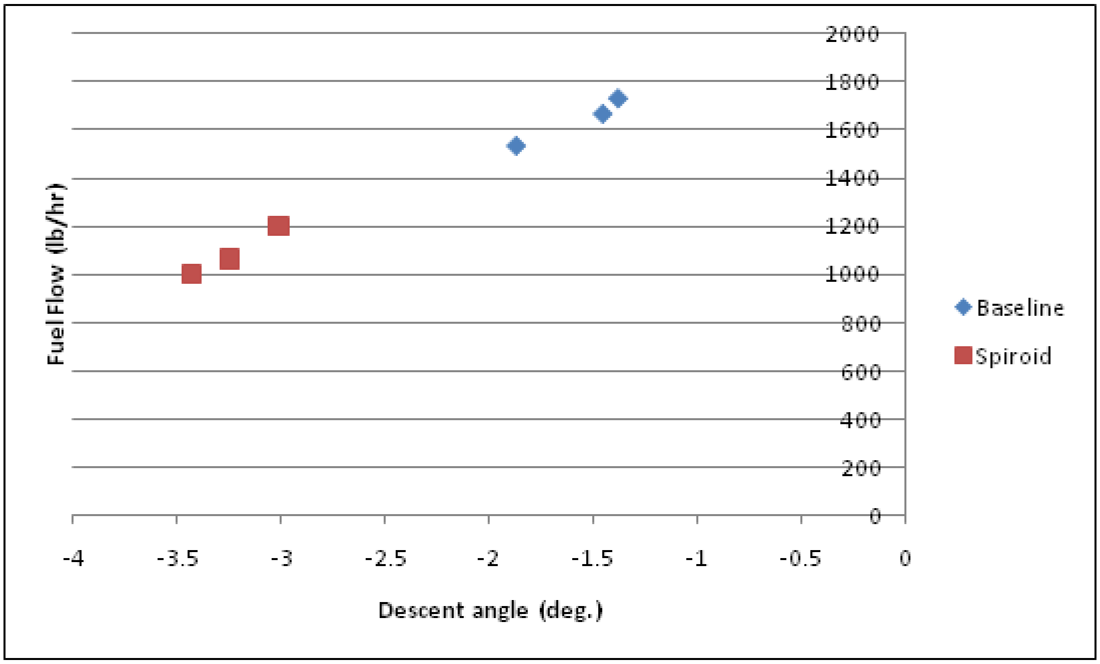

Figure 17. Fuel Flow as a Function of Flight Path Angle

While the level flyover events were too short to collect meaningful data, the aircraft also flew a long level segment *between* each test. This long level segment is the return flight along the downwind leg between each noise test event. These level segments when the aircraft was returning to the test area were generally long enough to consume enough fuel for an analysis.

Figure 18 below shows that the relationship between %N1, the engines' outer spool rotational speed as a percentage of the maximum rotational speed of the engine, and fuel flow. In the figure, the baseline configuration events are represented by blue diamonds, and the Spiroid configuration by red squares. The Spiroid-configured level segments were flown at two distinct altitudes; the higher altitude of 3000 feet MSL is represented in the figure by filled red squares and the lower altitude of 1700 feet MSL by open red squares. This same convention is used in Figure 19 and Figure 20 below. The engine operation is largely independent of the aircraft's characteristics; the operating characteristics of the engine are not directly impacted by whether or not the aircraft has Spiroid wingtips or a particular flap configuration. All the level events are included in the figure; some events used flaps 20, others used flaps 48. With the Spiroid configuration, the lower altitude events operated with a higher %N1 and a correspondingly higher fuel flow. All the data show the expected correlation of increasing fuel flow with increasing engine speed.

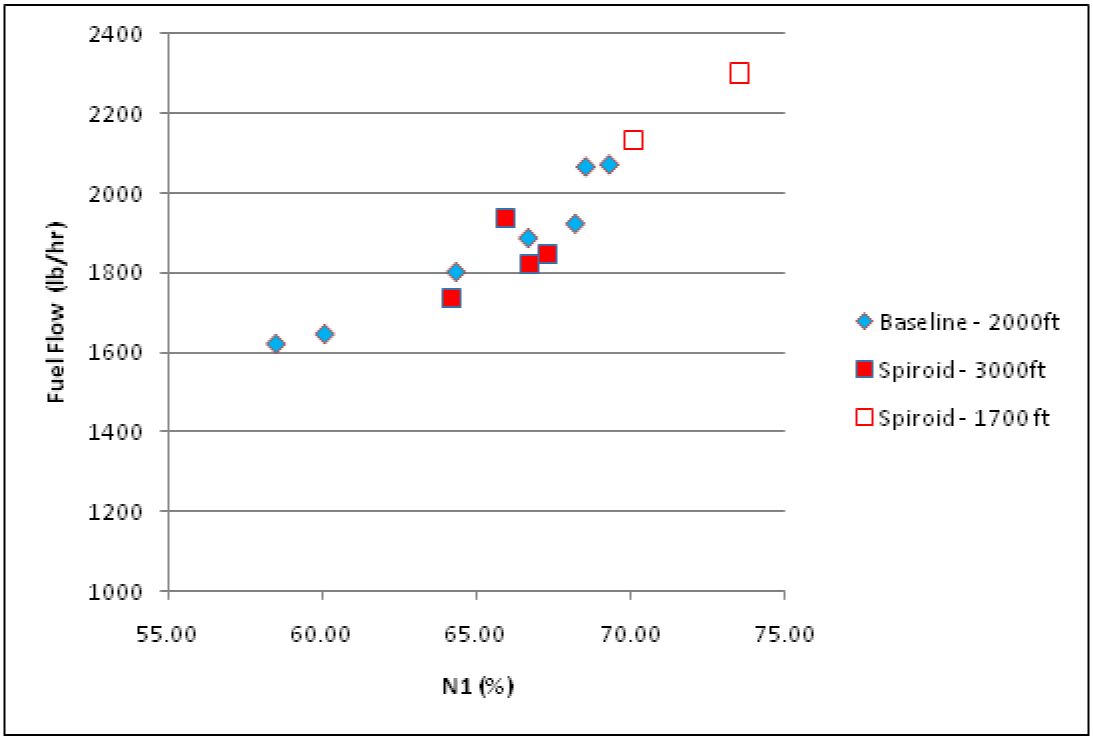

Figure 18. Level Segment Power Setting and Fuel Consumption, All Flaps

The fuel consumption also generally correlates with the true airspeed of the aircraft; the configuration of the aircraft does impact the speed at which the aircraft flies for a given engine power setting. Because of this effect of configuration on engine power requirements (and therefore on fuel consumption), only the flaps 20 configuration will be used for comparison for the remainder of this analysis – only a single flaps 48 configuration event was flown in Phase II while returning to the test area; comparison of a single data point would not be meaningful, so this configuration was dropped for this analysis.

Figure 19 below shows that for a given power setting, with the aircraft in level flight and with flaps 20 deployed, the aircraft cruises at a slightly higher speed for the baseline configuration compared to the spiroid configuration. Stated another way, for a given speed with flaps 20, less power is required with the baseline configuration than with the Spiroid wingtips.

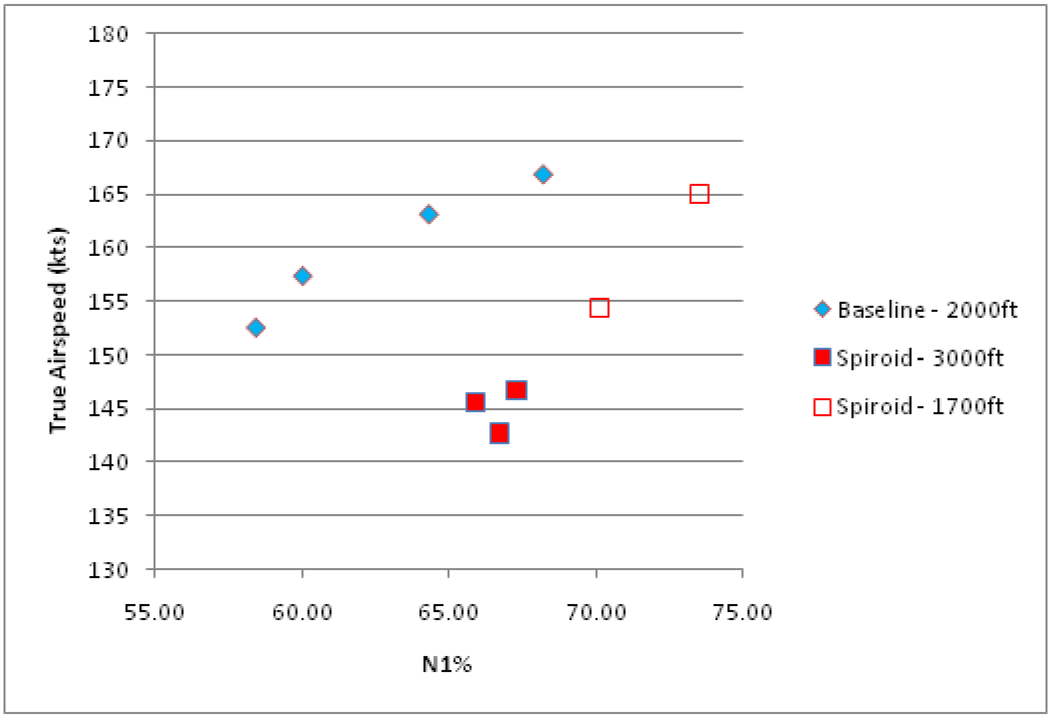

Figure 19. Level Segment Power Settings and Airspeed, Flaps 20

Figure 20 below shows the relationship between the level segment cruising airspeed and the fuel flow for the different aircraft configurations and operations. This figure presents a synthesis of the data in Figure 18 and Figure 19 above; for both configurations the fuel flow increases with increasing airspeed, while the Spiroid configuration has a higher fuel flow at a given airspeed.

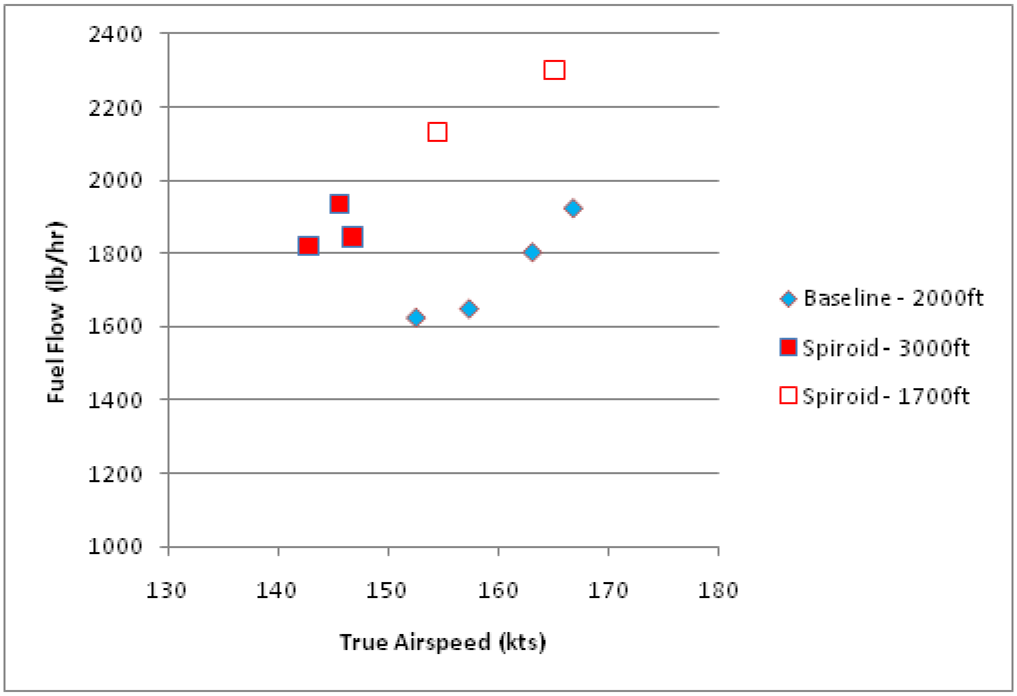

Figure 20. Level Segment Airspeed and Fuel Consumption, Flaps 20

Note that these finding are based on cruise operation at or below 3000 ft MSL, which is not a typical flight regime for the Falcon 50. The weights of the aircraft were probably not an influencing factor on fuel consumption, since the baseline configuration was typically heavier, but had less fuel consumption.

10.2 Noise Levels Results

The following tables present the comparison between the average noise levels of the test aircraft during Phase I and II measurements, rounded to the nearest tenth of a decibel. Noise levels are presented in four noise metrics: sound exposure level (SEL), denoted by the ANSI symbol L_{AE}, maximum, slow time- and A-weighted sound level (MXSA), denoted by the ANSI symbol L_{ASmx}, effective perceived noise level (EPNL), denoted by the ANSI symbol L_{EPN}, and tone-adjusted maximum, slow time-weighted, perceived noise level (MXSPNT), denoted by the symbol L_{PNTSmx}.

For consistency in comparing results, all noise levels have been adjusted to a source-to-receiver distance of 1,000 feet. Using the SAE-AIR-1845 methodology described in Section 8, the (SEL and EPNL) noise levels are adjusted to a speed of 160 knots and reference day atmospheric conditions.

Tables 8 through 11 present data for the centerline microphone, whereas Tables 12 through 15 present data for the sideline microphone. The “No. of Events” column represents the number of measured events that passed the Quality Assurance test described in Section 9 of this report and were used in calculation of the averaged noise levels. A minimum of three good events are desired for each series. However, a temporary malfunction on the time code system during the Phase II measurements resulted in some series with only two good passbys. For a full set of noise results for each good event, refer to Appendix C of this report.

Table 8. Comparison of Centerline Noise Levels in L_{AE}

Series	Series Description	Phase I (Baseline)			Phase II (Spiroid-installed)			Delta (Phase II minus Phase I, dB)
		No. of Events	Average (dB)	Std. Dev. (dB)	No. of Events	Average (dB)	Std. Dev. (dB)	
100	Normal Cruise	3	**81.1**	1.0	2	**80.0**	1.1	**-1.2**
300	Departure	3	**102.9**	1.3	2	**90.0**	0.5	**-12.9**
400	Cruise Climb	3	**97.3**	1.1	3	**91.5**	1.1	**-5.8**
500	Approach, Flaps 20, gear up	3	**78.5**	0.2	2	**74.0**	1.2	**-4.5**
600	Approach, Flaps 48, gear down	4	**82.8**	1.2	3	**78.7**	0.6	**-4.1**

Table 9. Comparison of Centerline Noise Levels in L_{ASmx}

Series	Series Description	Phase I (Baseline)			Phase II (Spiroid-installed)			Delta (Phase II minus Phase I, dB)
		No. of Events	Average (dB)	Std. Dev. (dB)	No. of Events	Average (dB)	Std. Dev. (dB)	
100	Normal Cruise	3	**74.9**	0.6	2	**74.1**	1.4	**-0.8**
300	Departure	3	**97.9**	2.0	2	**83.6**	0.0	**-14.3**
400	Cruise Climb	3	**90.8**	2.0	3	**85.1**	1.6	**-5.8**
500	Approach, Flaps 20, gear up	3	**73.3**	0.6	2	**67.7**	1.4	**-5.7**
600	Approach, Flaps 48, gear down	4	**77.2**	1.3	3	**73.4**	0.9	**-3.7**

Table 10. Comparison of Centerline Noise Levels in L_{EPN}

Series	Series Description	Phase I (Baseline)			Phase II (Spiroid-installed)			Delta (Phase II minus Phase I, dB)
		No. of Events	Average (dB)	Std. Dev. (dB)	No. of Events	Average (dB)	Std. Dev. (dB)	
100	Normal Cruise	3	**82.3**	1.8	2	**81.9**	1.7	**-0.4**
300	Departure	3	**106.0**	1.9	2	**91.6**	0.2	**-14.4**
400	Cruise Climb	3	**97.5**	0.5	3	**93.2**	1.4	**-4.3**
500	Approach, Flaps 20, gear up	3	**79.8**	1.2	2	**77.7**	1.8	**-2.1**
600	Approach, Flaps 48, gear down	4	**85.5**	1.4	3	**82.8**	0.7	**-2.8**

Table 11. Comparison of Centerline Noise Levels in L_{PNTSmx}

Series	Series Description	Phase I (Baseline)			Phase II (Spiroid-installed)			Delta (Phase II minus Phase I, dB)
		No. of Events	Average (dB)	Std. Dev. (dB)	No. of Events	Average (dB)	Std. Dev. (dB)	
100	Normal Cruise	3	**88.7**	1.8	2	**88.3**	1.1	**-0.3**
300	Departure	3	**110.0**	2.2	2	**99.2**	0.6	**-10.8**
400	Cruise Climb	3	**102.5**	0.7	3	**100.3**	1.4	**-2.1**
500	Approach, Flaps 20, gear up	3	**87.7**	0.2	2	**82.7**	2.0	**-5.0**
600	Approach, Flaps 48, gear down	4	**91.2**	1.0	3	**87.8**	0.6	**-3.4**

Table 12. Comparison of Sideline Noise Levels in L_{AE}

Series	Series Description	Phase I (Baseline)			Phase II (Spiroid-installed)			Delta (Phase II minus Phase I, dB)
		No. of Events	Average (dB)	Std. Dev. (dB)	No. of Events	Average (dB)	Std. Dev. (dB)	
100	Normal Cruise	3	**80.7**	0.8	2	**80.9**	1.0	**0.1**
300	Departure	3	**99.1**	0.6	2	**88.5**	0.4	**-10.6**
400	Cruise Climb	3	**95.2**	0.9	3	**90.9**	1.9	**-4.3**
500	Approach, Flaps 20, gear up	3	**77.5**	1.1	2	**73.4**	1.3	**-4.1**
600	Approach, Flaps 48, gear down	4	**82.5**	1.0	3	**78.4**	1.4	**-4.1**

Table 13. Comparison of Sideline Noise Levels in L_{ASmx}

Series	Series Description	Phase I (Baseline)			Phase II (Spiroid-installed)			Delta (Phase II minus Phase I, dB)
		No. of Events	Average (dB)	Std. Dev. (dB)	No. of Events	Average (dB)	Std. Dev. (dB)	
100	Normal Cruise	3	**74.5**	0.8	2	**75.7**	2.1	**1.1**
300	Departure	3	**93.9**	0.7	2	**81.3**	0.5	**-12.5**
400	Cruise Climb	3	**89.2**	0.9	3	**85.0**	2.2	**-4.1**
500	Approach, Flaps 20, gear up	3	**71.2**	1.1	2	**66.9**	2.7	**-4.3**
600	Approach, Flaps 48, gear down	4	**77.1**	1.1	3	**73.4**	1.8	**-3.8**

Table 14. Comparison of Sideline Noise Levels in L_{EPN}

Series	Series Description	Phase I (Baseline)			Phase II (Spiroid-installed)			Delta (Phase II minus Phase I, dB)
		No. of Events	Average (dB)	Std. Dev. (dB)	No. of Events	Average (dB)	Std. Dev. (dB)	
100	Normal Cruise	3	**85.2**	2.5	2	**83.6**	1.5	**-1.6**
300	Departure	3	**99.8**	0.5	2	**90.6**	2.2	**-9.2**
400	Cruise Climb	3	**97.3**	0.5	3	**93.2**	0.8	**-4.1**
500	Approach, Flaps 20, gear up	3	**80.4**	1.2	2	**78.3**	0.8	**-2.2**
600	Approach, Flaps 48, gear down	4	**87.2**	0.9	3	**82.3**	0.9	**-5.0**

Table 15. Comparison of Sideline Noise Levels in L_{PNTSmx}

Series	Series Description	Phase I (Baseline)			Phase II (Spiroid-installed)			Delta (Phase II minus Phase I, dB)
		No. of Events	Average (dB)	Std. Dev. (dB)	No. of Events	Average (dB)	Std. Dev. (dB)	
100	Normal Cruise	3	**89.9**	2.9	2	**89.7**	2.7	**-0.1**
300	Departure	3	**103.7**	1.3	2	**94.2**	3.0	**-9.6**
400	Cruise Climb	3	**101.3**	1.3	3	**98.6**	0.3	**-2.7**
500	Approach, Flaps 20, gear up	3	**85.2**	0.8	2	**82.3**	0.1	**-2.8**
600	Approach, Flaps 48, gear down	4	**91.0**	1.4	3	**86.6**	1.2	**-4.4**

The graphics below represent the comparison of the averaged spectral data recorded during the time of maximum A-weighted sound level (L_{ASmx}) for LFO, APP, and DEP events. The spectral data is presented in 30 one-third octave bands ranging from bands 11 to 40, representing nominal center frequencies of 12.5 hertz and 10,000 hertz, respectively. No weighting was applied to these spectral data. For consistency in comparing results, all spectral data have been adjusted to a source-to-receiver distance of 1,000 feet. For a complete set of spectral data for individual events, refer to Appendix D of this report.

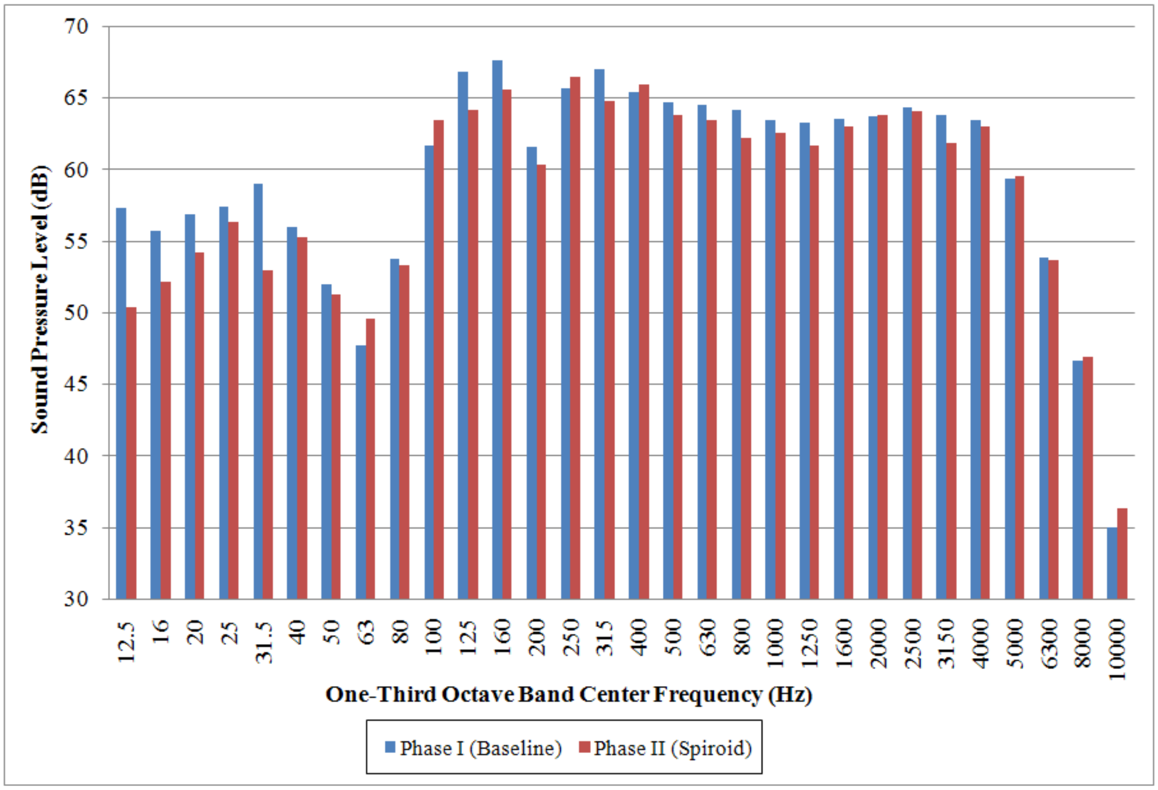

Figure 21. Comparison of Centerline Series 100 Spectral Data

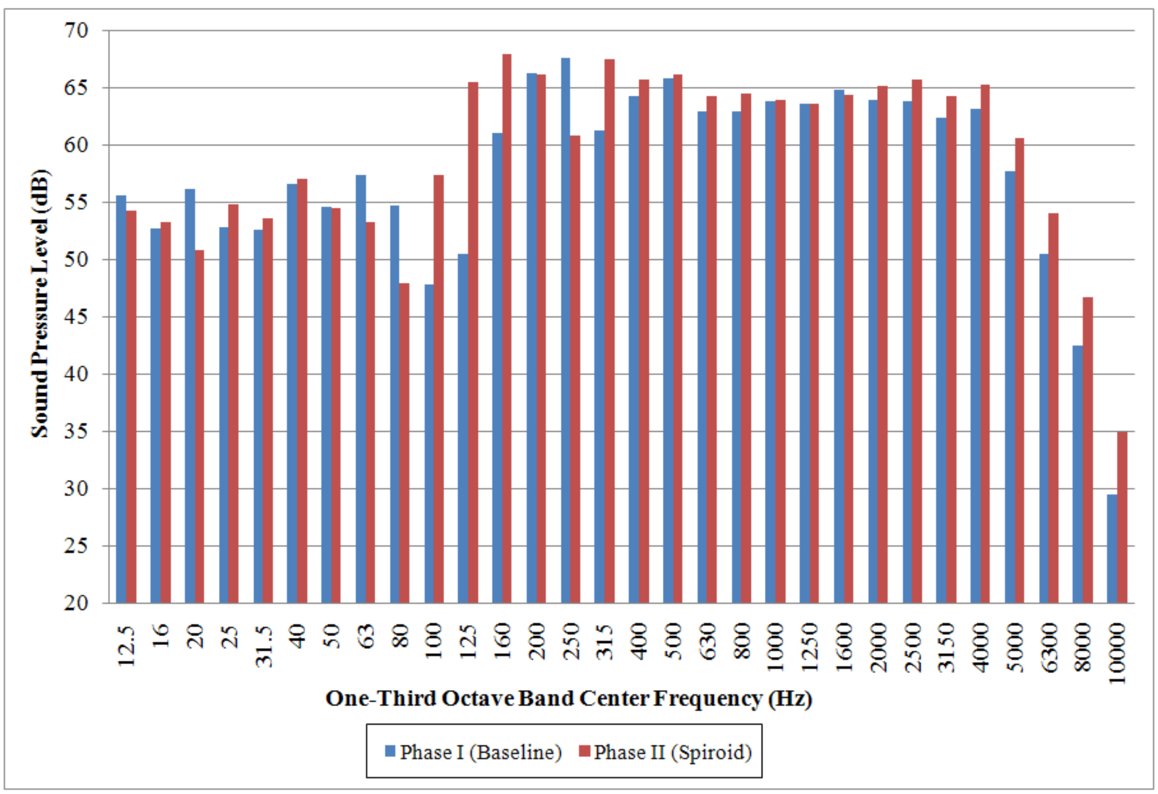

Figure 22. Comparison of Sideline Series 100 Spectral Data

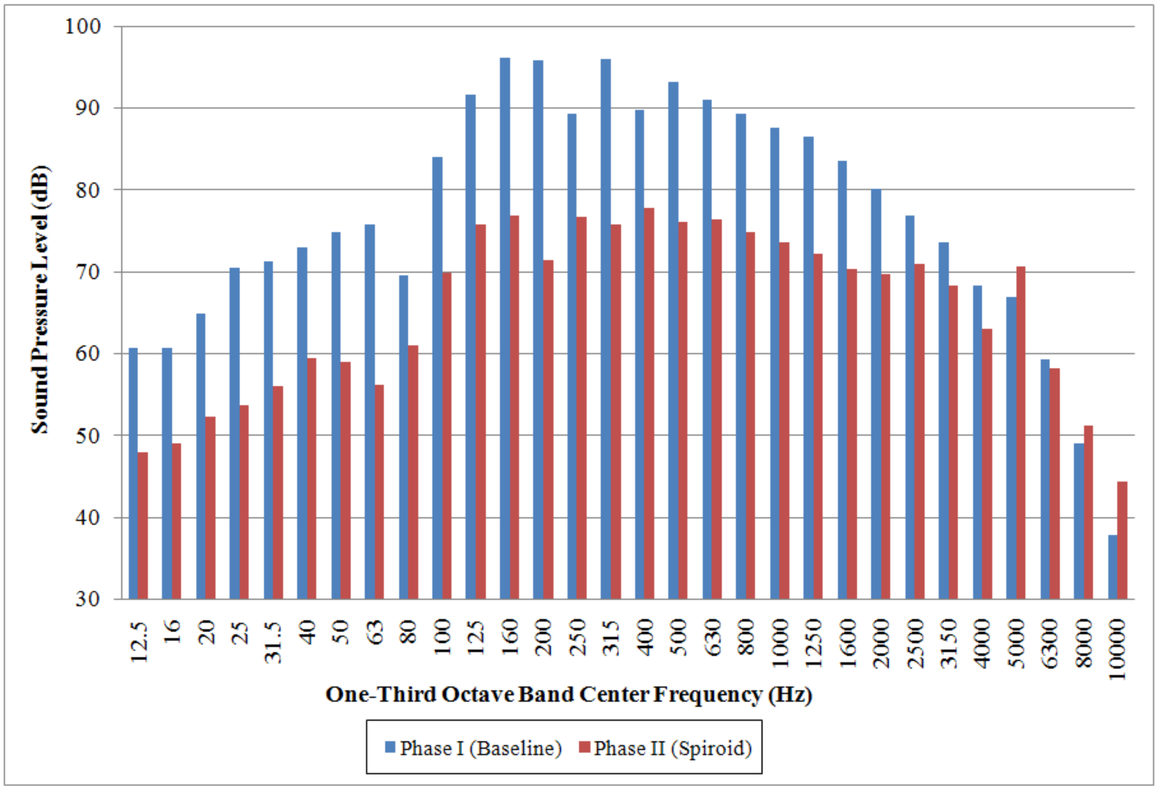

Figure 23. Comparison of Centerline Series 300 Spectral Data

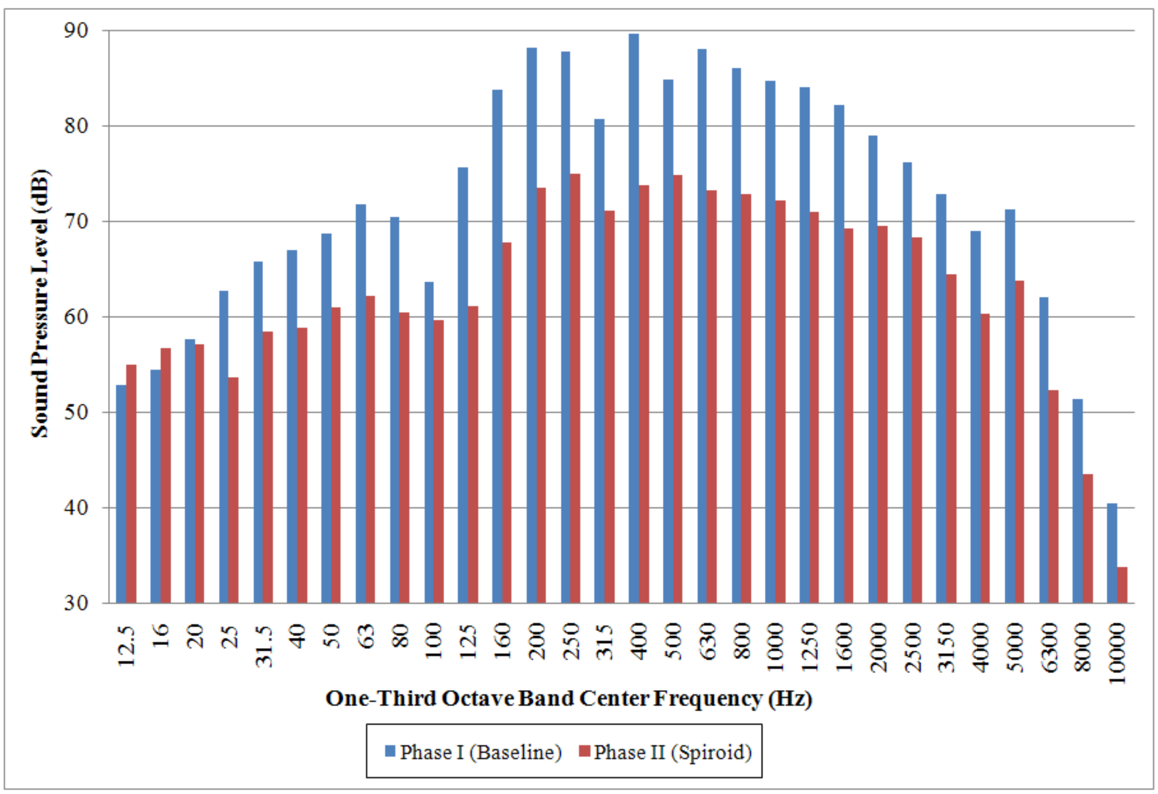

Figure 24. Comparison of Sideline Series 300 Spectral Data

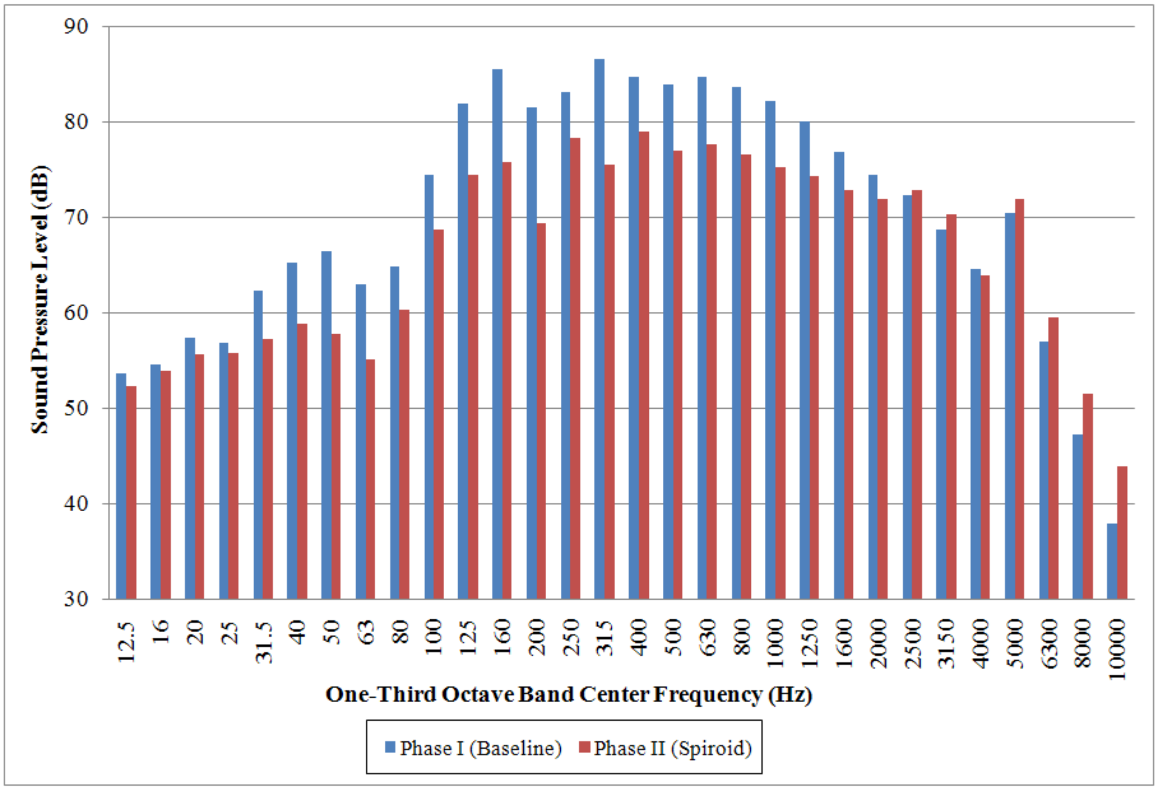

Figure 25. Comparison of Centerline Series 400 Spectral Data

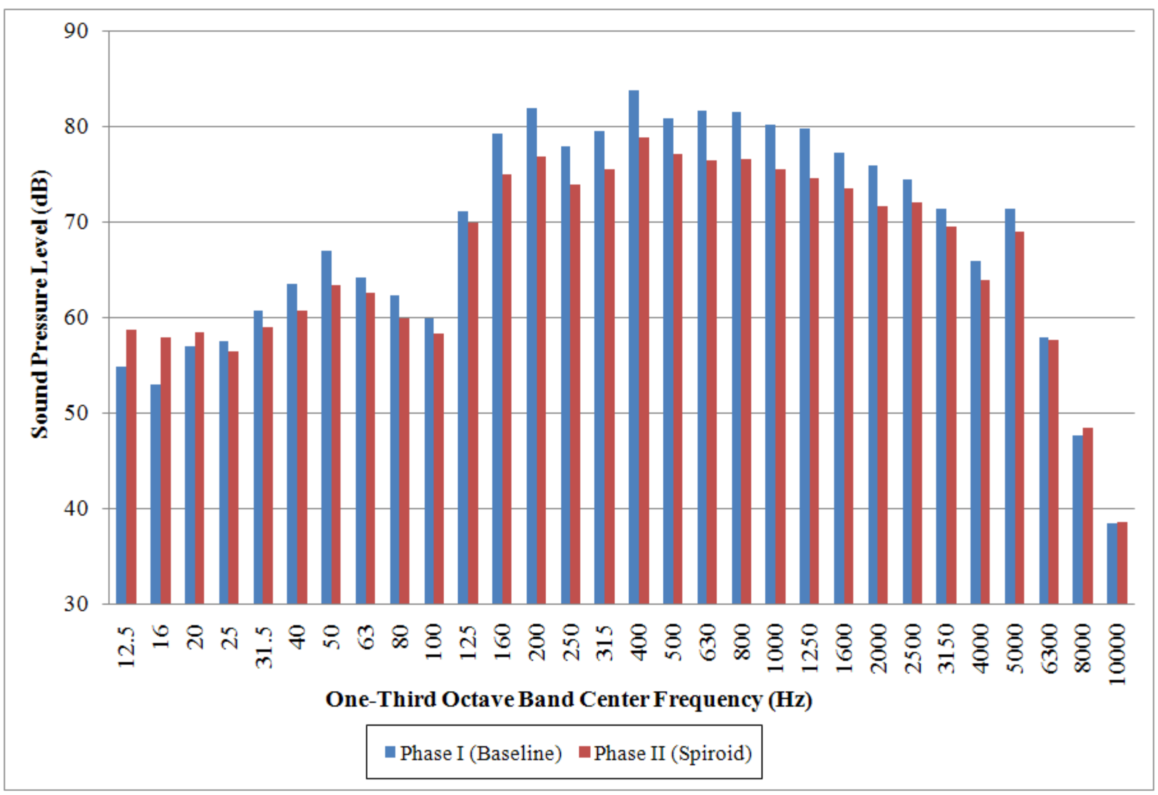

Figure 26. Comparison of Sideline Series 400 Spectral Data

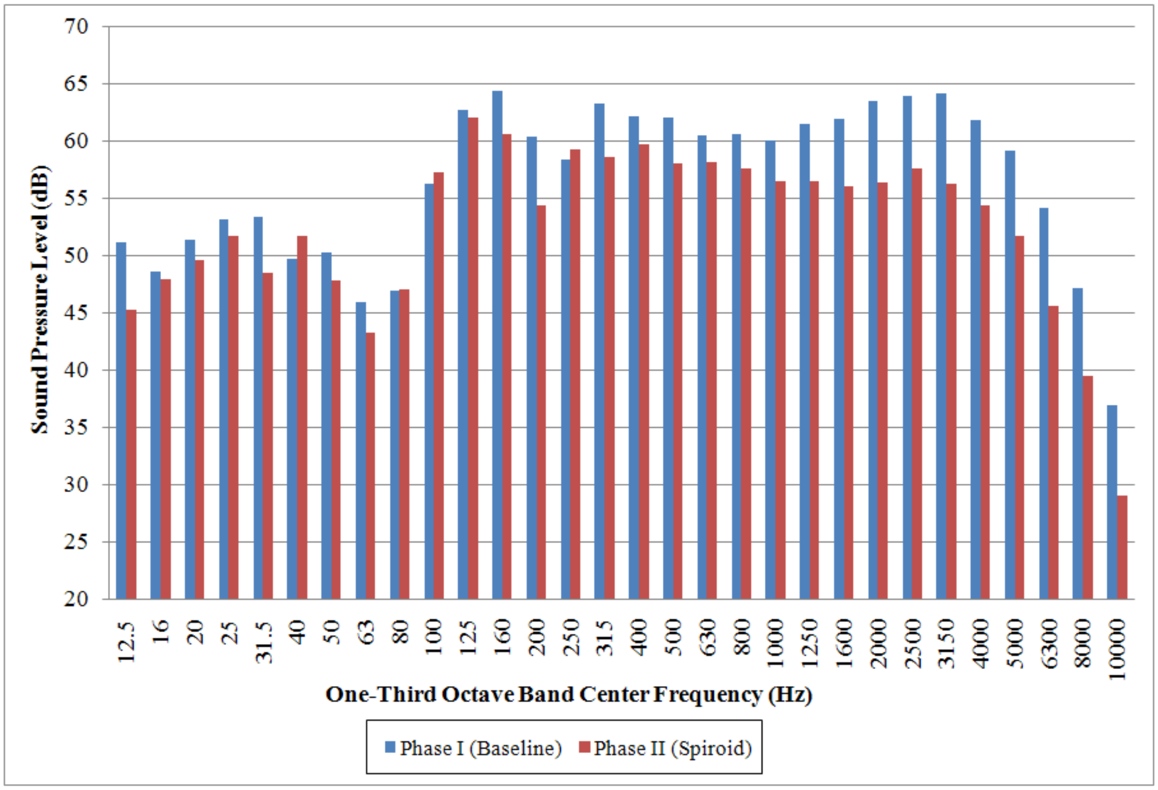

Figure 27. Comparison of Centerline Series 500 Spectral Data

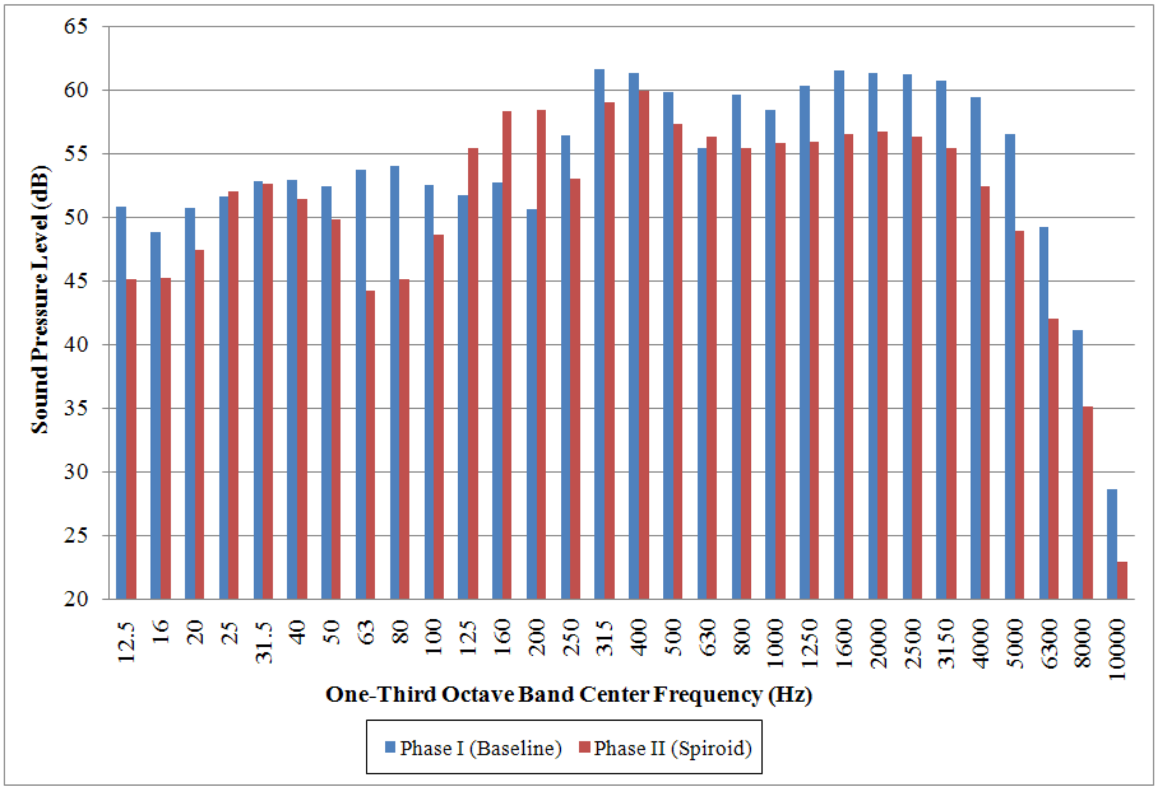

Figure 28. Comparison of Sideline Series 500 Spectral Data

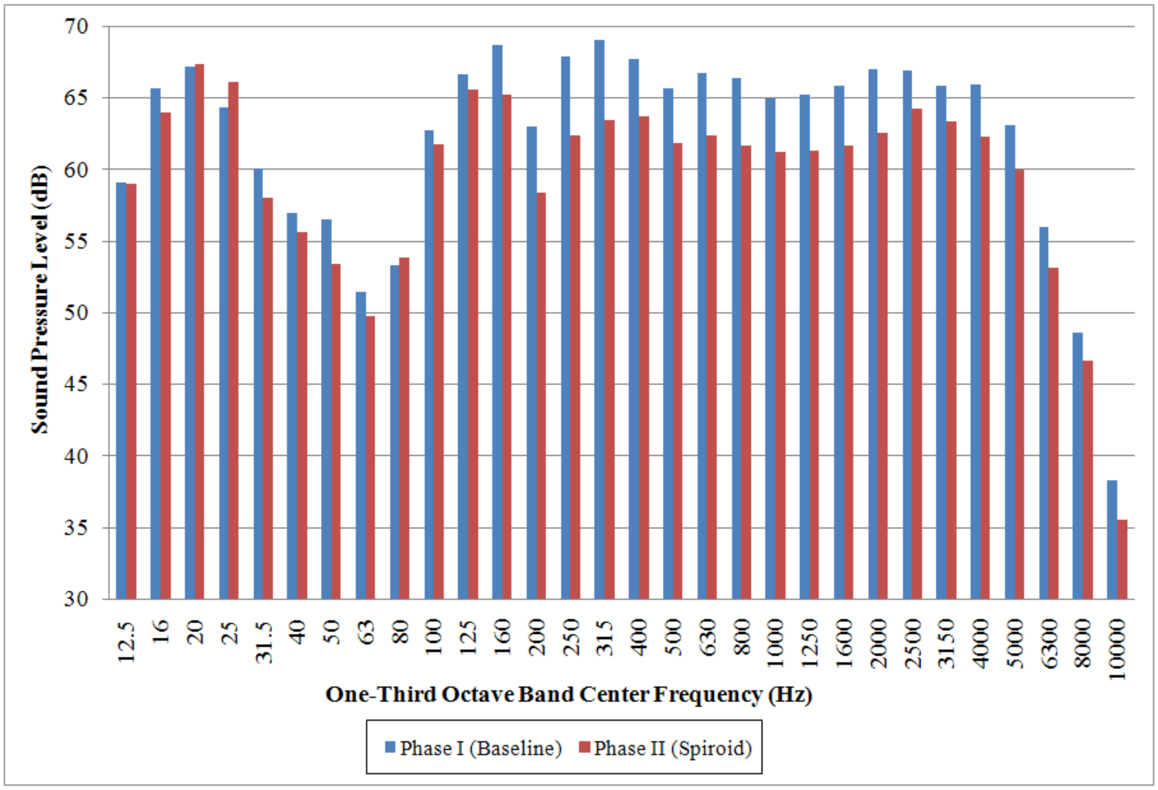

Figure 29. Comparison of Centerline Series 600 Spectral Data

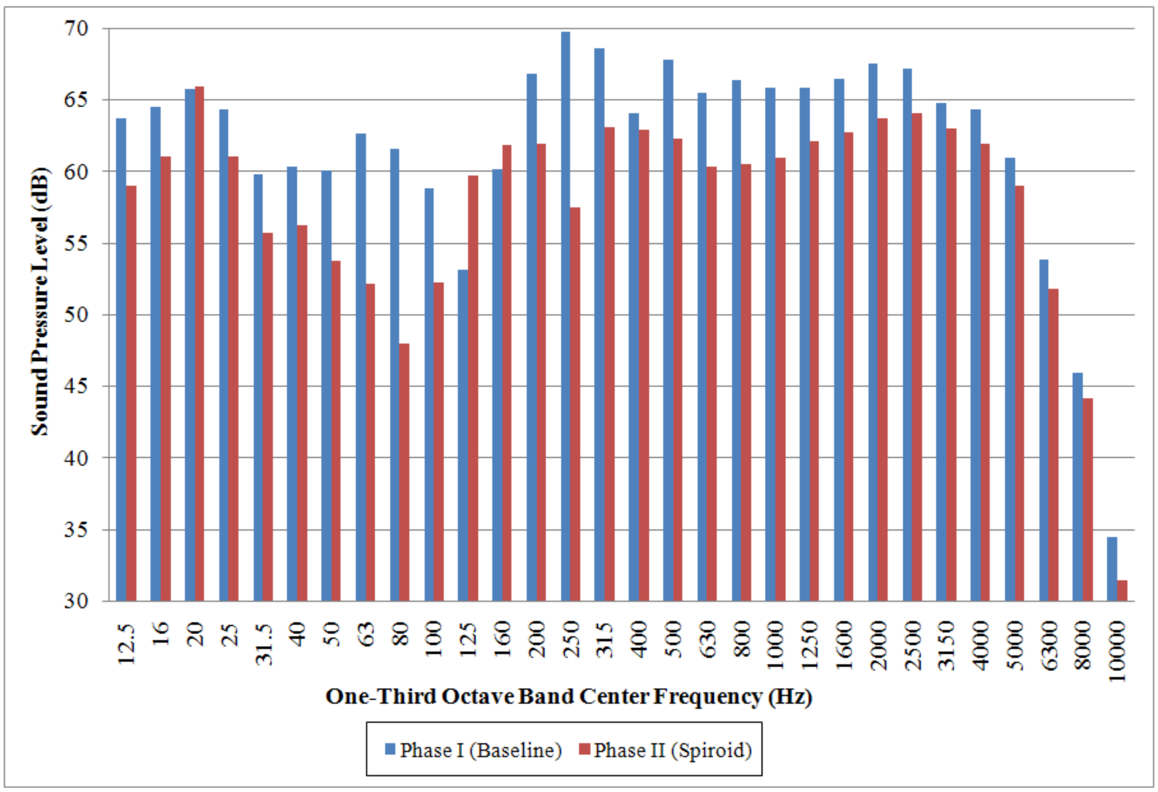

Figure 30. Comparison of Sideline Series 600 Spectral Data

11 CONCLUSIONS

11.1 Fuel Burn

Fuel flow analyses were conducted for periods when the aircraft was in a stable configuration for long enough the collect meaningful data. These conditions occurred when the aircraft was either on downwind returning to the test area or during the approach to the test area. For the approach condition, the fuel flow difference between the baseline and the Spiroid was dominated by the different approach angle flown, so that a clear determination of the difference in fuel consumption could not be made. On the level segments during the downwind returns to the test area, the Phase I baseline measurements showed *lower* fuel consumption than the Phase II Spiroid measurements for a given airspeed. Note that these results are based on flights at or below 3000 feet MSL and with the aircraft using flaps 20.

11.2 Acoustics

11.2.1 Overall Noise Levels

The overall noise results for level flyover events (Series 100 Normal Cruise) showed very small differences between the Phase I and II measurements. For the L_{ASmx} metric, the differences were around 1 decibel for both the centerline and sideline microphones. Because the standard deviation of the averaged noise levels was 1 decibel and greater, there was no statistical evidence that the spiroid winglets affected the overall noise levels of the aircraft during level flyover pass-bys. However, it is noted that the test aircraft flew at a higher engine power setting of N1 = 71-78% during the Phase II tests compared to the baseline tests, where the test aircraft flew at N1 = 65-73%; a difference of about 5%[*]. This typically would have translated to higher sound levels during the Phase II results.

The standard departure events (Series 300) showed the largest differences in noise levels between the Phase I and II measurements. For the L_{ASmx} metric, the Phase II measurements were on average 14.3 decibels lower than the baseline for the centerline microphone. For the sideline microphone, the Phase II measurements were 12.5 decibels lower. To put these numbers into perspective, an increase of 10 decibels is generally perceived to be approximately twice as loud. So in this case, the data indicate the standard departure events during the baseline measurements were more than twice as loud as the Phase II measurements. This significant difference in noise levels is believed to be related to the engine power setting, N1, used during the standard departure events.

Tables 16 and 17 below show a comparison of the engine power settings used during the Phase I and II measurements. These data indicate that the engine power settings used during the Phase II Spiroid measurements were much lower than the settings used during

[*] For a list of N1 power settings used for all events, refer to Appendix E.

the baseline measurements. During the baseline measurements, the test aircraft used N=100%, or maximum power, during departure. While in the Phase II measurements, the test aircraft used 94% power, which may have resulted in significantly lower noise levels.

Table 16. Engine Power Settings Used During Phase I Standard Departure Events

Event	Event Description	Time at L_{ASmx}	Engine 1 N1 (%)	Engine 2 N1 (%)	Engine 3 N1 (%)	Average N1 (%)
320	DEP: Standard	11:48:35	98.88	100.76	99.97	**99.87**
340	DEP: Standard	12:01:29	99.15	100.94	100.10	**100.06**
350	DEP: Standard	12:07:35	99.19	100.97	100.13	**100.09**

Table 17. Engine Power Settings Used During Phase II Standard Departure Events

Event	Event Description	Time at L_{ASmx}	Engine 1 N1 (%)	Engine 2 N1 (%)	Engine 3 N1 (%)	Average N1 (%)
320	DEP: Standard	14:36:22	93.89	93.44	93.92	**93.75**
330	DEP: Standard	14:40:45	93.67	94.25	94.75	**94.23**

To investigate whether or not the spiroid winglets, which are claimed to reduce drag and increase lift of the aircraft, was the attributing factor to why a lower engine power setting was used, the rate of climb (ROC) and test aircraft gradient were calculated. Recorded TSPI data were used to calculate the ROC and test aircraft gradient during the 10 dB up/down times in the standard departure events. Tables 18 and 19 below present these data along with the average N1 values and instantaneous aircraft speeds at time of L_{ASmx}. It can be seen in these data that the lower engine power used in the Phase II measurements did not provide an equal or improved ROC and gradient, as compared to the baseline measurements. It is therefore, unknown why a lower engine power setting was used during the Phase II measurements.

Table 18. ROC and Test Aircraft Gradient During Phase I Series 300 Events

Event	Event Description	Average N1 (%)	Test Speed (kts)	Rate of Climb (ft/min)	Gradient
320	DEP: Standard	99.87	121.7	2795.4	0.23
340	DEP: Standard	100.06	121.5	3114.0	0.25
350	DEP: Standard	100.09	113.8	2908.2	0.25

Table 19. ROC and Test Aircraft Gradient During Phase II Series 300 Events

Event	Event Description	Average N1 (%)	Test Speed (kts)	Rate of Climb (ft/min)	Gradient
320	DEP: Standard	93.75	129	1917.0	0.15
330	DEP: Standard	94.23	129	2479.2	0.17

The cruise climb departure events (Series 400) also showed the Phase II measurements were quieter, although the differences were not as large as the standard departures. Differences of 5.8 and 4.1 decibels for the centerline and sideline microphones, respectively, were seen in the L_{ASmx} results. Review of the engine power setting data showed the power settings used during the Phase I and II measurements were within 1% of one another. The ROC and aircraft gradient during the 400 series were also the same for both measurements, as shown in Tables 20 and 21. This is the only series of events where the test aircraft used similar engine power settings and had similar ROC and gradient values during the Phase I and II measurements.

Table 20. ROC and Test Aircraft Gradient During Phase I Series 400 Events

Event	Event Description	Average N1 (%)	Test Speed (kts)	Rate of Climb (ft/min)	Gradient
410	DEP: Cruise Climb	96.53	157.4	3900.0	0.24
420	DEP: Cruise Climb	97.22	155.5	2878.8	0.18
430	DEP: Cruise Climb	97.01	159.3	3897.6	0.24

Table 21. ROC and Test Aircraft Gradient During Phase I Series 400 Events

Event	Event Description	Average N1 (%)	Test Speed (kts)	Rate of Climb (ft/min)	Gradient
420	DEP: Cruise Climb	95.68	151.9	3566.4	0.23
430	DEP: Cruise Climb	96.18	152	2835.0	0.18
440	DEP: Cruise Climb	95.79	151.1	2701.8	0.18

The approach events (Series 500 and 600) both showed the Phase II measurements were quieter than the baseline. The Series 500 events, approach with flap settings of 20 degrees and gears up, had almost identical differences as the Series 400 departure events. Differences of 5.7 and 4.3 decibels for the centerline and sideline microphones, respectively, were seen in the L_{ASmx} results. The series 600 events, approach with flap settings of 48 degrees and gear down, showed smaller differences. Differences of 3.7-3.8 decibels were seen in the L_{ASmx} results for this series. In both approach series, the test aircraft used a significantly lower power setting during the Phase II measurements. During the Phase II measurements the test aircraft operated at a N1 setting that was approximately 15% lower for the 500 series and about 10% lower for the 600 series. Figure 31 below shows the correlation of the test aircraft's engine power and the L_{ASmx}

for each approach event. It can be concluded in this figure that lower engine power used during approach events resulted in lower L_{ASmx} values.

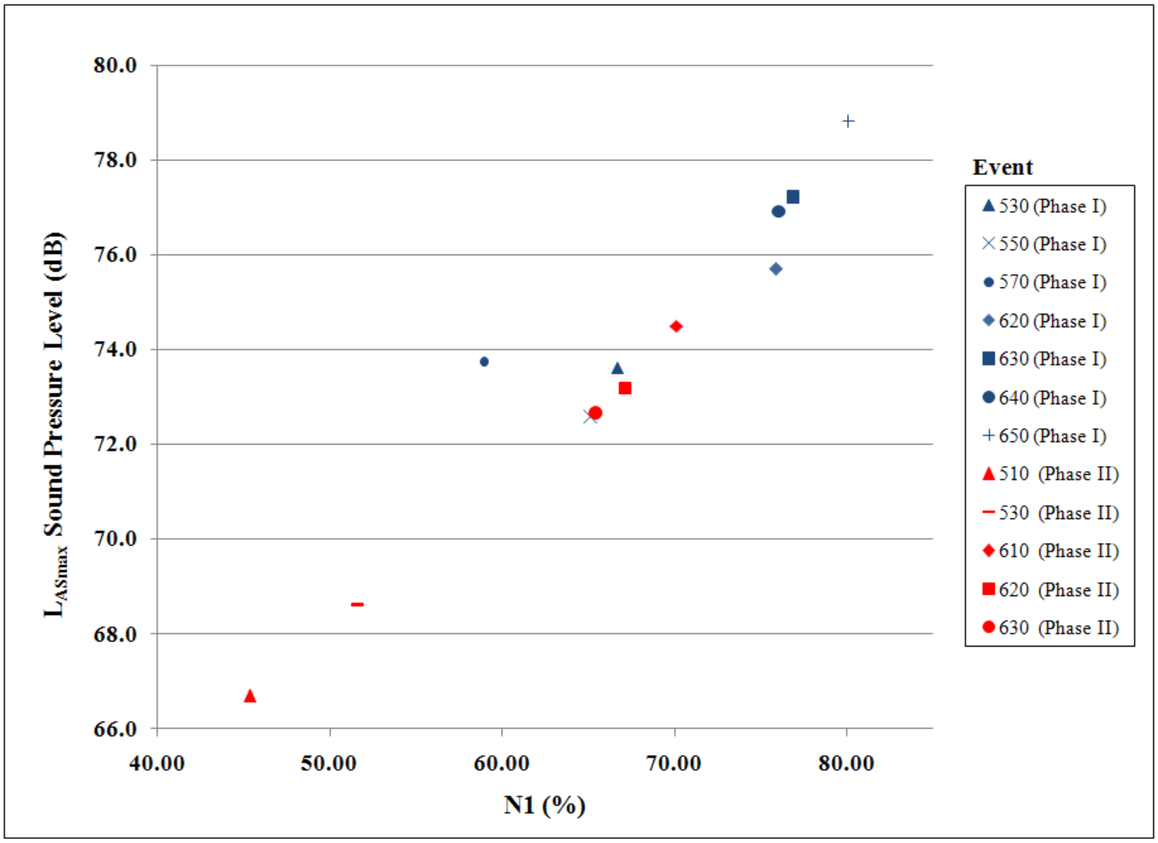

Figure 31. Comparison of Engine Power and Sound Pressure Level for Series 500 and 600 (Approach) Events

11.2.2 Spectral Data Analyses

An examination of the spectral data indicates that the Phase II results were generally quieter across the entire measured spectrum. However, there were frequencies that consistently showed an increase of sound pressure levels in the Phase II results. Specifically, there was a trend of increased levels at the high frequencies, from 5,000 to 10,000 hertz. This was apparent only during level flyover and departure events, but not in the approach events where the test aircraft speed was lower. This was seen in both the centerline and sideline microphones. An inspection of the ambient noise data during the Phase I and II measurements showed that it was a not factor in these differences.

Another phenomenon was also seen around 125 Hz during all level flyover and approach events, but not departure events. At and around this frequency, the Phase II results showed a consistently higher tone ranging from 3.7 decibels for approach events to 15.1 decibels for level flyover events. However, this was only seen in the sideline microphone and not at the centerline microphone. An analysis of the ambient noise data surrounding these events also indicated it was not a factor in these differences.

APPENDIX A: METEOROLOGICAL DATA

This appendix presents the measured test day meteorological data used in the processing of the acoustic data. Temperature in degrees Fahrenheit and relative humidity in percent taken at the aircraft's time at maximum sound pressure level during flyover, along with average wind speed in knots over the duration of the event, are presented for each event in Tables 22 and 23. For the purposes of these tests, changes in temperature and relative humidity are assumed to be negligible over short periods of time; accordingly, for the purpose of data processing, temperature and relative humidity were assumed to be constant over the ten-decibel up and down period of each aircraft event. Note that only meteorological data for events that passed the Quality Assurance test outlined in Section 9.3 are provided.

All acoustic data presented herein were analyzed in accordance with wind speed and direction criteria as specified in FAR 36 / Annex 16. As described in Section 8.3.2, test day meteorological data were used to correct the acoustic data to the SAE-AIR-1845 reference day atmospheric conditions.

Table 22. Phase I Meteorological Data

Event	Time of Day	Temperature (^{o}F)	Relative Humidity (%)	Average Wind Speed (kts)
120	10:29:21	55.6	69	2.5
130	12:43:50	58.3	67	4.9
140	12:49:07	59	68	4.3
320	11:48:35	58.6	68	5.4
340	12:01:29	57.9	68	3.9
350	12:07:35	58.5	68	2.7
410	12:13:26	57.2	69	4.1
420	12:19:01	57.9	69	4.5
430	12:24:35	57.7	69	4.3
530	10:47:47	56.7	68	1.9
550	11:00:57	57.7	67	2.1
570	12:38:21	58.5	68	3.1
620	11:15:09	55.9	70	2.9
630	11:21:46	56.7	70	2.7
640	11:28:41	57.7	70	4.7
650	11:35:40	57.7	70	2.9

Table 23. Phase II Meteorological Data

Event	Time of Day	Temperature (^oF)	Relative Humidity (%)	Average Wind Speed (kts)
120	14:03:40	72.7	72	3.5
130	14:07:59	73.5	71	3.5
320	14:36:22	65.1	74	4.7
330	14:40:45	64	78	5.8
420	15:00:09	68.7	75	2.7
430	15:05:19	67.6	74	5.2
440	15:13:53	64.6	76	5.6
510	15:23:27	66.2	77	2.7
530	15:40:22	68.7	74	3.1
610	15:49:19	70.5	73	3.3
620	15:57:53	69.3	73	3.3
630	16:06:11	67.3	73	3.1

APPENDIX B: TIME SPACE POSITION INFORMATION (TSPI)

This appendix presents a summary of the TSPI data used in the processing of the acoustic data measured for each aircraft event, including overhead time, aircraft test altitude, test speed, and reference speed. Altitude and test speed data represent instantaneous values at the overhead time. Note that a 160 knot reference speed is used in the FAA's noise prediction models; for reference, values of DUR_{ADJ}, which is used to adjust exposure-based metrics from reference to modeled conditions, are provided in the last column. Note that only TSPI data for events that passed the Quality Assurance test outlined in Section 9 are provided.

Table 24. Phase I TSPI Data

Event	Event Description	Time at L_{ASmx}	Test Altitude (ft, AGL)	Test Speed (kts)	DUR_{ADJ} (dB)
120	LFO: Normal Cruise @ 500 ft	10:29:21	398.9	135.7	0.7
130	LFO: Normal Cruise @ 500 ft	12:43:50	527.4	156.9	0.1
140	LFO: Normal Cruise @ 500 ft	12:49:07	519.7	154.8	0.1
320	DEP: Standard	11:48:35	652.2	121.7	1.2
340	DEP: Standard	12:01:29	675.0	121.5	1.2
350	DEP: Standard	12:07:35	703.9	113.8	1.5
410	DEP: Cruise Climb	12:13:26	805.0	157.4	0.1
420	DEP: Cruise Climb	12:19:01	741.6	155.5	0.1
430	DEP: Cruise Climb	12:24:35	748.0	159.3	0.0
530	APP: Flaps 20 Degrees, Gear Up	10:47:47	197.7	127.8	1.0
550	APP: Flaps 20 Degrees, Gear Up	11:00:57	241.5	125.7	1.0
570	APP: Flaps 20 Degrees, Gear Up	12:38:21	362.5	132.4	0.8
620	APP: Flaps 48 Degrees, Gear Down	11:15:09	403.6	111.3	1.6
630	APP: Flaps 48 Degrees, Gear Down	11:21:46	353.4	115.6	1.4
640	APP: Flaps 48 Degrees, Gear Down	11:28:41	405.3	108.4	1.7
650	APP: Flaps 48 Degrees, Gear Down	11:35:40	425.8	110.8	1.6

Table 25. Phase II TSPI Data

Event	Event Description	Time at L_{ASmx}	Test Altitude (ft, AGL)	Test Speed (kts)	DUR_{ADJ} (dB)
120	LFO: Normal Cruise @ 500 ft	14:03:40	469.8	159.1	0.0
130	LFO: Normal Cruise @ 500 ft	14:07:59	506.6	158.2	0.0
320	DEP: Standard	14:36:22	396.6	129	0.9
330	DEP: Standard	14:40:45	308.2	129	0.9
420	DEP: Cruise Climb	15:00:09	424.7	151.9	0.2
430	DEP: Cruise Climb	15:05:19	472.6	152	0.2
440	DEP: Cruise Climb	15:13:53	535.7	151.1	0.2
510	APP: Flaps 20 Degrees, Gear Up	15:23:27	444.5	126.4	1.0
530	APP: Flaps 20 Degrees, Gear Up	15:40:22	537.9	132.3	0.8
610	APP: Flaps 48 Degrees, Gear Down	15:49:19	511.0	117	1.4
620	APP: Flaps 48 Degrees, Gear Down	15:57:53	499.7	118	1.3
630	APP: Flaps 48 Degrees, Gear Down	16:06:11	522.9	115	1.4

APPENDIX C: AIRCRAFT NOISE POWER DISTANCE DATA

Appendix C presents individual event centerline and sideline NPD data corrected to the SAE-AIR-1845 reference day atmospheric conditions and reference speed of 160 knots. Averages and standard deviation are also presented for each series and distance. Only events that passed the Quality Assurance test outlined in Section 9 are included.

C.1 Phase I Noise Power Distance Tables

Table 26. Phase I Centerline Series 100 L_{AE} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{AE} @ 160 kts (dB)				
	Event 120	Event 130	Event 140	Average	Std. Dev.
200	92.8	95.1	94.4	94.1	1.2
400	87.8	90.0	89.4	89.1	1.1
630	84.1	86.2	85.7	85.3	1.1
1000	80.0	81.8	81.6	81.1	1.0
2000	73.2	74.7	74.8	74.3	0.9
4000	66.0	67.4	67.5	67.0	0.8
6300	60.9	62.3	62.4	61.9	0.8
10000	55.2	56.7	56.7	56.2	0.9
16000	48.6	50.3	50.3	49.8	1.0
25000	41.6	43.4	43.6	42.9	1.1

Table 27. Phase I Centerline Series 100 L_{ASmx} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{ASmx} @ 160 kts (dB)				
	Event 120	Event 130	Event 140	Average	Std. Dev.
200	92.7	94.1	92.5	93.1	0.9
400	85.4	86.7	85.2	85.8	0.8
630	80.2	81.4	80.1	80.6	0.8
1000	74.6	75.6	74.4	74.9	0.6
2000	65.6	66.2	65.4	65.7	0.4
4000	56.1	56.6	55.8	56.2	0.4
6300	49.5	50.1	49.2	49.6	0.4
10000	42.3	43.0	42.0	42.4	0.5
16000	34.2	35.1	34.1	34.4	0.5
25000	25.7	26.6	25.9	26.1	0.5

Table 28. Phase I Centerline Series 100 L_{EPN} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{EPN} @ 160 kts (dB)				
	Event 120	Event 130	Event 140	Average	Std. Dev.
200	101.1	104.2	102.0	102.4	1.6
400	93.4	96.5	94.4	94.8	1.6
630	87.3	90.9	88.7	89.0	1.8
1000	80.7	84.2	82.0	82.3	1.8
2000	69.6	72.3	70.1	70.7	1.4
4000	58.7	61.4	59.6	59.9	1.4
6300	51.9	54.8	53.0	53.2	1.5
10000	44.4	47.6	45.8	46.0	1.6
16000	33.1	37.1	35.1	35.1	2.0
25000	16.0	21.4	19.1	18.8	2.7

Table 29. Phase I Centerline Series 100 L_{PNTSmx} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{PNTSmx} @ 160 kts (dB)				
	Event 120	Event 130	Event 140	Average	Std. Dev.
200	107.8	110.7	107.9	108.8	1.6
400	100.1	103.0	100.3	101.1	1.6
630	94.1	97.3	94.6	95.3	1.8
1000	87.4	90.7	87.9	88.7	1.8
2000	76.3	78.8	76.0	77.0	1.5
4000	65.4	67.8	65.5	66.2	1.4
6300	58.6	61.2	58.9	59.6	1.4
10000	51.1	54.1	51.7	52.3	1.6
16000	39.8	43.6	41.0	41.5	1.9
25000	22.8	27.8	25.0	25.2	2.5

Table 30. Phase I Centerline Series 300 L_{AE} NPD Data

Distance (ft)	DEP: Standard L_{AE} @ 160 kts (dB)				
	Event 320	Event 340	Event 350	Average	Std. Dev.
200	111.4	113.4	113.8	112.9	1.3
400	107.3	109.3	109.8	108.8	1.3
630	104.5	106.4	107.0	106.0	1.3
1000	101.5	103.4	104.0	102.9	1.3
2000	96.5	98.3	99.0	97.9	1.3
4000	90.7	92.3	93.3	92.1	1.3
6300	86.3	87.7	88.9	87.6	1.3
10000	81.1	82.3	83.8	82.4	1.4
16000	74.9	75.9	77.7	76.2	1.4
25000	68.2	68.8	70.9	69.3	1.4

Table 31. Phase I Centerline Series 300 L_{ASmx} NPD Data

Distance (ft)	DEP: Standard L_{ASmx} @ 160 kts (dB)				
	Event 320	Event 340	Event 350	Average	Std. Dev.
200	110.7	114.2	114.2	113.0	2.0
400	104.4	107.8	107.8	106.7	2.0
630	100.1	103.5	103.6	102.4	2.0
1000	95.6	98.9	99.1	97.9	2.0
2000	88.4	91.5	91.9	90.6	1.9
4000	80.3	83.3	83.9	82.5	1.9
6300	74.4	77.2	78.1	76.6	1.9
10000	67.7	70.3	71.4	69.8	1.9
16000	60.0	62.4	63.8	62.1	1.9
25000	51.8	53.9	55.5	53.7	1.9

Table 32. Phase I Centerline Series 300 L_{EPN} NPD Data

Distance (ft)	DEP: Standard L_{EPN} @ 160 kts (dB)				
	Event 320	Event 340	Event 350	Average	Std. Dev.
200	119.7	122.7	123.1	121.8	1.8
400	113.4	116.1	116.6	115.3	1.7
630	109.0	111.5	112.1	110.9	1.7
1000	103.9	106.7	107.4	106.0	1.9
2000	96.5	99.0	99.9	98.5	1.7
4000	88.7	91.1	92.0	90.6	1.7
6300	83.4	85.7	86.7	85.3	1.7
10000	77.7	80.0	81.5	79.7	1.9
16000	71.5	73.9	75.9	73.7	2.2
25000	62.9	64.8	67.0	64.9	2.0

Table 33. Phase I Centerline Series 300 L_{PNTSmx} NPD Data

Distance (ft)	DEP: Standard L_{PNTSmx} @ 160 kts (dB)				
	Event 320	Event 340	Event 350	Average	Std. Dev.
200	123.3	126.8	127.3	125.8	2.2
400	117.0	120.2	120.8	119.3	2.1
630	112.6	115.7	116.4	114.9	2.0
1000	107.5	110.8	111.7	110.0	2.2
2000	100.1	103.1	104.1	102.4	2.1
4000	92.3	95.3	96.2	94.6	2.0
6300	86.9	89.9	90.9	89.3	2.1
10000	81.2	84.2	85.7	83.7	2.3
16000	75.0	78.1	80.1	77.7	2.5
25000	66.5	69.0	71.2	68.9	2.4

Table 34. Phase I Centerline Series 400 L_{AE} NPD Data

Distance (ft)	DEP: Cruise Climb L_{AE} @ 160 kts (dB)				
	Event 410	Event 420	Event 430	Average	Std. Dev.
200	106.1	108.2	108.6	107.7	1.3
400	102.0	103.9	104.3	103.4	1.3
630	99.1	101.0	101.3	100.5	1.2
1000	96.0	97.8	98.1	97.3	1.1
2000	90.9	92.4	92.7	92.0	1.0
4000	84.9	86.1	86.5	85.8	0.8
6300	80.2	81.1	81.7	81.0	0.7
10000	74.7	75.2	76.0	75.3	0.6
16000	68.1	68.2	69.1	68.5	0.5
25000	60.9	60.7	61.5	61.0	0.4

Table 35. Phase I Centerline Series 400 L_{ASmx} NPD Data

Distance (ft)	DEP: Cruise Climb L_{ASmx} @ 160 kts (dB)				
	Event 410	Event 420	Event 430	Average	Std. Dev.
200	103.8	107.7	107.8	106.5	2.3
400	97.4	101.2	101.2	100.0	2.2
630	93.1	96.8	96.7	95.5	2.1
1000	88.5	92.1	92.0	90.8	2.0
2000	81.1	84.4	84.4	83.3	1.9
4000	72.9	75.8	75.9	74.9	1.7
6300	66.7	69.4	69.6	68.6	1.6
10000	59.7	62.0	62.4	61.3	1.5
16000	51.6	53.5	54.0	53.0	1.3
25000	42.9	44.5	45.0	44.1	1.1

Table 36. Phase I Centerline Series 400 L_{EPN} NPD Data

Distance (ft)	DEP: Cruise Climb L_{EPN} @ 160 kts (dB)				
	Event 410	Event 420	Event 430	Average	Std. Dev.
200	115.3	116.5	115.3	115.7	0.7
400	108.2	109.3	108.3	108.6	0.6
630	103.0	104.1	103.2	103.4	0.6
1000	97.1	98.0	97.4	97.5	0.5
2000	86.8	86.8	87.9	87.2	0.6
4000	76.1	76.9	78.8	77.2	1.4
6300	69.8	70.6	71.1	70.5	0.7
10000	63.2	64.1	64.7	64.0	0.8
16000	55.2	56.6	56.8	56.2	0.9
25000	43.2	45.4	44.9	44.5	1.2

Table 37. Phase I Centerline Series 400 L_{PNTSmx} NPD Data

Distance (ft)	DEP: Cruise Climb L_{PNTSmx} @ 160 kts (dB)				
	Event 410	Event 420	Event 430	Average	Std. Dev.
200	120.0	121.7	120.3	120.7	0.9
400	112.9	114.5	113.2	113.5	0.9
630	107.7	109.3	108.1	108.4	0.8
1000	101.8	103.3	102.4	102.5	0.7
2000	91.5	92.1	92.8	92.1	0.7
4000	80.8	82.1	83.7	82.2	1.4
6300	74.5	75.8	76.1	75.5	0.8
10000	67.9	69.3	69.6	69.0	0.9
16000	59.9	61.9	61.7	61.2	1.1
25000	47.9	50.6	49.8	49.5	1.4

Table 38. Phase I Centerline Series 500 L_{AE} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{AE} @ 160 kts (dB)				
	Event 530	Event 550	Event 570	Average	Std. Dev.
200	92.5	91.9	92.0	92.1	0.3
400	87.1	86.7	86.9	86.9	0.2
630	83.1	82.8	83.1	83.0	0.2
1000	78.6	78.3	78.7	78.5	0.2
2000	71.1	70.6	71.1	70.9	0.3
4000	63.2	62.5	62.7	62.8	0.4
6300	57.8	57.0	57.0	57.3	0.5
10000	52.0	51.2	51.0	51.4	0.5
16000	45.4	44.7	44.2	44.8	0.6
25000	38.5	37.6	37.0	37.7	0.7

Table 39. Phase I Centerline Series 500 L_{ASmx} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{ASmx} @ 160 kts (dB)				
	Event 530	Event 550	Event 570	Average	Std. Dev.
200	92.8	91.5	92.3	92.2	0.7
400	85.2	84.0	85.0	84.7	0.6
630	79.7	78.6	79.6	79.3	0.6
1000	73.6	72.6	73.8	73.3	0.6
2000	63.8	62.7	63.9	63.5	0.7
4000	53.7	52.3	53.2	53.1	0.7
6300	46.9	45.4	46.1	46.1	0.8
10000	39.5	38.0	38.6	38.7	0.8
16000	31.4	29.9	30.3	30.5	0.8
25000	23.0	21.5	21.6	22.0	0.9

Table 40. Phase I Centerline Series 500 L_{EPN} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{EPN} @ 160 kts (dB)				
	Event 530	Event 550	Event 570	Average	Std. Dev.
200	98.4	98.5	100.5	99.1	1.2
400	90.9	91.1	92.9	91.6	1.1
630	85.3	85.7	87.4	86.1	1.1
1000	78.9	79.4	81.2	79.8	1.2
2000	67.7	68.0	70.4	68.7	1.5
4000	56.0	55.3	57.4	56.2	1.1
6300	49.0	48.1	49.9	49.0	0.9
10000	41.2	39.3	41.1	40.5	1.1
16000	29.2	25.0	26.9	27.0	2.1
25000	11.2	3.5	5.5	6.7	4.0

Table 41. Phase I Centerline Series 500 L_{PNTSmx} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{PNTSmx} @ 160 kts (dB)				
	Event 530	Event 550	Event 570	Average	Std. Dev.
200	107.4	106.6	107.0	107.0	0.4
400	99.8	99.2	99.4	99.5	0.3
630	94.3	93.8	93.9	94.0	0.3
1000	87.9	87.5	87.8	87.7	0.2
2000	76.6	76.1	76.9	76.5	0.4
4000	65.0	63.4	64.0	64.1	0.8
6300	58.0	56.3	56.5	56.9	1.0
10000	50.2	47.4	47.7	48.4	1.5
16000	38.2	33.1	33.4	34.9	2.8
25000	20.2	11.6	12.1	14.6	4.8

Table 42. Phase I Centerline Series 600 L_{AE} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{AE} @ 160 kts (dB)					
	Event 620	Event 630	Event 640	Event 650	Average	Std. Dev.
200	95.3	95.7	95.7	97.0	95.9	0.7
400	90.0	90.6	90.6	92.1	90.8	0.9
630	86.1	86.8	86.8	88.4	87.0	1.0
1000	81.7	82.6	82.5	84.4	82.8	1.2
2000	74.3	75.4	75.4	77.7	75.7	1.4
4000	66.6	67.8	67.8	70.6	68.2	1.7
6300	61.4	62.5	62.6	65.6	63.0	1.8
10000	55.6	56.7	56.8	59.9	57.3	1.9
16000	49.1	50.1	50.2	53.4	50.7	1.9
25000	42.2	42.9	43.2	46.1	43.6	1.7

Table 43. Phase I Centerline Series 600 L_{ASmx} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{ASmx} @ 160 kts (dB)					
	Event 620	Event 630	Event 640	Event 650	Average	Std. Dev.
200	94.6	95.6	95.4	96.7	95.6	0.9
400	87.1	88.3	88.0	89.5	88.2	1.0
630	81.7	83.0	82.7	84.4	82.9	1.1
1000	75.7	77.2	76.9	78.8	77.2	1.3
2000	66.1	67.8	67.5	69.9	67.8	1.6
4000	56.1	58.0	57.7	60.5	58.1	1.8
6300	49.4	51.2	51.0	54.0	51.4	1.9
10000	42.2	43.9	43.7	46.9	44.2	2.0
16000	34.1	35.7	35.6	38.8	36.1	2.0
25000	25.7	27.1	27.2	30.1	27.5	1.8

Table 44. Phase I Centerline Series 600 L_{EPN} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{EPN} @ 160 kts (dB)					
	Event 620	Event 630	Event 640	Event 650	Average	Std. Dev.
200	104.4	104.3	105.3	106.5	105.1	1.0
400	96.8	96.8	97.6	99.0	97.5	1.0
630	91.1	91.1	92.0	93.6	91.9	1.2
1000	84.6	84.6	85.3	87.6	85.5	1.4
2000	73.5	74.0	73.5	77.6	74.7	2.0
4000	62.1	62.7	62.8	67.4	63.8	2.4
6300	55.3	56.0	56.2	61.0	57.1	2.6
10000	48.0	48.9	49.2	54.3	50.1	2.9
16000	37.3	38.5	39.0	44.5	39.8	3.2
25000	21.1	22.9	23.6	29.8	24.3	3.8

Table 45. Phase I Centerline Series 600 L_{PNTSmx} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{PNTSmx} @ 160 kts (dB)					
	Event 620	Event 630	Event 640	Event 650	Average	Std. Dev.
200	109.9	110.8	111.4	111.3	110.8	0.7
400	102.3	103.3	103.7	103.8	103.2	0.7
630	96.6	97.6	98.1	98.3	97.6	0.8
1000	90.0	91.1	91.4	92.4	91.2	1.0
2000	79.0	80.5	79.6	82.4	80.4	1.5
4000	67.6	69.1	68.9	72.2	69.5	1.9
6300	60.7	62.5	62.3	65.8	62.8	2.1
10000	53.5	55.4	55.3	59.1	55.8	2.4
16000	42.7	45.0	45.1	49.3	45.5	2.7
25000	26.6	29.3	29.7	34.6	30.0	3.3

Table 46. Phase I Sideline NPD Series 100 L_{AE} Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{AE} @ 160 kts (dB)				
	Event 120	Event 130	Event 140	Average	Std. Dev.
200	92.9	94.1	93.0	93.3	0.6
400	87.9	89.2	88.2	88.4	0.7
630	84.2	85.6	84.6	84.8	0.7
1000	80.1	81.6	80.5	80.7	0.8
2000	73.1	74.9	73.8	73.9	0.9
4000	65.3	67.6	66.6	66.5	1.1
6300	59.8	62.4	61.5	61.2	1.3
10000	53.8	56.6	55.8	55.4	1.5
16000	46.9	50.0	49.4	48.8	1.6
25000	39.5	42.9	42.3	41.5	1.8

Table 47. Phase I Sideline NPD Series 100 L_{ASmx} Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{ASmx} @ 160 kts (dB)				
	Event 120	Event 130	Event 140	Average	Std. Dev.
200	92.7	93.0	91.5	92.4	0.8
400	85.5	85.9	84.4	85.2	0.8
630	80.3	80.8	79.3	80.1	0.8
1000	74.6	75.3	73.7	74.5	0.8
2000	65.3	66.3	64.8	65.5	0.8
4000	55.3	56.7	55.3	55.8	0.8
6300	48.4	50.0	48.7	49.0	0.9
10000	40.8	42.8	41.5	41.7	1.0
16000	32.4	34.7	33.6	33.6	1.1
25000	23.5	26.0	25.0	24.9	1.3

Table 48. Phase I Sideline Series 100 L_{EPN} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{EPN} @ 160 kts (dB)				
	Event 120	Event 130	Event 140	Average	Std. Dev.
200	108.1	104.2	102.8	105.0	2.7
400	100.4	96.7	95.2	97.4	2.7
630	94.6	91.1	89.6	91.8	2.6
1000	87.9	84.6	83.1	85.2	2.5
2000	75.6	74.0	72.0	73.9	1.8
4000	63.9	63.3	61.4	62.9	1.3
6300	57.4	56.7	54.8	56.3	1.4
10000	50.5	48.6	47.1	48.7	1.7
16000	42.1	35.5	34.8	37.5	4.1
25000	29.6	15.9	16.3	20.6	7.8

Table 49. Phase I Sideline Series 100 L_{PNTSmx} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{PNTSmx} @ 160 kts (dB)				
	Event 120	Event 130	Event 140	Average	Std. Dev.
200	113.3	108.4	107.3	109.7	3.2
400	105.6	100.9	99.8	102.1	3.1
630	99.9	95.2	94.2	96.4	3.0
1000	93.1	88.8	87.6	89.9	2.9
2000	80.8	78.1	76.6	78.5	2.1
4000	69.1	67.4	66.0	67.5	1.6
6300	62.6	60.8	59.3	60.9	1.7
10000	55.7	52.7	51.7	53.4	2.1
16000	47.4	39.7	39.4	42.1	4.5
25000	34.8	20.0	20.8	25.2	8.3

Table 50. Phase I Sideline Series 300 L_{AE} NPD Data

Distance (ft)	DEP: Standard L_{AE} @ 160 kts (dB)				
	Event 320	Event 340	Event 350	Average	Std. Dev.
200	110.0	109.5	109.2	109.6	0.4
400	105.8	105.2	104.9	105.3	0.5
630	102.9	102.2	101.9	102.3	0.5
1000	99.8	98.9	98.7	99.1	0.6
2000	94.6	93.5	93.2	93.7	0.7
4000	88.5	87.0	86.6	87.4	1.0
6300	83.9	82.0	81.5	82.4	1.3
10000	78.4	76.0	75.5	76.6	1.6
16000	72.0	68.9	68.3	69.8	2.0
25000	64.8	61.1	60.5	62.1	2.3

Table 51. Phase I Sideline Series 300 L_{ASmx} NPD Data

Distance (ft)	DEP: Standard L_{ASmx} @ 160 kts (dB)				
	Event 320	Event 340	Event 350	Average	Std. Dev.
200	110.1	109.5	109.1	109.5	0.5
400	103.7	102.9	102.5	103.0	0.6
630	99.3	98.4	98.1	98.6	0.6
1000	94.6	93.7	93.3	93.9	0.7
2000	87.2	86.0	85.6	86.2	0.8
4000	78.8	77.2	76.8	77.6	1.1
6300	72.7	70.7	70.1	71.2	1.4
10000	65.8	63.2	62.6	63.9	1.7
16000	57.8	54.6	53.9	55.5	2.1
25000	49.2	45.4	44.7	46.4	2.4

Table 52. Phase I Sideline Series 300 L_{EPN} NPD Data

Distance (ft)	DEP: Standard L_{EPN} @ 160 kts (dB)				
	Event 320	Event 340	Event 350	Average	Std. Dev.
200	119.1	117.8	118.1	118.3	0.7
400	111.8	110.6	110.9	111.1	0.6
630	106.4	105.3	105.7	105.8	0.6
1000	100.3	99.3	99.8	99.8	0.5
2000	89.2	88.6	89.6	89.1	0.5
4000	76.1	77.6	79.8	77.8	1.9
6300	68.7	71.0	73.6	71.1	2.4
10000	61.9	64.4	67.1	64.5	2.6
16000	53.5	56.1	59.1	56.2	2.8
25000	40.9	43.7	47.2	43.9	3.2

Table 53. Phase I Sideline Series 300 L_{PNTSmx} NPD Data

Distance (ft)	DEP: Standard L_{PNTSmx} @ 160 kts (dB)				
	Event 320	Event 340	Event 350	Average	Std. Dev.
200	124.0	121.6	121.3	122.3	1.5
400	116.7	114.3	114.0	115.0	1.5
630	111.4	109.1	108.9	109.8	1.4
1000	105.2	103.0	102.9	103.7	1.3
2000	94.2	92.3	92.7	93.1	1.0
4000	81.0	81.3	83.0	81.8	1.0
6300	73.6	74.7	76.8	75.0	1.6
10000	66.8	68.2	70.3	68.4	1.8
16000	58.4	59.8	62.3	60.2	2.0
25000	45.8	47.4	50.3	47.8	2.3

Table 54. Phase I Sideline Series 400 L_{AE} NPD Data

Distance (ft)	DEP: Cruise Climb L_{AE} @ 160 kts (dB)				
	Event 410	Event 420	Event 430	Average	Std. Dev.
200	106.5	106.3	105.7	106.2	0.4
400	102.2	101.9	101.1	101.7	0.6
630	99.3	98.8	97.8	98.6	0.7
1000	96.0	95.3	94.2	95.2	0.9
2000	90.6	89.6	88.2	89.5	1.2
4000	84.3	82.9	81.3	82.8	1.5
6300	79.3	77.7	76.0	77.7	1.7
10000	73.5	71.6	69.9	71.6	1.8
16000	66.5	64.3	62.6	64.5	2.0
25000	58.7	56.3	54.5	56.5	2.1

Table 55. Phase I Sideline Series 400 L_{ASmx} NPD Data

Distance (ft)	DEP: Cruise Climb L_{ASmx} @ 160 kts (dB)				
	Event 410	Event 420	Event 430	Average	Std. Dev.
200	105.7	105.6	104.9	105.4	0.4
400	99.1	98.9	98.1	98.7	0.5
630	94.7	94.3	93.3	94.1	0.7
1000	89.9	89.4	88.2	89.2	0.9
2000	82.3	81.4	79.9	81.2	1.2
4000	73.6	72.4	70.8	72.3	1.4
6300	67.2	65.7	64.0	65.7	1.6
10000	59.9	58.1	56.4	58.1	1.8
16000	51.4	49.4	47.5	49.4	1.9
25000	42.1	39.9	38.0	40.0	2.0

Table 56. Phase I Sideline Series 400 L_{EPN} NPD Data

Distance (ft)	DEP: Cruise Climb				
	L_{EPN} @ 160 kts (dB)				
	Event 410	Event 420	Event 430	Average	Std. Dev.
200	115.5	115.8	116.0	115.8	0.2
400	108.3	108.6	108.6	108.5	0.2
630	102.9	103.3	103.4	103.2	0.2
1000	96.8	97.3	97.9	97.3	0.5
2000	85.9	86.4	88.9	87.0	1.6
4000	74.3	75.8	80.3	76.8	3.1
6300	67.9	69.6	72.4	70.0	2.2
10000	61.1	63.0	65.8	63.3	2.4
16000	50.9	53.1	56.2	53.4	2.7
25000	35.5	38.4	41.7	38.5	3.1

Table 57. Phase I Sideline Series 400 L_{PNTSmx} NPD Data

Distance (ft)	DEP: Cruise Climb				
	L_{PNTSmx} @ 160 kts (dB)				
	Event 410	Event 420	Event 430	Average	Std. Dev.
200	119.3	119.2	120.9	119.8	1.0
400	112.0	111.9	113.6	112.5	0.9
630	106.7	106.7	108.3	107.2	0.9
1000	100.6	100.6	102.8	101.3	1.3
2000	89.7	89.7	93.8	91.1	2.4
4000	78.1	79.2	85.2	80.8	3.8
6300	71.7	72.9	77.3	74.0	3.0
10000	64.9	66.3	70.8	67.3	3.0
16000	54.7	56.5	61.1	57.4	3.3
25000	39.3	41.7	46.6	42.5	3.8

Table 58. Phase I Sideline Series 500 L_{AE} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{AE} @ 160 kts (dB)				
	Event 530	Event 550	Event 570	Average	Std. Dev.
200	91.7	90.6	89.5	90.6	1.1
400	86.6	85.7	84.4	85.6	1.1
630	82.8	82.0	80.7	81.8	1.1
1000	78.5	77.8	76.3	77.5	1.1
2000	71.1	70.8	69.0	70.3	1.2
4000	62.9	63.0	60.9	62.2	1.2
6300	57.1	57.5	55.3	56.6	1.2
10000	50.9	51.4	49.3	50.5	1.1
16000	43.7	44.2	42.6	43.5	0.8
25000	35.6	36.0	35.3	35.6	0.3

Table 59. Phase I Sideline Series 500 L_{ASmx} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{ASmx} @ 160 kts (dB)				
	Event 530	Event 550	Event 570	Average	Std. Dev.
200	90.8	89.3	88.5	89.5	1.2
400	83.5	82.0	81.2	82.2	1.1
630	78.2	76.9	75.9	77.0	1.1
1000	72.4	71.2	70.1	71.2	1.1
2000	62.7	61.9	60.5	61.7	1.1
4000	52.3	51.9	50.1	51.4	1.1
6300	45.0	44.9	43.1	44.3	1.1
10000	37.3	37.3	35.6	36.7	1.0
16000	28.6	28.6	27.4	28.2	0.7
25000	19.0	18.9	18.6	18.9	0.2

Table 60. Phase I Sideline Series 500 L_{EPN} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{EPN} @ 160 kts (dB)				
	Event 530	Event 550	Event 570	Average	Std. Dev.
200	101.4	99.9	98.5	99.9	1.4
400	93.8	92.5	90.9	92.4	1.4
630	88.1	87.1	85.4	86.8	1.4
1000	81.4	80.8	79.1	80.4	1.2
2000	70.5	69.9	68.1	69.5	1.3
4000	58.8	59.0	55.1	57.7	2.2
6300	51.7	51.9	47.5	50.4	2.5
10000	43.6	43.3	38.0	41.6	3.1
16000	31.0	29.4	22.6	27.7	4.4
25000	12.2	8.5	-0.5	6.7	6.5

Table 61. Phase I Sideline Series 500 L_{PNTSmx} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{PNTSmx} @ 160 kts (dB)				
	Event 530	Event 550	Event 570	Average	Std. Dev.
200	106.0	103.8	104.1	104.6	1.2
400	98.4	96.5	96.5	97.1	1.1
630	92.7	91.0	90.9	91.5	1.0
1000	86.0	84.7	84.7	85.2	0.8
2000	75.1	73.8	73.7	74.2	0.8
4000	63.4	62.9	60.7	62.4	1.5
6300	56.3	55.8	53.1	55.1	1.7
10000	48.2	47.2	43.6	46.3	2.4
16000	35.6	33.3	28.2	32.4	3.8
25000	16.8	12.4	5.1	11.4	5.9

Table 62. Phase I Sideline Series 600 L_{AE} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{AE} @ 160 kts (dB)					
	Event 620	Event 630	Event 640	Event 650	Average	Std. Dev.
200	95.2	93.8	95.1	96.0	95.1	0.9
400	90.3	88.9	90.3	91.2	90.1	0.9
630	86.6	85.3	86.7	87.6	86.5	1.0
1000	82.5	81.2	82.8	83.5	82.5	1.0
2000	75.5	74.3	76.2	76.6	75.7	1.0
4000	67.9	66.8	69.0	68.8	68.1	1.0
6300	62.5	61.5	63.8	63.3	62.8	1.0
10000	56.7	55.6	58.0	57.5	56.9	1.1
16000	50.0	48.9	51.2	50.9	50.3	1.0
25000	42.9	41.7	43.6	43.8	43.0	1.0

Table 63. Phase I Sideline Series 600 L_{ASmx} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{ASmx} @ 160 kts (dB)					
	Event 620	Event 630	Event 640	Event 650	Average	Std. Dev.
200	95.2	93.5	94.9	96.2	94.9	1.1
400	87.9	86.3	87.8	89.1	87.8	1.1
630	82.8	81.2	82.7	84.0	82.7	1.1
1000	77.2	75.7	77.3	78.4	77.1	1.1
2000	67.9	66.5	68.4	69.2	68.0	1.1
4000	58.1	56.8	59.0	59.2	58.2	1.1
6300	51.2	50.0	52.4	52.3	51.4	1.1
10000	43.9	42.6	45.0	44.9	44.1	1.1
16000	35.7	34.4	36.7	36.8	35.9	1.1
25000	27.1	25.7	27.7	28.2	27.2	1.1

Table 64. Phase I Sideline Series 600 L_{EPN} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{EPN} @ 160 kts (dB)					
	Event 620	Event 630	Event 640	Event 650	Average	Std. Dev.
200	106.2	106.2	105.5	107.1	106.2	0.6
400	98.7	98.7	98.1	99.7	98.8	0.7
630	93.1	93.1	92.6	94.5	93.3	0.8
1000	87.0	86.7	86.6	88.6	87.2	0.9
2000	76.5	76.7	76.2	78.2	76.9	0.9
4000	64.6	66.5	65.3	66.7	65.8	1.0
6300	57.6	59.4	58.4	60.2	58.9	1.1
10000	50.5	52.6	51.5	53.3	52.0	1.2
16000	40.2	42.5	41.5	43.1	41.8	1.3
25000	24.8	27.4	26.6	27.9	26.6	1.4

Table 65. Phase I Sideline Series 600 L_{PNTSmx} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{PNTSmx} @ 160 kts (dB)					
	Event 620	Event 630	Event 640	Event 650	Average	Std. Dev.
200	110.8	110.1	108.2	111.0	110.0	1.3
400	103.3	102.6	100.8	103.7	102.6	1.3
630	97.7	97.1	95.3	98.5	97.1	1.3
1000	91.6	90.7	89.3	92.5	91.0	1.4
2000	81.0	80.6	78.9	82.1	80.7	1.3
4000	69.2	70.4	68.0	70.7	69.6	1.2
6300	62.2	63.4	61.2	64.1	62.7	1.3
10000	55.1	56.5	54.2	57.2	55.7	1.3
16000	44.8	46.4	44.2	47.0	45.6	1.3
25000	29.3	31.3	29.3	31.8	30.4	1.3

C.2 Phase II Noise Power Distance Tables

Table 66. Phase II Centerline Series 100 L_{AE} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{AE} @ 160 kts (dB)			
	Event 120	Event 130	Average	Std. Dev.
200	92.4	93.8	93.1	1.0
400	87.3	88.7	88.0	1.0
630	83.5	85.0	84.2	1.0
1000	79.2	80.8	80.0	1.1
2000	72.2	73.8	73.0	1.2
4000	64.8	66.5	65.6	1.2
6300	59.7	61.4	60.6	1.2
10000	54.1	55.8	54.9	1.3
16000	47.6	49.5	48.5	1.3
25000	40.6	42.5	41.5	1.4

Table 67. Phase II Centerline Series 100 L_{ASmx} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{ASmx} @ 160 kts (dB)			
	Event 120	Event 130	Average	Std. Dev.
200	91.5	93.4	92.5	1.3
400	84.1	86.0	85.1	1.3
630	78.8	80.8	79.8	1.4
1000	73.1	75.1	74.1	1.4
2000	63.8	65.9	64.8	1.5
4000	54.1	56.3	55.2	1.5
6300	47.6	49.7	48.6	1.5
10000	40.4	42.6	41.5	1.6
16000	32.4	34.7	33.6	1.7
25000	23.9	26.3	25.1	1.7

Table 68. Phase II Centerline Series 100 L_{EPN} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{EPN} @ 160 kts (dB)			
	Event 120	Event 130	Average	Std. Dev.
200	100.7	102.5	101.6	1.3
400	93.1	94.9	94.0	1.3
630	87.4	89.3	88.3	1.4
1000	80.7	83.2	81.9	1.7
2000	69.3	72.6	71.0	2.3
4000	58.5	62.0	60.2	2.5
6300	51.7	55.4	53.5	2.6
10000	44.3	48.2	46.3	2.8
16000	33.1	37.5	35.3	3.1
25000	16.3	21.4	18.8	3.7

Table 69. Phase II Centerline Series 100 L_{PNTSmx} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{PNTSmx} @ 160 kts (dB)			
	Event 120	Event 130	Average	Std. Dev.
200	107.5	108.5	108.0	0.7
400	99.9	100.9	100.4	0.7
630	94.2	95.3	94.7	0.8
1000	87.5	89.1	88.3	1.1
2000	76.1	78.6	77.4	1.7
4000	65.3	68.0	66.6	1.9
6300	58.5	61.3	59.9	2.0
10000	51.1	54.2	52.7	2.2
16000	39.9	43.5	41.7	2.5
25000	23.1	27.4	25.2	3.0

Table 70. Phase II Centerline Series 300 L_{AE} NPD Data

Distance (ft)	DEP: Standard L_{AE} @ 160 kts (dB)			
	Event 320	Event 330	Average	Std. Dev.
200	101.8	102.0	101.9	0.2
400	97.1	97.1	97.1	0.0
630	93.9	93.6	93.7	0.2
1000	90.4	89.7	90.0	0.5
2000	84.9	83.4	84.1	1.1
4000	78.7	76.5	77.6	1.5
6300	73.9	71.5	72.7	1.7
10000	68.3	65.7	67.0	1.9
16000	61.7	58.9	60.3	2.0
25000	54.4	51.6	53.0	1.9

Table 71. Phase II Centerline Series 300 L_{ASmx} NPD Data

Distance (ft)	DEP: Standard L_{ASmx} @ 160 kts (dB)			
	Event 320	Event 330	Average	Std. Dev.
200	100.2	101.3	100.7	0.7
400	93.3	94.1	93.7	0.6
630	88.6	89.1	88.8	0.3
1000	83.6	83.7	83.6	0.0
2000	75.8	75.1	75.4	0.5
4000	67.3	66.0	66.7	1.0
6300	61.1	59.5	60.3	1.2
10000	54.0	52.2	53.1	1.3
16000	45.9	43.9	44.9	1.4
25000	37.1	35.2	36.1	1.4

Table 72. Phase II Centerline Series 300 L_{EPN} NPD Data

Distance (ft)	DEP: Standard L_{EPN} @ 160 kts (dB)			
	Event 320	Event 330	Average	Std. Dev.
200	110.7	110.2	110.4	0.4
400	103.3	102.7	103.0	0.4
630	97.9	97.2	97.5	0.5
1000	91.7	91.5	91.6	0.2
2000	83.4	81.7	82.6	1.2
4000	75.1	72.4	73.7	1.9
6300	67.5	64.6	66.0	2.1
10000	61.3	58.1	59.7	2.2
16000	53.5	50.2	51.9	2.3
25000	41.9	38.3	40.1	2.5

Table 73. Phase II Centerline Series 300 L_{PNTSmx} NPD Data

Distance (ft)	DEP: Standard L_{PNTSmx} @ 160 kts (dB)			
	Event 320	Event 330	Average	Std. Dev.
200	117.7	118.3	118.0	0.4
400	110.3	110.9	110.6	0.4
630	104.9	105.4	105.1	0.3
1000	98.8	99.7	99.2	0.6
2000	90.4	89.9	90.2	0.3
4000	82.1	80.6	81.4	1.1
6300	74.5	72.8	73.6	1.2
10000	68.3	66.3	67.3	1.4
16000	60.6	58.4	59.5	1.5
25000	49.0	46.5	47.7	1.7

Table 74. Phase II Centerline Series 400 L_{AE} NPD Data

Distance (ft)	DEP: Cruise Climb L_{AE} @ 160 kts (dB)				
	Event 420	Event 430	Event 440	Average	Std. Dev.
200	102.3	103.5	104.3	103.4	1.0
400	97.5	98.9	99.5	98.6	1.0
630	94.1	95.6	96.1	95.2	1.0
1000	90.3	92.0	92.3	91.5	1.1
2000	84.1	86.2	86.3	85.5	1.2
4000	77.5	79.5	79.6	78.8	1.2
6300	72.5	74.4	74.6	73.8	1.1
10000	66.8	68.3	68.8	68.0	1.1
16000	59.9	61.2	62.1	61.1	1.1
25000	52.3	53.4	54.7	53.5	1.2

Table 75. Phase II Centerline Series 400 L_{ASmx} NPD Data

Distance (ft)	DEP: Cruise Climb L_{ASmx} @ 160 kts (dB)				
	Event 420	Event 430	Event 440	Average	Std. Dev.
200	100.6	102.3	103.6	102.2	1.5
400	93.6	95.4	96.6	95.2	1.5
630	88.6	90.6	91.6	90.3	1.5
1000	83.3	85.5	86.4	85.1	1.6
2000	74.9	77.5	78.1	76.8	1.7
4000	66.0	68.5	69.1	67.9	1.7
6300	59.6	61.9	62.7	61.4	1.6
10000	52.3	54.4	55.4	54.0	1.6
16000	43.9	45.7	47.1	45.6	1.6
25000	34.8	36.5	38.3	36.5	1.7

Table 76. Phase II Centerline Series 400 L_{EPN} NPD Data

Distance (ft)	DEP: Cruise Climb L_{EPN} @ 160 kts (dB)				
	Event 420	Event 430	Event 440	Average	Std. Dev.
200	110.4	111.9	113.9	111.9	1.7
400	103.0	104.5	106.4	104.6	1.7
630	97.5	99.1	100.9	99.2	1.7
1000	91.9	93.1	94.6	93.2	1.4
2000	82.3	84.1	85.2	83.9	1.5
4000	73.7	75.5	76.6	75.2	1.5
6300	65.9	67.7	70.9	68.2	2.5
10000	59.5	61.3	62.5	61.1	1.5
16000	51.7	53.2	54.9	53.3	1.6
25000	40.0	41.1	43.5	41.5	1.8

Table 77. Phase II Centerline Series 400 L_{PNTSmx} NPD Data

Distance (ft)	DEP: Cruise Climb L_{PNTSmx} @ 160 kts (dB)				
	Event 420	Event 430	Event 440	Average	Std. Dev.
200	117.6	118.9	121.2	119.2	1.8
400	110.2	111.5	113.7	111.8	1.8
630	104.7	106.0	108.2	106.3	1.8
1000	99.1	100.1	101.9	100.3	1.4
2000	89.5	91.0	92.5	91.0	1.5
4000	80.9	82.5	83.9	82.4	1.5
6300	73.1	74.7	78.2	75.3	2.6
10000	66.6	68.3	69.8	68.2	1.6
16000	58.9	60.2	62.2	60.4	1.7
25000	47.2	48.0	50.8	48.7	1.9

Table 78. Phase II Centerline Series 500 L_{AE} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{AE} @ 160 kts (dB)			
	Event 510	Event 530	Average	Std. Dev.
200	85.6	87.6	86.6	1.4
400	80.7	82.6	81.6	1.4
630	77.1	78.9	78.0	1.3
1000	73.1	74.8	74.0	1.2
2000	66.6	68.1	67.3	1.1
4000	59.5	60.9	60.2	1.0
6300	54.4	55.9	55.2	1.0
10000	48.8	50.3	49.5	1.0
16000	42.3	43.9	43.1	1.1
25000	35.5	37.2	36.4	1.2

Table 79. Phase II Centerline Series 500 L_{ASmx} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{ASmx} @ 160 kts (dB)			
	Event 510	Event 530	Average	Std. Dev.
200	84.4	86.6	85.5	1.5
400	77.3	79.3	78.3	1.5
630	72.2	74.2	73.2	1.4
1000	66.7	68.6	67.7	1.4
2000	57.9	59.7	58.8	1.2
4000	48.6	50.2	49.4	1.1
6300	42.1	43.7	42.9	1.1
10000	34.9	36.5	35.7	1.2
16000	26.9	28.7	27.8	1.2
25000	18.7	20.5	19.6	1.3

Table 80. Phase II Centerline Series 500 L_{EPN} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{EPN} @ 160 kts (dB)			
	Event 510	Event 530	Average	Std. Dev.
200	95.6	98.1	96.9	1.7
400	88.2	90.5	89.4	1.6
630	82.7	85.1	83.9	1.7
1000	76.4	79.0	77.7	1.8
2000	66.2	68.3	67.3	1.5
4000	54.7	56.4	55.5	1.2
6300	47.4	49.4	48.4	1.4
10000	38.3	40.8	39.6	1.8
16000	23.5	26.9	25.2	2.3
25000	1.4	5.9	3.6	3.2

Table 81. Phase II Centerline Series 500 L_{PNTSmx} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{PNTSmx} @ 160 kts (dB)			
	Event 510	Event 530	Average	Std. Dev.
200	100.5	103.2	101.9	1.9
400	93.1	95.6	94.3	1.8
630	87.6	90.1	88.9	1.8
1000	81.3	84.1	82.7	2.0
2000	71.1	73.4	72.2	1.6
4000	59.5	61.4	60.5	1.3
6300	52.3	54.5	53.4	1.6
10000	43.2	45.9	44.5	1.9
16000	28.4	31.9	30.2	2.5
25000	6.3	11.0	8.6	3.3

Table 82. Phase II Centerline Series 600 L_{AE} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{AE} @ 160 kts (dB)				
	Event 610	Event 620	Event 630	Average	Std. Dev.
200	92.9	91.8	91.7	92.1	0.6
400	87.7	86.6	86.6	87.0	0.6
630	83.8	82.7	82.8	83.1	0.6
1000	79.4	78.3	78.4	78.7	0.6
2000	72.0	70.9	71.2	71.3	0.5
4000	64.1	63.2	63.5	63.6	0.4
6300	58.7	58.0	58.2	58.3	0.4
10000	52.9	52.3	52.4	52.6	0.3
16000	46.4	46.0	45.8	46.1	0.3
25000	39.7	39.4	38.8	39.3	0.4

Table 83. Phase II Centerline Series 600 L_{ASmx} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{ASmx} @ 160 kts (dB)				
	Event 610	Event 620	Event 630	Average	Std. Dev.
200	93.2	92.0	91.2	92.1	1.0
400	85.8	84.5	83.8	84.7	1.0
630	80.4	79.1	78.5	79.4	1.0
1000	74.5	73.2	72.7	73.4	0.9
2000	64.8	63.6	63.2	63.8	0.8
4000	54.6	53.6	53.2	53.8	0.7
6300	47.8	46.9	46.5	47.1	0.7
10000	40.5	39.8	39.2	39.8	0.7
16000	32.5	31.9	31.0	31.8	0.7
25000	24.3	23.8	22.6	23.6	0.9

Table 84. Phase II Centerline Series 600 L_{EPN} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{EPN} @ 160 kts (dB)				
	Event 610	Event 620	Event 630	Average	Std. Dev.
200	102.8	101.6	102.5	102.3	0.6
400	95.2	94.0	95.0	94.7	0.6
630	89.5	88.4	89.5	89.1	0.7
1000	83.1	82.0	83.2	82.8	0.7
2000	72.4	71.4	72.2	72.0	0.5
4000	60.6	60.1	60.4	60.3	0.2
6300	53.7	53.2	53.4	53.4	0.2
10000	46.0	45.5	45.7	45.8	0.2
16000	34.2	33.9	34.0	34.1	0.2
25000	16.6	16.6	16.5	16.6	0.1

Table 85. Phase II Centerline Series 600 L_{PNTSmx} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{PNTSmx} @ 160 kts (dB)				
	Event 610	Event 620	Event 630	Average	Std. Dev.
200	108.1	106.9	107.0	107.4	0.7
400	100.5	99.3	99.6	99.8	0.7
630	94.9	93.6	94.1	94.2	0.6
1000	88.5	87.3	87.7	87.8	0.6
2000	77.7	76.7	76.8	77.1	0.6
4000	65.9	65.3	64.9	65.4	0.5
6300	59.0	58.5	58.0	58.5	0.5
10000	51.4	50.8	50.3	50.8	0.5
16000	39.6	39.2	38.6	39.1	0.5
25000	22.0	21.8	21.1	21.6	0.5

Table 86. Phase II Sideline Series 100 L_{AE} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{AE} @ 160 kts (dB)			
	Event 120	Event 130	Average	Std. Dev.
200	93.2	94.8	94.0	1.1
400	88.2	89.7	88.9	1.1
630	84.4	85.9	85.1	1.0
1000	80.2	81.6	80.9	1.0
2000	73.2	74.4	73.8	0.9
4000	65.7	66.8	66.3	0.8
6300	60.4	61.6	61.0	0.8
10000	54.6	55.9	55.3	0.9
16000	47.8	49.4	48.6	1.1
25000	40.5	42.3	41.4	1.3

Table 87. Phase II Sideline Series 100 L_{ASmx} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{ASmx} @ 160 kts (dB)			
	Event 120	Event 130	Average	Std. Dev.
200	92.5	95.6	94.0	2.2
400	85.2	88.3	86.7	2.2
630	79.9	83.0	81.5	2.1
1000	74.2	77.2	75.7	2.1
2000	64.9	67.7	66.3	2.0
4000	55.2	57.9	56.5	1.9
6300	48.5	51.2	49.8	1.9
10000	41.1	44.0	42.5	2.0
16000	32.8	35.9	34.4	2.2
25000	24.0	27.4	25.7	2.4

Table 88. Phase II Sideline Series 100 L_{EPN} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{EPN} @ 160 kts (dB)			
	Event 120	Event 130	Average	Std. Dev.
200	102.6	104.6	103.6	1.4
400	95.0	97.1	96.0	1.5
630	89.2	91.4	90.3	1.5
1000	82.6	84.7	83.6	1.5
2000	71.8	73.6	72.7	1.3
4000	60.8	62.2	61.5	1.0
6300	54.0	55.7	54.9	1.2
10000	46.0	48.8	47.4	2.0
16000	32.9	38.7	35.8	4.1
25000	13.3	23.5	18.4	7.2

Table 89. Phase II Sideline Series 100 L_{PNTSmx} NPD Data

Distance (ft)	LFO: Normal Cruise @ 500 ft. L_{PNTSmx} @ 160 kts (dB)			
	Event 120	Event 130	Average	Std. Dev.
200	107.9	111.5	109.7	2.6
400	100.3	104.0	102.1	2.6
630	94.5	98.3	96.4	2.7
1000	87.8	91.6	89.7	2.7
2000	77.1	80.5	78.8	2.5
4000	66.0	69.1	67.6	2.2
6300	59.3	62.6	61.0	2.3
10000	51.2	55.7	53.5	3.2
16000	38.2	45.6	41.9	5.2
25000	18.6	30.4	24.5	8.4

Table 90. Phase II Sideline Series 300 L_{AE} NPD Data

Distance (ft)	DEP: Standard L_{AE} @ 160 kts (dB)			
	Event 320	Event 330	Average	Std. Dev.
200	100.2	99.2	99.7	0.7
400	95.6	94.8	95.2	0.6
630	92.4	91.7	92.0	0.5
1000	88.8	88.3	88.5	0.4
2000	83.0	82.5	82.7	0.3
4000	76.4	75.9	76.1	0.4
6300	71.4	70.8	71.1	0.4
10000	65.5	65.0	65.2	0.4
16000	58.5	58.1	58.3	0.3
25000	50.6	50.7	50.7	0.0

Table 91. Phase II Sideline Series 300 L_{ASmx} NPD Data

Distance (ft)	DEP: Standard L_{ASmx} @ 160 kts (dB)			
	Event 320	Event 330	Average	Std. Dev.
200	98.3	97.2	97.7	0.7
400	91.4	90.5	91.0	0.6
630	86.7	85.9	86.3	0.6
1000	81.7	81.0	81.3	0.5
2000	73.6	73.0	73.3	0.4
4000	64.7	64.1	64.4	0.4
6300	58.2	57.6	57.9	0.5
10000	50.9	50.2	50.5	0.5
16000	42.3	41.9	42.1	0.3
25000	33.0	32.9	33.0	0.1

Table 92. Phase II Sideline Series 300 L_{EPN} NPD Data

Distance (ft)	DEP: Standard L_{EPN} @ 160 kts (dB)			
	Event 320	Event 330	Average	Std. Dev.
200	110.1	108.2	109.2	1.4
400	102.8	100.7	101.8	1.4
630	97.7	95.2	96.5	1.8
1000	92.2	89.1	90.6	2.2
2000	83.4	79.2	81.3	2.9
4000	73.4	69.8	71.6	2.5
6300	67.3	61.7	64.5	4.0
10000	60.7	54.6	57.6	4.4
16000	52.7	44.1	48.4	6.1
25000	40.7	28.5	34.6	8.6

Table 93. Phase II Sideline Series 300 L_{PNTSmx} NPD Data

Distance (ft)	DEP: Standard L_{PNTSmx} @ 160 kts (dB)			
	Event 320	Event 330	Average	Std. Dev.
200	113.7	111.7	112.7	1.4
400	106.3	104.2	105.3	1.5
630	101.3	98.7	100.0	1.8
1000	95.8	92.6	94.2	2.3
2000	87.0	82.7	84.9	3.0
4000	77.0	73.3	75.2	2.6
6300	70.9	65.2	68.0	4.0
10000	64.3	58.1	61.2	4.4
16000	56.3	47.6	52.0	6.1
25000	44.3	32.0	38.1	8.7

Table 94. Phase II Sideline Series 400 L_{AE} NPD Data

Distance (ft)	DEP: Cruise Climb L_{AE} @ 160 kts (dB)				
	Event 420	Event 430	Event 440	Average	Std. Dev.
200	101.4	102.9	102.9	102.4	0.9
400	96.5	98.4	98.5	97.8	1.2
630	92.9	95.3	95.5	94.5	1.5
1000	88.8	91.8	92.2	90.9	1.9
2000	81.9	86.0	86.7	84.9	2.6
4000	74.6	79.3	80.3	78.1	3.1
6300	69.3	74.2	75.4	73.0	3.2
10000	63.3	68.1	69.7	67.0	3.3
16000	56.4	60.8	62.7	60.0	3.3
25000	48.7	52.8	54.9	52.1	3.1

Table 95. Phase II Sideline Series 400 L_{ASmx} NPD Data

Distance (ft)	DEP: Cruise Climb L_{ASmx} @ 160 kts (dB)				
	Event 420	Event 430	Event 440	Average	Std. Dev.
200	100.4	103.1	101.9	101.8	1.3
400	93.2	96.3	95.3	94.9	1.6
630	88.1	91.7	90.7	90.2	1.8
1000	82.5	86.7	85.9	85.0	2.2
2000	73.4	78.7	78.2	76.8	2.9
4000	63.8	69.7	69.5	67.7	3.4
6300	57.1	63.1	63.2	61.1	3.5
10000	49.6	55.5	55.9	53.6	3.5
16000	41.1	46.6	47.5	45.1	3.5
25000	32.0	37.2	38.1	35.8	3.3

Table 96. Phase II Sideline Series 400 L_{EPN} NPD Data

Distance (ft)	DEP: Cruise Climb L_{EPN} @ 160 kts (dB)				
	Event 420	Event 430	Event 440	Average	Std. Dev.
200	110.6	111.6	112.1	111.5	0.8
400	103.5	104.5	104.9	104.3	0.8
630	98.2	99.2	99.8	99.1	0.8
1000	92.3	93.3	93.9	93.2	0.8
2000	81.8	82.7	84.0	82.8	1.1
4000	71.7	72.5	74.0	72.7	1.2
6300	63.9	64.6	66.0	64.8	1.1
10000	57.0	57.7	59.2	58.0	1.1
16000	46.7	47.6	49.0	47.8	1.2
25000	31.3	32.5	33.8	32.6	1.3

Table 97. Phase II Sideline Series 400 L_{PNTSmx} NPD Data

Distance (ft)	DEP: Cruise Climb L_{PNTSmx} @ 160 kts (dB)				
	Event 420	Event 430	Event 440	Average	Std. Dev.
200	116.6	117.1	117.0	116.9	0.3
400	109.4	109.9	109.9	109.7	0.3
630	104.2	104.7	104.7	104.5	0.3
1000	98.3	98.8	98.8	98.6	0.3
2000	87.7	88.2	88.9	88.3	0.6
4000	77.6	77.9	78.9	78.1	0.7
6300	69.8	70.0	70.9	70.2	0.6
10000	62.9	63.2	64.1	63.4	0.6
16000	52.6	53.1	53.9	53.2	0.7
25000	37.2	38.0	38.8	38.0	0.8

Table 98. Phase II Sideline Series 500 L_{AE} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{AE} @ 160 kts (dB)			
	Event 510	Event 530	Average	Std. Dev.
200	84.4	86.8	85.6	1.7
400	79.7	81.9	80.8	1.6
630	76.3	78.4	77.3	1.4
1000	72.5	74.3	73.4	1.3
2000	66.1	67.6	66.9	1.0
4000	59.1	60.2	59.6	0.8
6300	54.1	54.9	54.5	0.6
10000	48.4	49.1	48.8	0.5
16000	41.8	42.3	42.0	0.4
25000	34.2	34.8	34.5	0.4

Table 99. Phase II Sideline Series 500 L_{ASmx} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{ASmx} @ 160 kts (dB)			
	Event 510	Event 530	Average	Std. Dev.
200	82.2	86.6	84.4	3.1
400	75.2	79.4	77.3	3.0
630	70.3	74.4	72.4	2.9
1000	65.0	68.9	66.9	2.7
2000	56.4	59.8	58.1	2.4
4000	47.1	50.2	48.6	2.2
6300	40.6	43.5	42.0	2.0
10000	33.4	36.1	34.8	1.9
16000	25.2	27.8	26.5	1.8
25000	16.2	18.9	17.5	1.8

Table 100. Phase II Sideline Series 500 L_{EPN} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{EPN} @ 160 kts (dB)			
	Event 510	Event 530	Average	Std. Dev.
200	97.9	96.7	97.3	0.9
400	90.6	89.3	89.9	0.9
630	85.2	83.9	84.5	0.9
1000	78.9	77.7	78.3	0.8
2000	67.6	67.0	67.3	0.4
4000	55.2	56.0	55.6	0.5
6300	47.5	48.9	48.2	1.0
10000	36.1	39.9	38.0	2.7
16000	17.8	25.3	21.6	5.3
25000	-9.7	3.5	-3.1	9.4

Table 101. Phase II Sideline Series 500 L_{PNTSmx} NPD Data

Distance (ft)	APP: Flaps 20 Degrees, Gear Up L_{PNTSmx} @ 160 kts (dB)			
	Event 510	Event 530	Average	Std. Dev.
200	101.3	101.4	101.4	0.0
400	94.0	94.0	94.0	0.1
630	88.5	88.6	88.6	0.1
1000	82.3	82.4	82.3	0.1
2000	70.9	71.8	71.3	0.6
4000	58.6	60.7	59.7	1.5
6300	50.8	53.6	52.2	2.0
10000	39.5	44.6	42.1	3.6
16000	21.2	30.1	25.6	6.3
25000	-6.3	8.2	1.0	10.3

Table 102. Phase II Sideline Series 600 L_{AE} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{AE} @ 160 kts (dB)				
	Event 610	Event 620	Event 630	Average	Std. Dev.
200	93.0	91.3	90.5	91.6	1.3
400	87.9	86.3	85.4	86.5	1.3
630	84.2	82.5	81.6	82.7	1.3
1000	79.9	78.2	77.2	78.4	1.4
2000	72.6	70.8	69.6	71.0	1.5
4000	64.8	62.6	61.4	62.9	1.7
6300	59.3	56.9	55.7	57.3	1.8
10000	53.4	50.7	49.6	51.2	1.9
16000	46.5	43.7	42.8	44.4	1.9
25000	38.9	36.1	35.6	36.8	1.8

Table 103. Phase II Sideline Series 600 L_{ASmx} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{ASmx} @ 160 kts (dB)				
	Event 610	Event 620	Event 630	Average	Std. Dev.
200	93.1	92.4	89.9	91.8	1.7
400	85.8	85.1	82.5	84.5	1.7
630	80.6	79.8	77.2	79.2	1.8
1000	74.8	74.0	71.3	73.4	1.8
2000	65.3	64.4	61.5	63.7	2.0
4000	55.1	53.9	51.0	53.3	2.1
6300	48.2	46.7	43.9	46.3	2.2
10000	40.8	39.1	36.3	38.7	2.3
16000	32.4	30.6	27.9	30.3	2.2
25000	23.3	21.5	19.2	21.3	2.0

Table 104. Phase II Sideline Series 600 L_{EPN} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{EPN} @ 160 kts (dB)				
	Event 610	Event 620	Event 630	Average	Std. Dev.
200	102.3	101.5	100.8	101.6	0.7
400	94.8	94.0	93.2	94.0	0.8
630	89.4	88.5	87.7	88.5	0.8
1000	83.1	82.2	81.4	82.3	0.9
2000	72.4	71.6	70.6	71.6	0.9
4000	60.4	59.7	58.1	59.4	1.2
6300	53.4	52.7	50.8	52.3	1.3
10000	45.1	44.2	41.7	43.7	1.7
16000	31.6	30.4	27.0	29.7	2.4
25000	11.4	9.7	4.9	8.7	3.4

Table 105. Phase II Sideline Series 600 L_{PNTSmx} NPD Data

Distance (ft)	APP: Flaps 48 Degrees, Gear Down L_{PNTSmx} @ 160 kts (dB)				
	Event 610	Event 620	Event 630	Average	Std. Dev.
200	106.3	106.8	104.7	105.9	1.1
400	98.8	99.2	97.1	98.4	1.1
630	93.4	93.8	91.6	92.9	1.2
1000	87.1	87.5	85.3	86.6	1.2
2000	76.4	76.9	74.5	75.9	1.3
4000	64.4	65.0	62.0	63.8	1.6
6300	57.4	57.9	54.7	56.7	1.8
10000	49.1	49.5	45.6	48.0	2.1
16000	35.6	35.7	30.9	34.0	2.8
25000	15.4	15.0	8.8	13.1	3.7

APPENDIX D: SPECTRAL DATA

Appendix D presents measured spectral data recorded at the time of maximum A-weighted sound level (L_{ASmx}) for all LFO, APP, and DEP events. The spectral data are presented on a logarithmic scale with 30 one-third octave bands ranging from bands 11 to 40, representing nominal center frequencies of 12.5 hertz and 10,000 hertz, respectively. No weighting was applied to these spectral data. For consistency in comparing results, all data have been adjusted to a source-to-receiver distance of 1,000 feet. Using the SAE-AIR-1845 methodology described in Section 8, the data are also adjusted to a reference day atmospheric conditions. Note that only spectral data for events that passed the Quality Assurance test outlined in Section 9 are provided.

D.1   Phase I Spectral Data

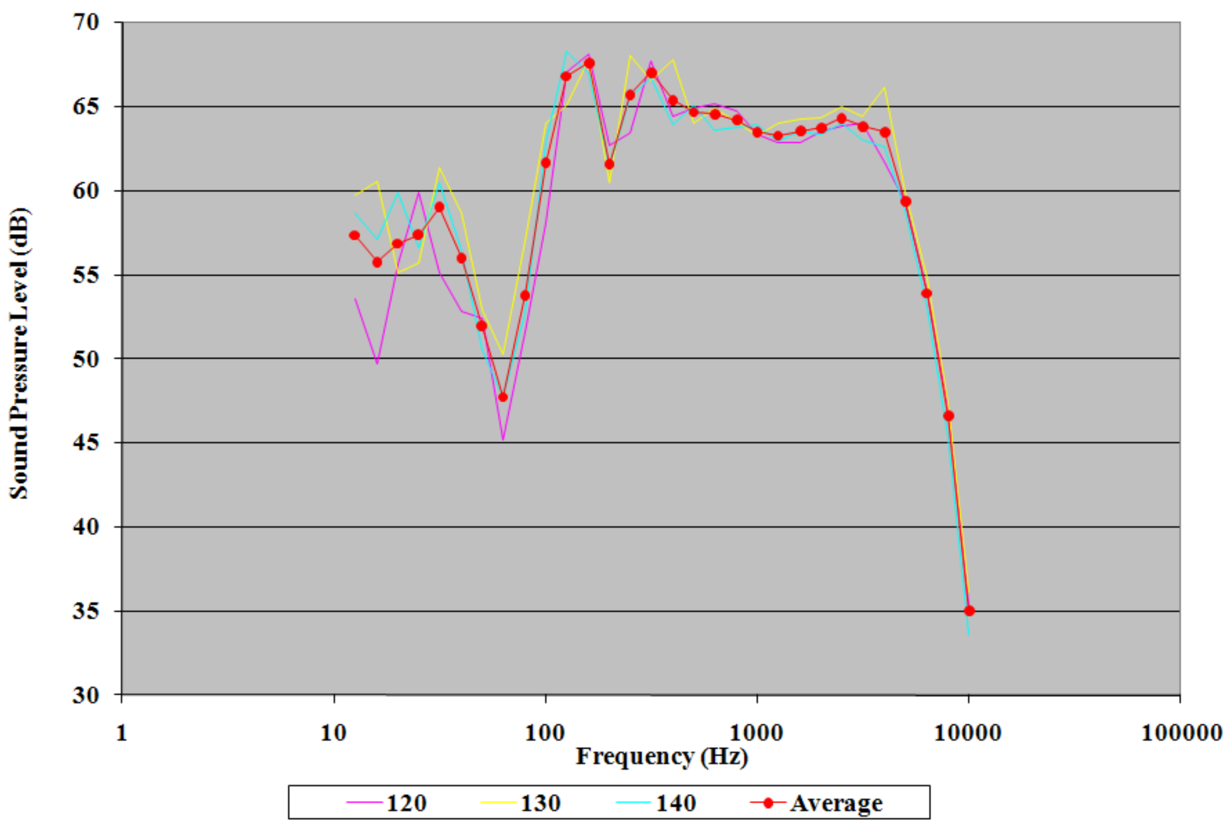

Figure 32. Phase I Centerline Series 100 Spectra

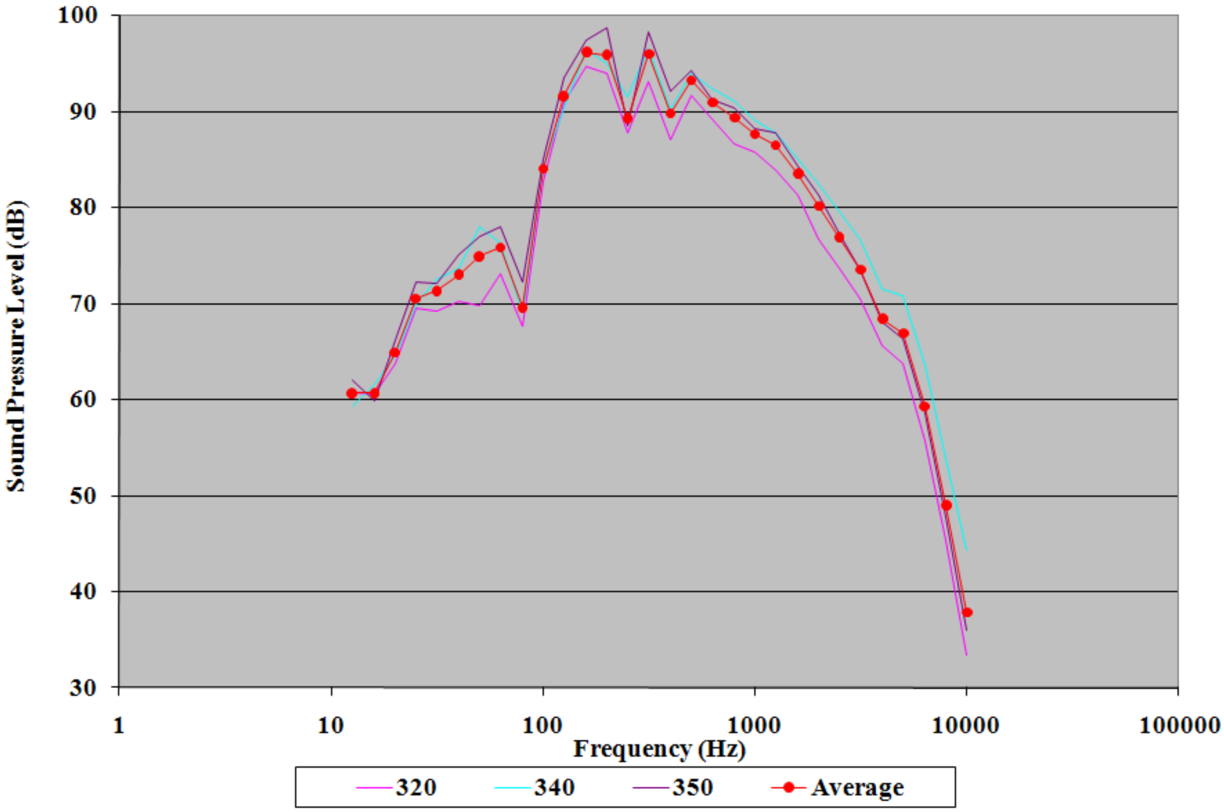

Figure 33. Phase I Centerline Series 300 Spectra

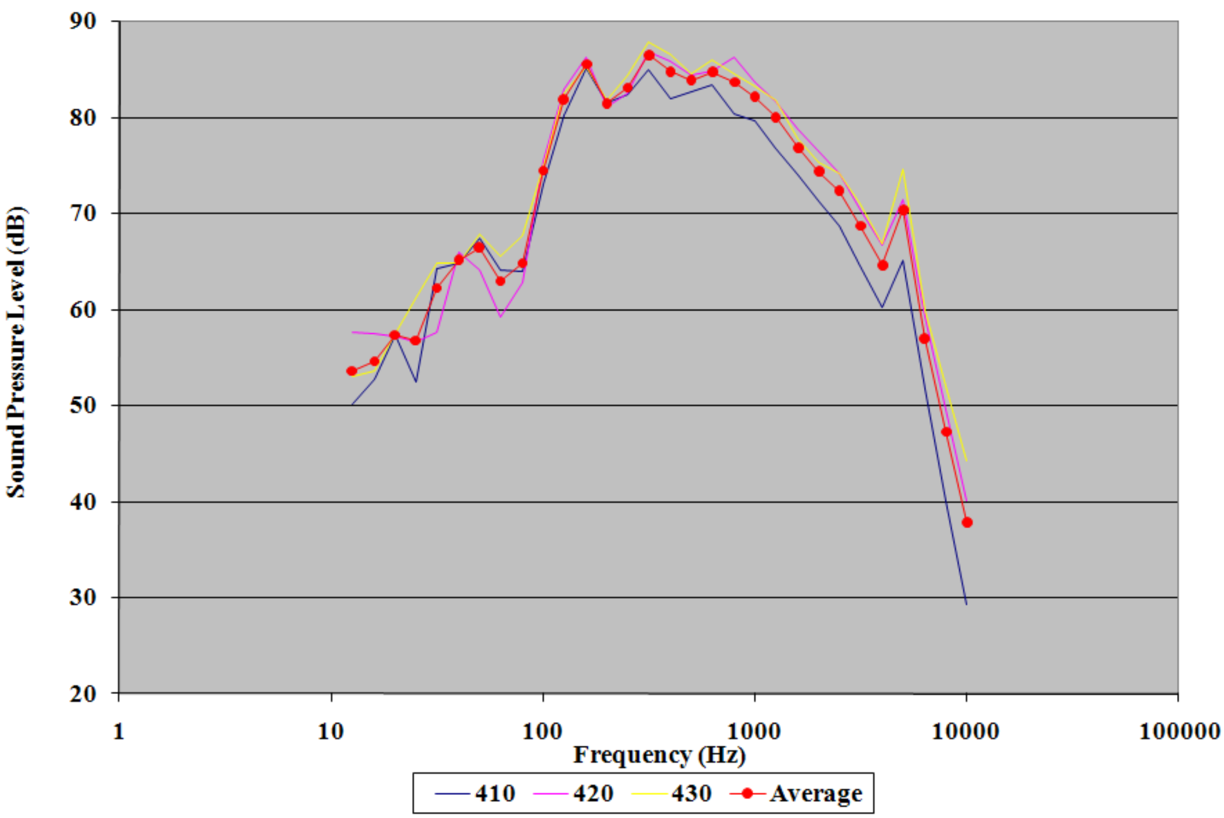

Figure 34. Phase I Centerline Series 400 Spectra

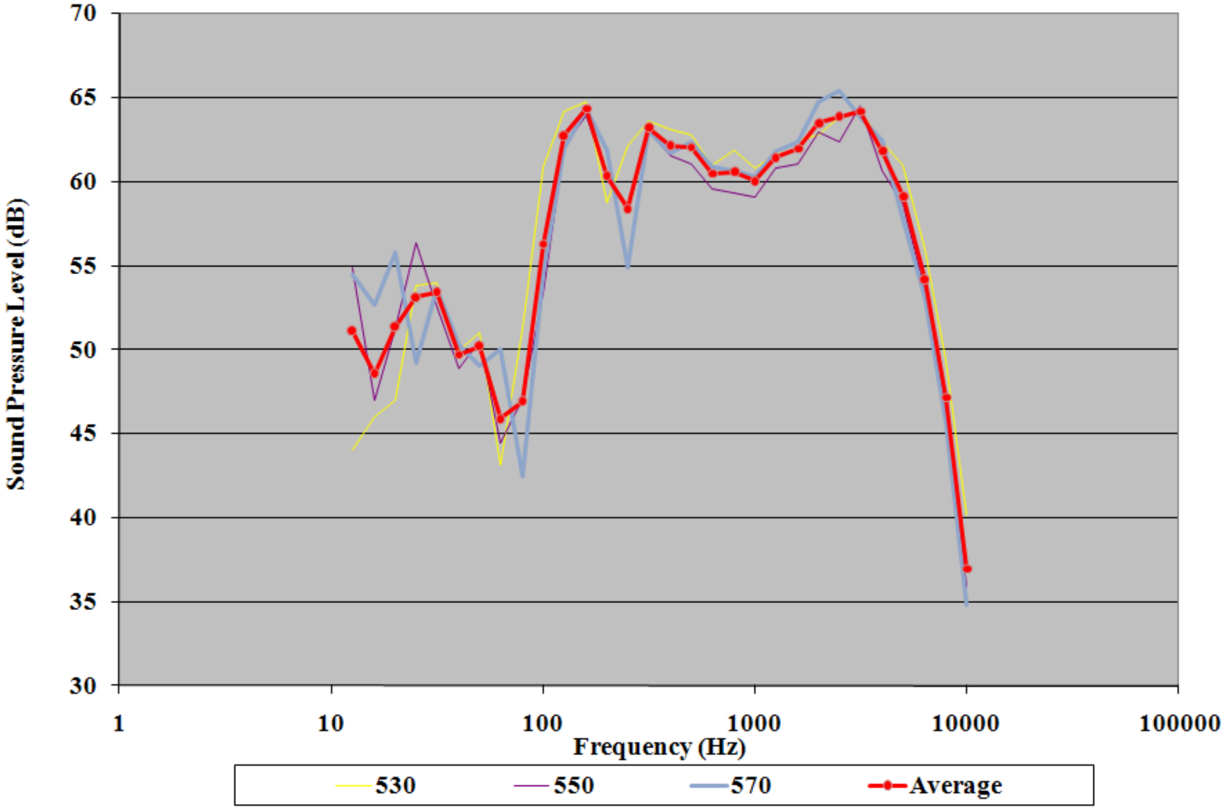

Figure 35. Phase I Centerline Series 500 Spectra

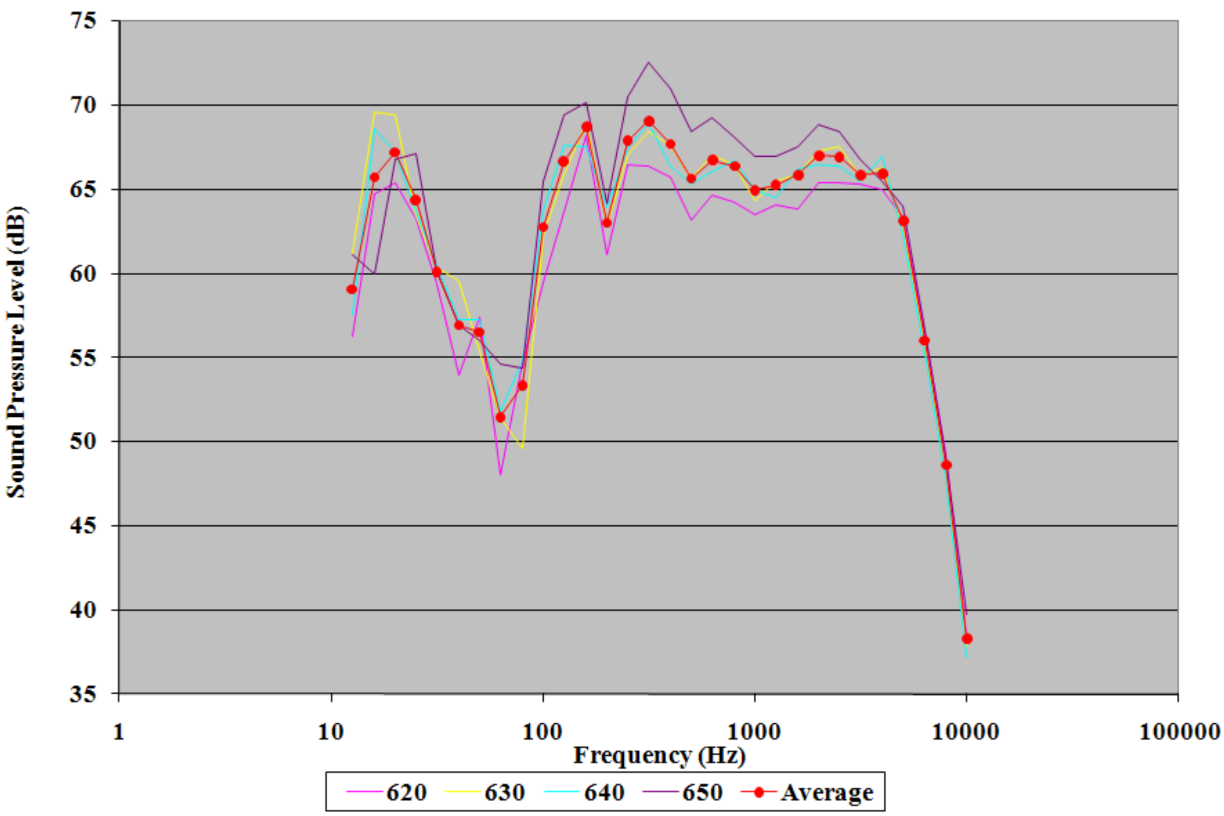

Figure 36. Phase I Centerline Series 600 Spectra

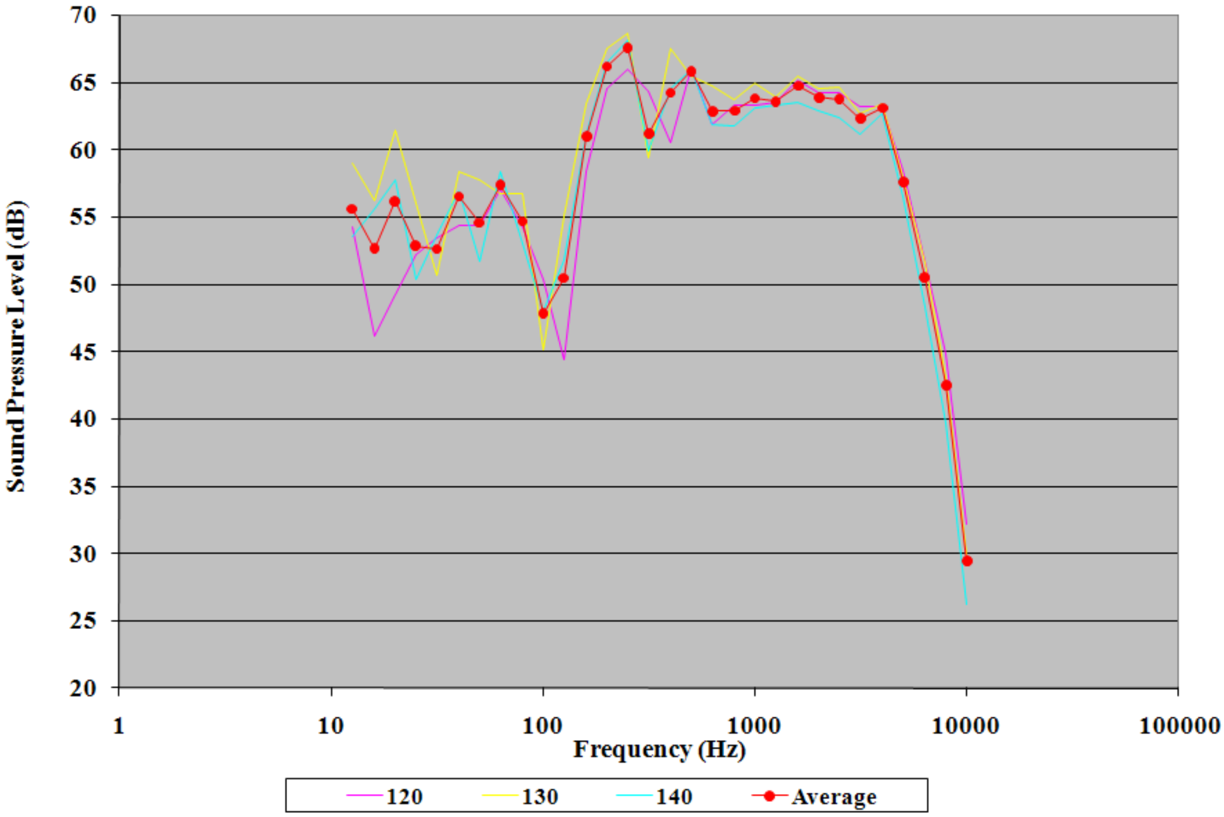

Figure 37. Phase I Sideline Series 100 Spectra

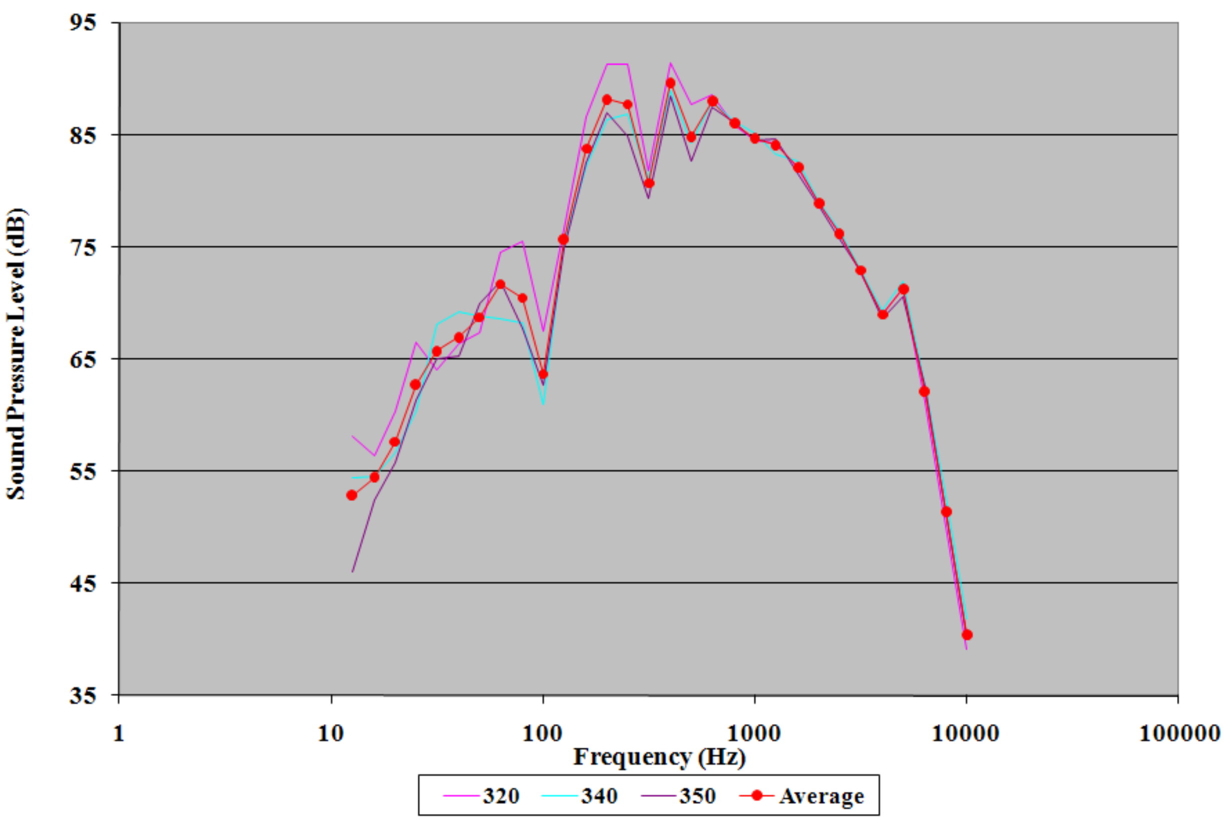

Figure 38. Phase I Sideline Series 300 Spectra

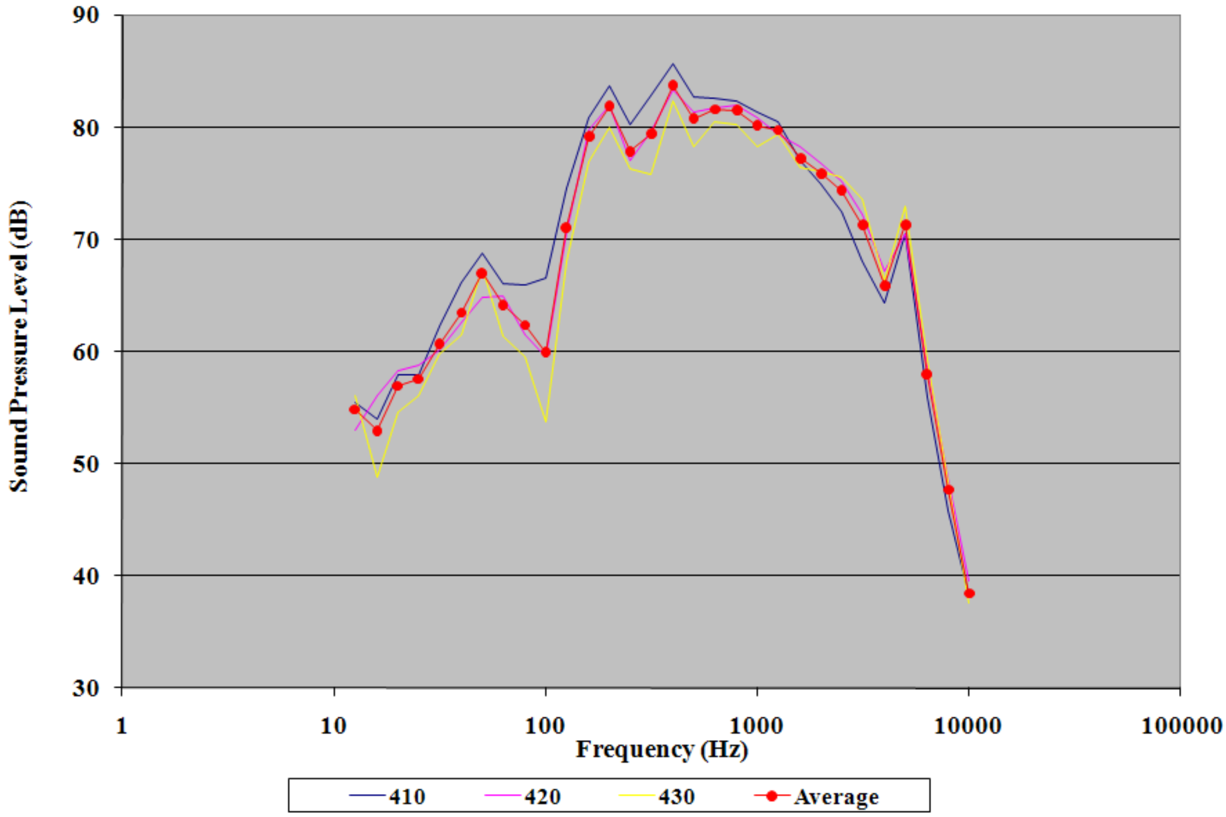

Figure 39. Phase I Sideline Series 400 Spectra

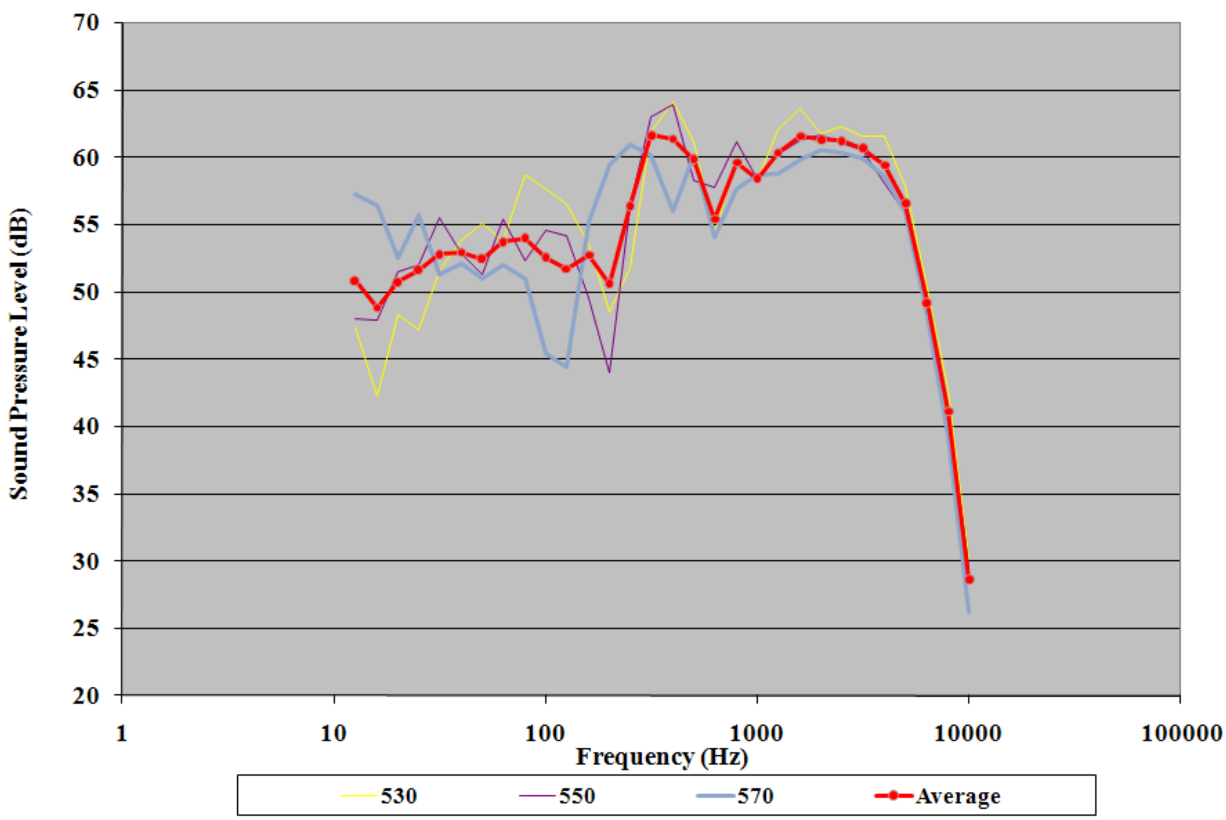

Figure 40. Phase I Sideline Series 500 Spectra

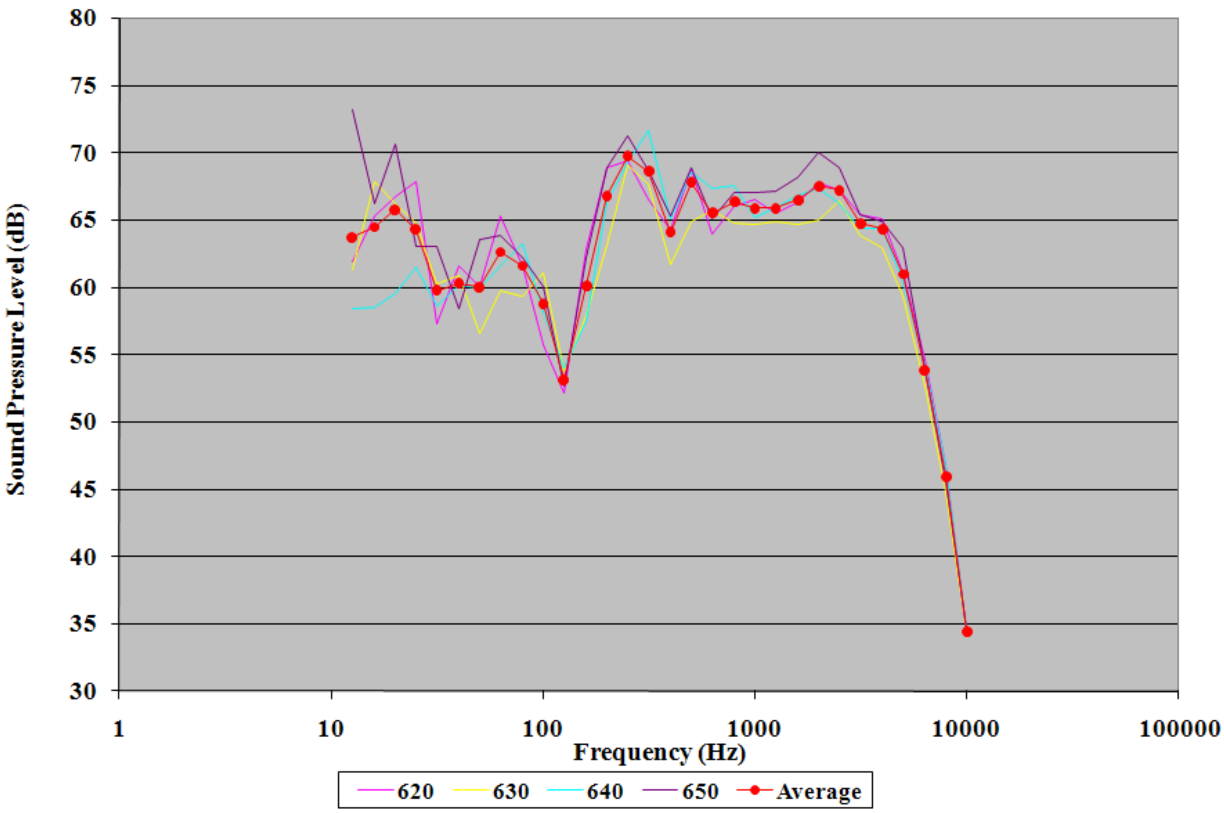

Figure 41. Phase I Sideline Series 600 Spectra

D.2 Phase II Spectral Data

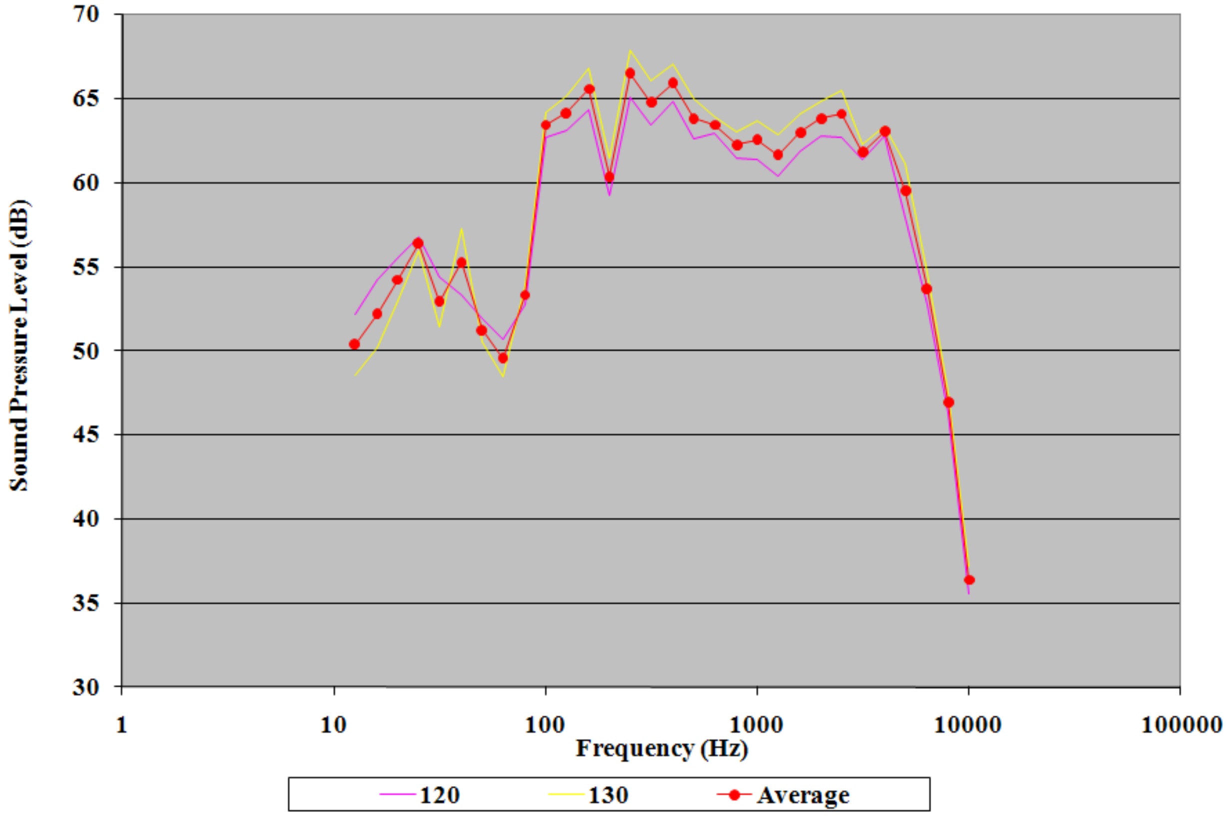

Figure 42. Phase II Centerline Series 100 Spectra

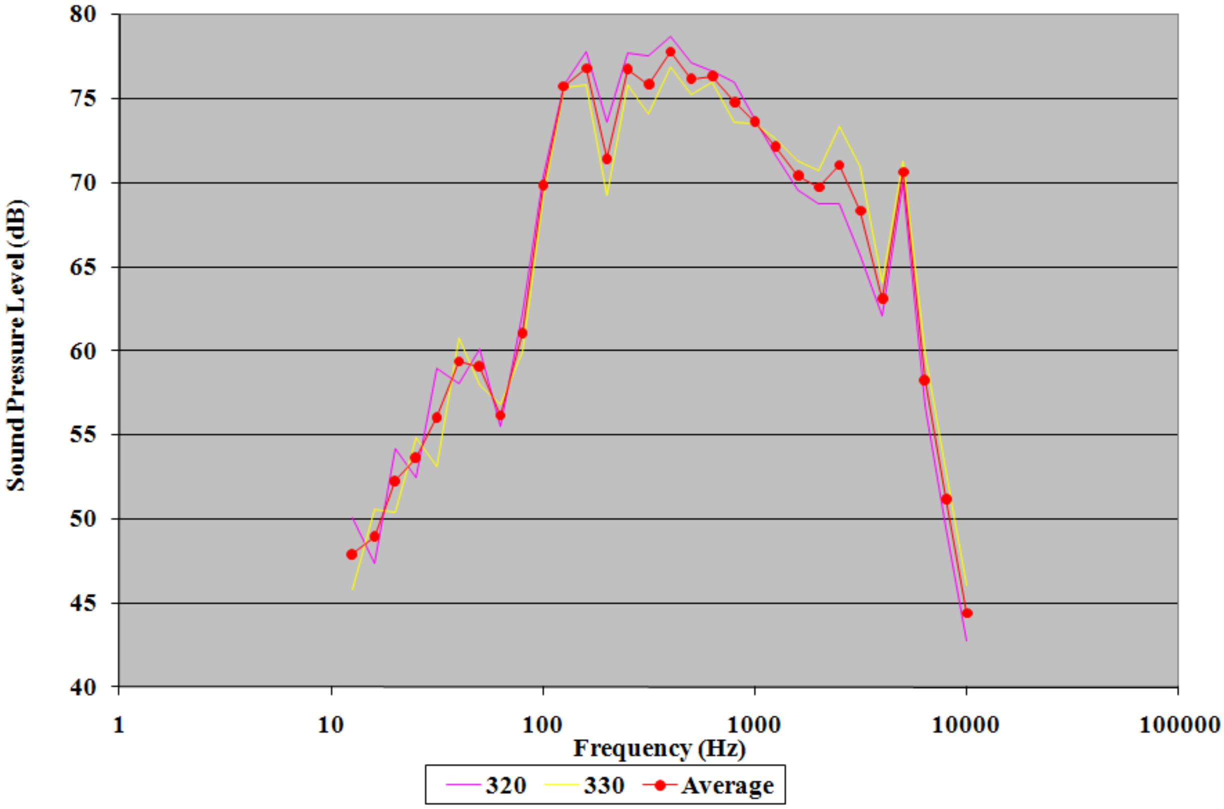

Figure 43. Phase II Centerline Series 300 Spectra

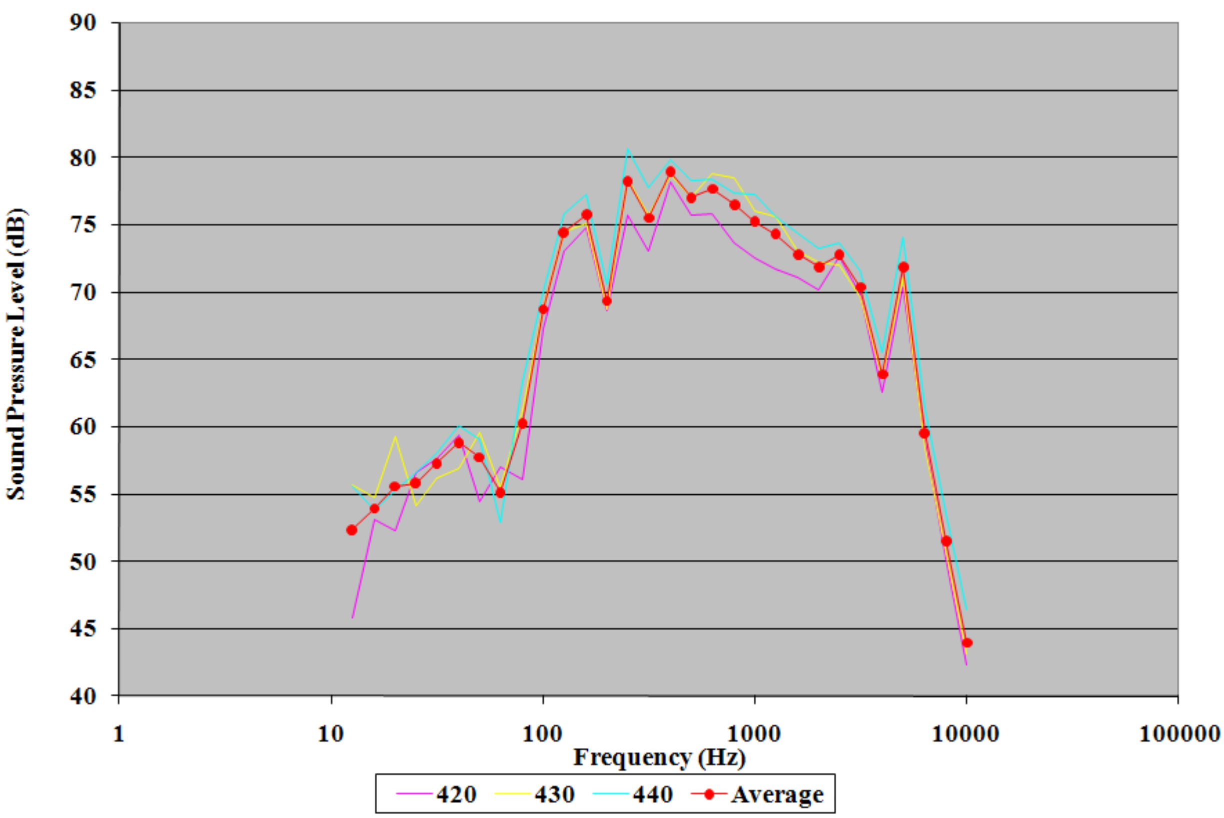

Figure 44. Phase II Centerline Series 400 Spectra

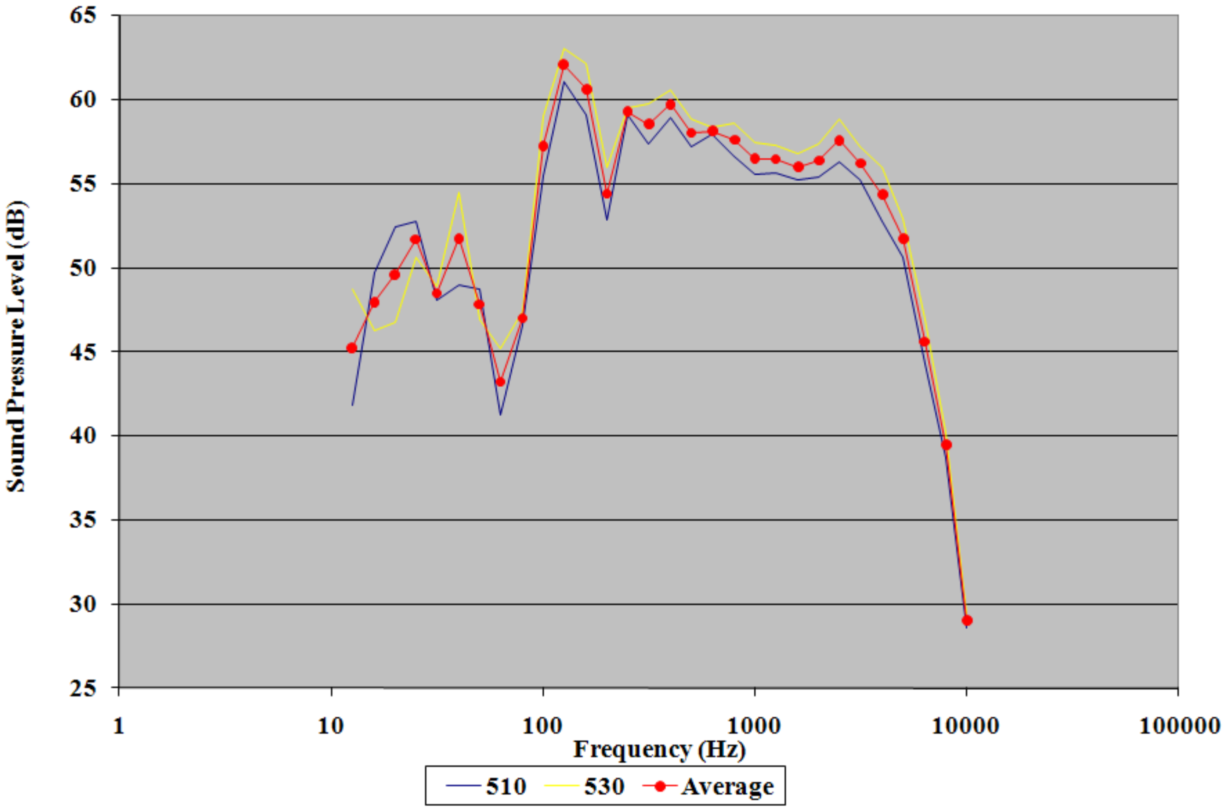

Figure 45. Phase II Centerline Series 500 Spectra

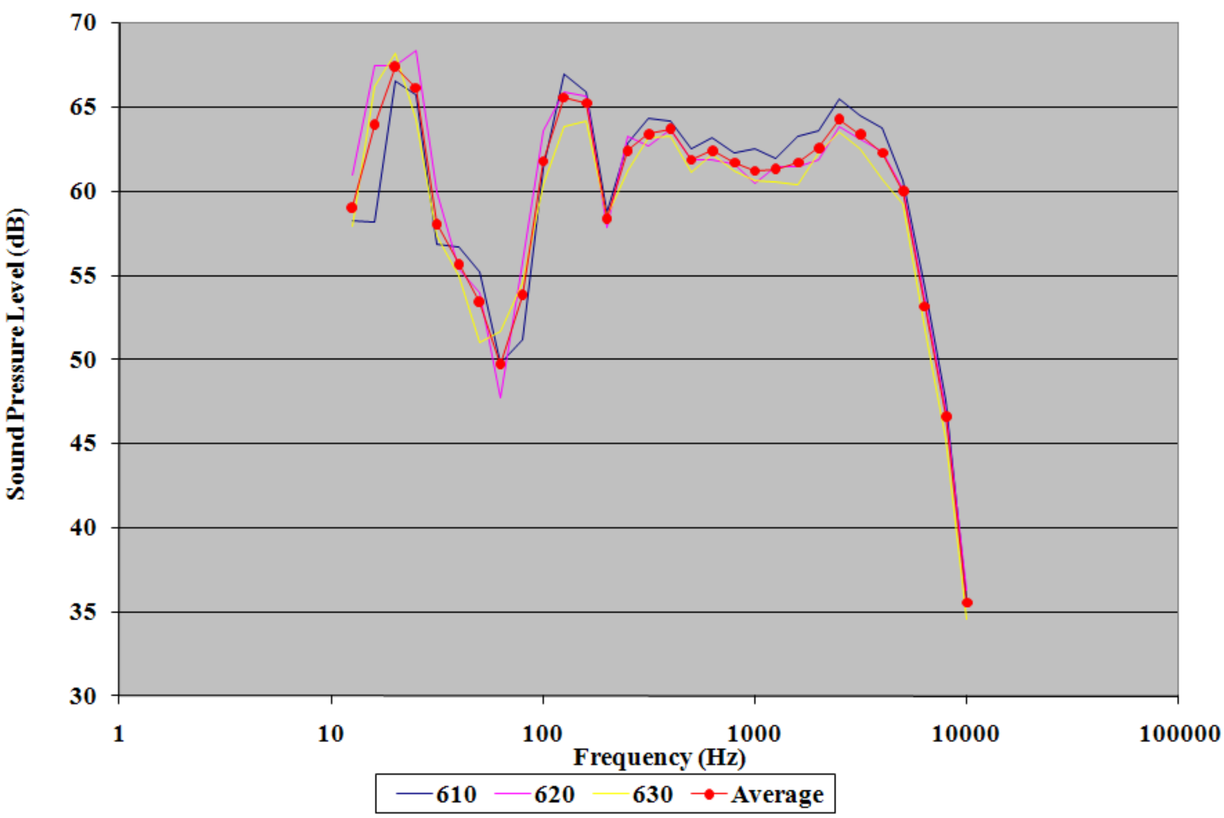

Figure 46. Phase II Centerline Series 600 Spectra

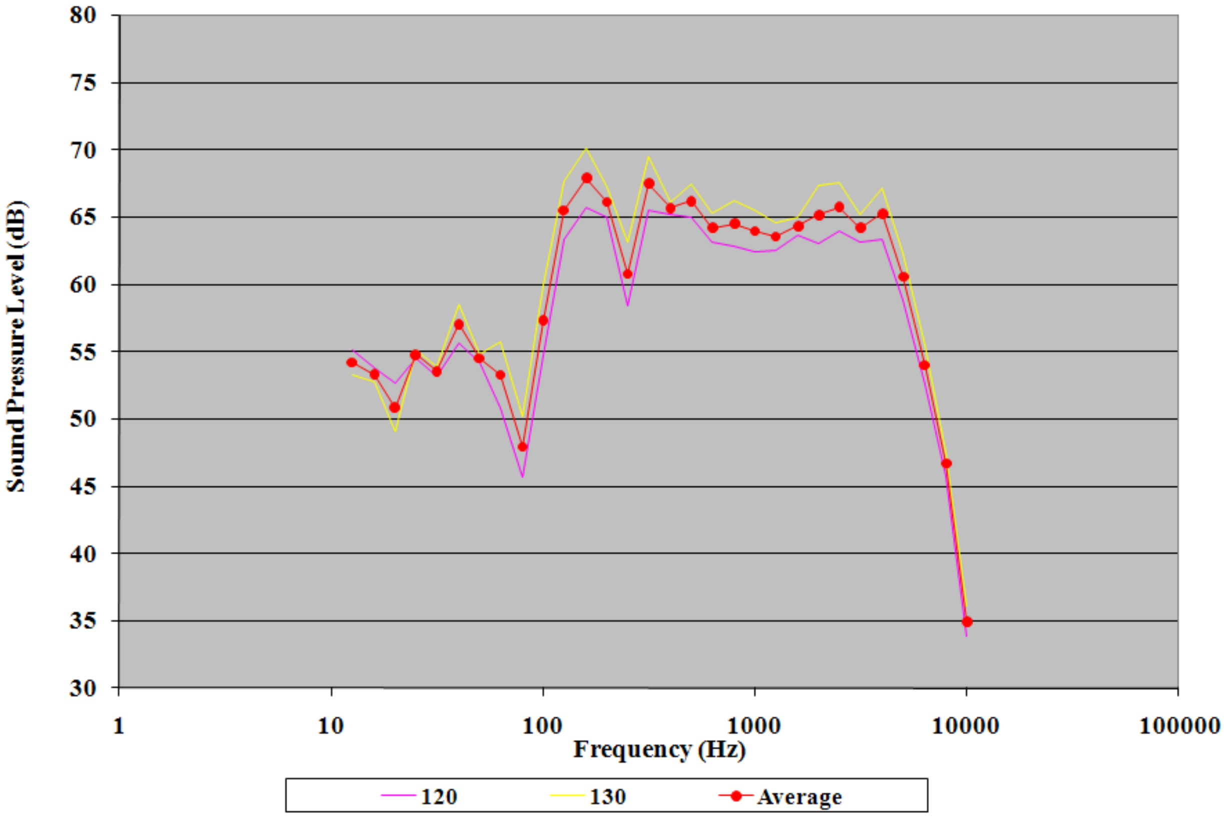

Figure 47. Phase II Sideline Series 100 Spectra

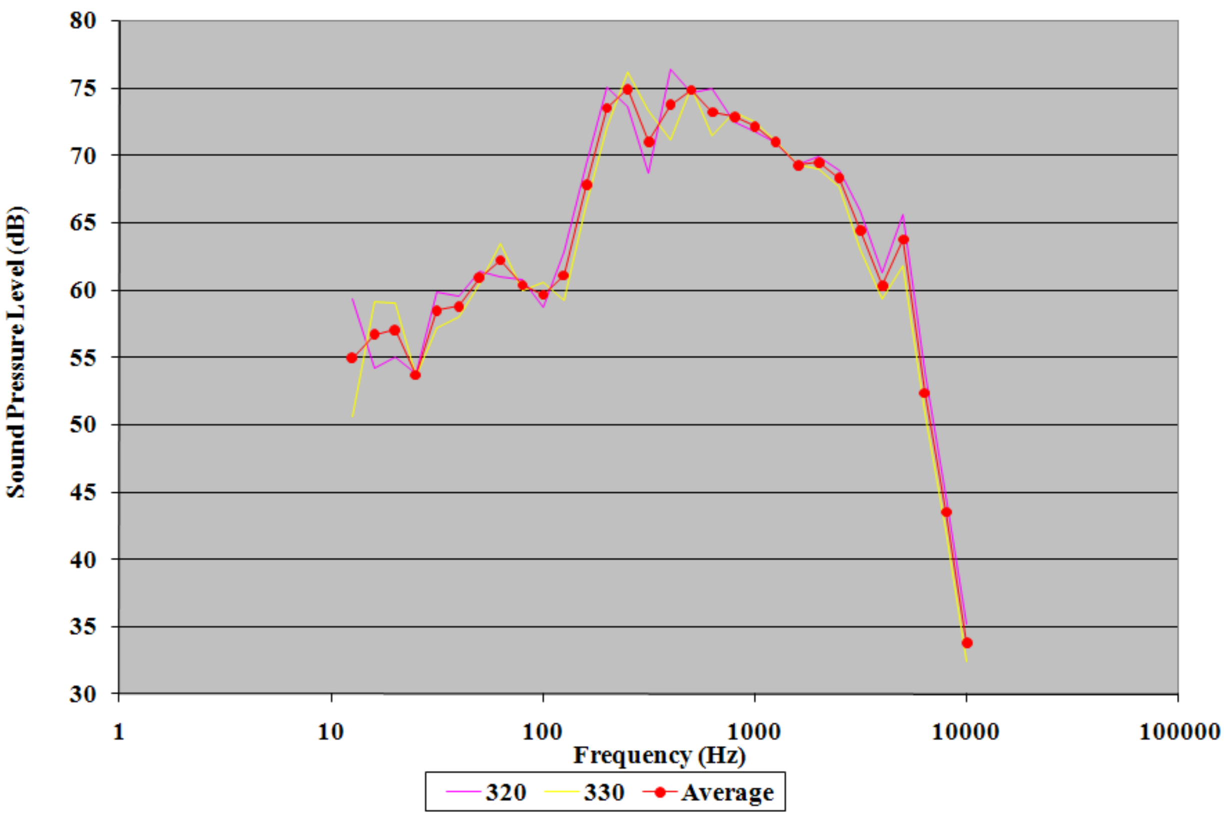

Figure 48. Phase II Sideline Series 300 Spectra

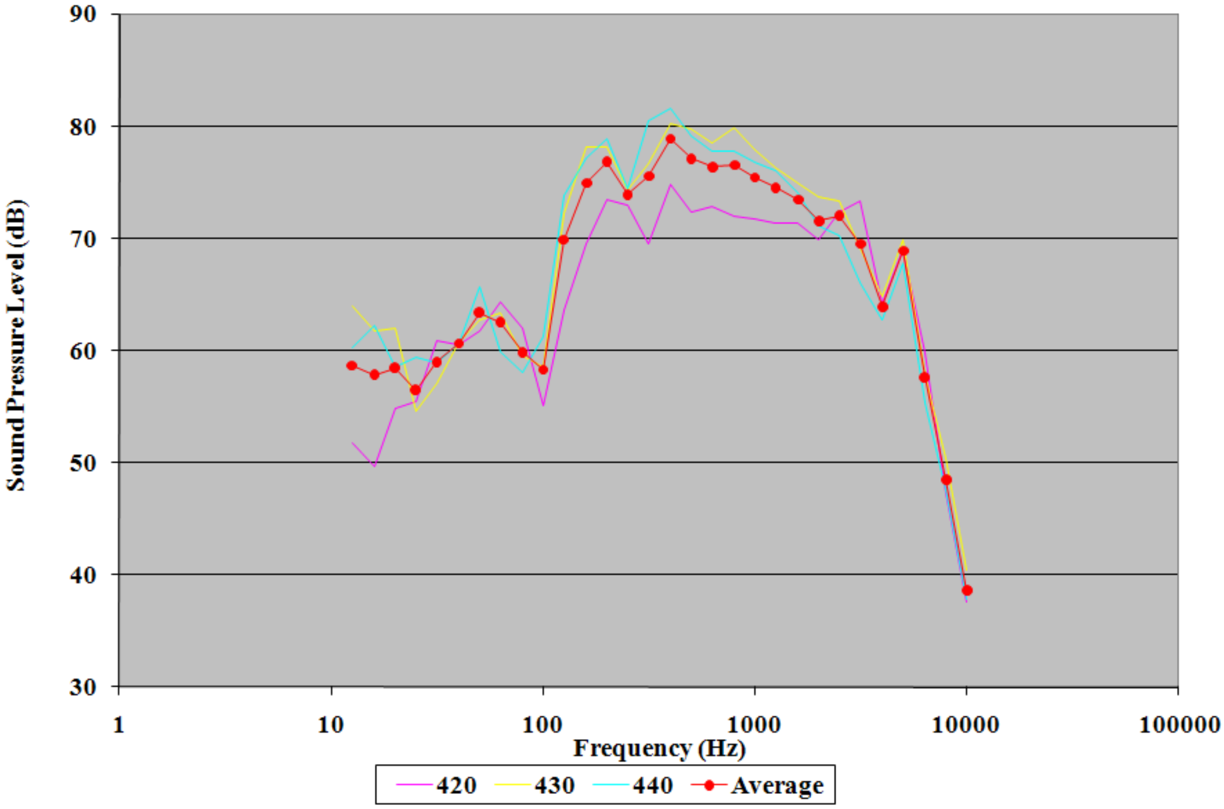

Figure 49. Phase II Sideline Series 400 Spectra

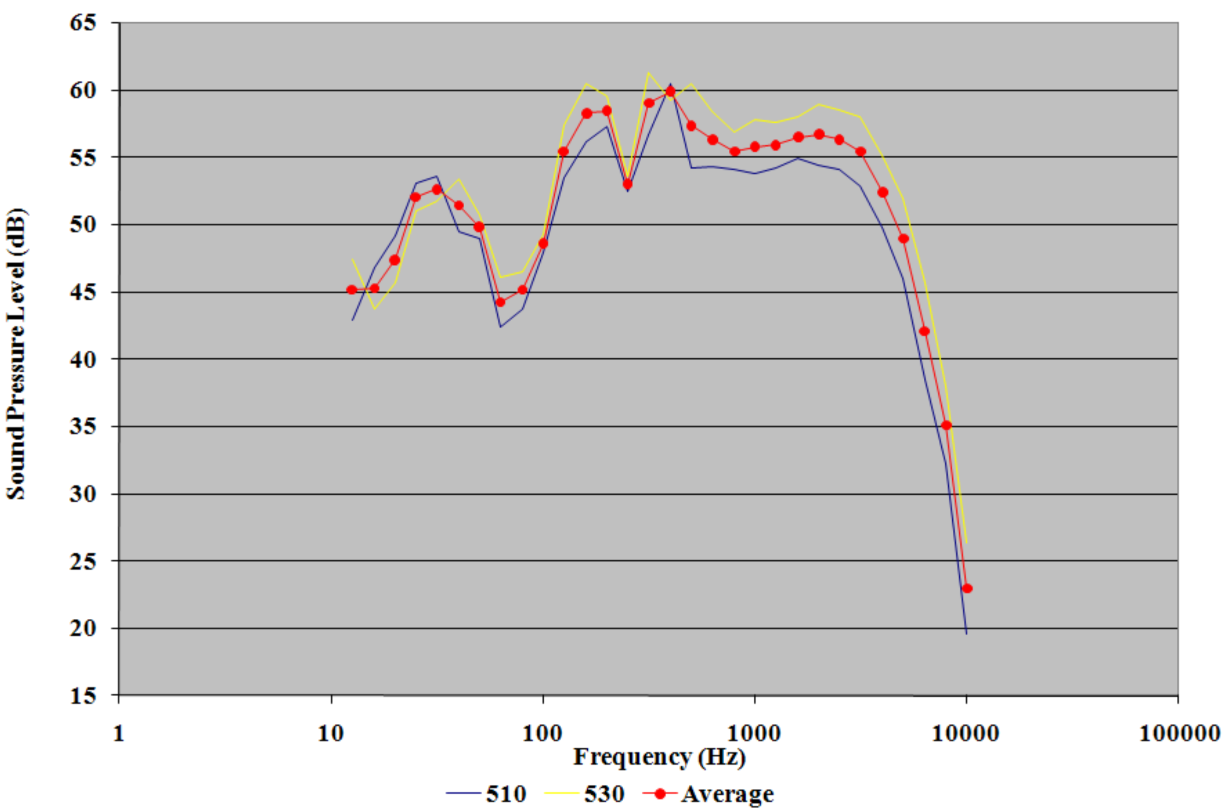

Figure 50. Phase II Sideline Series 500 Spectra

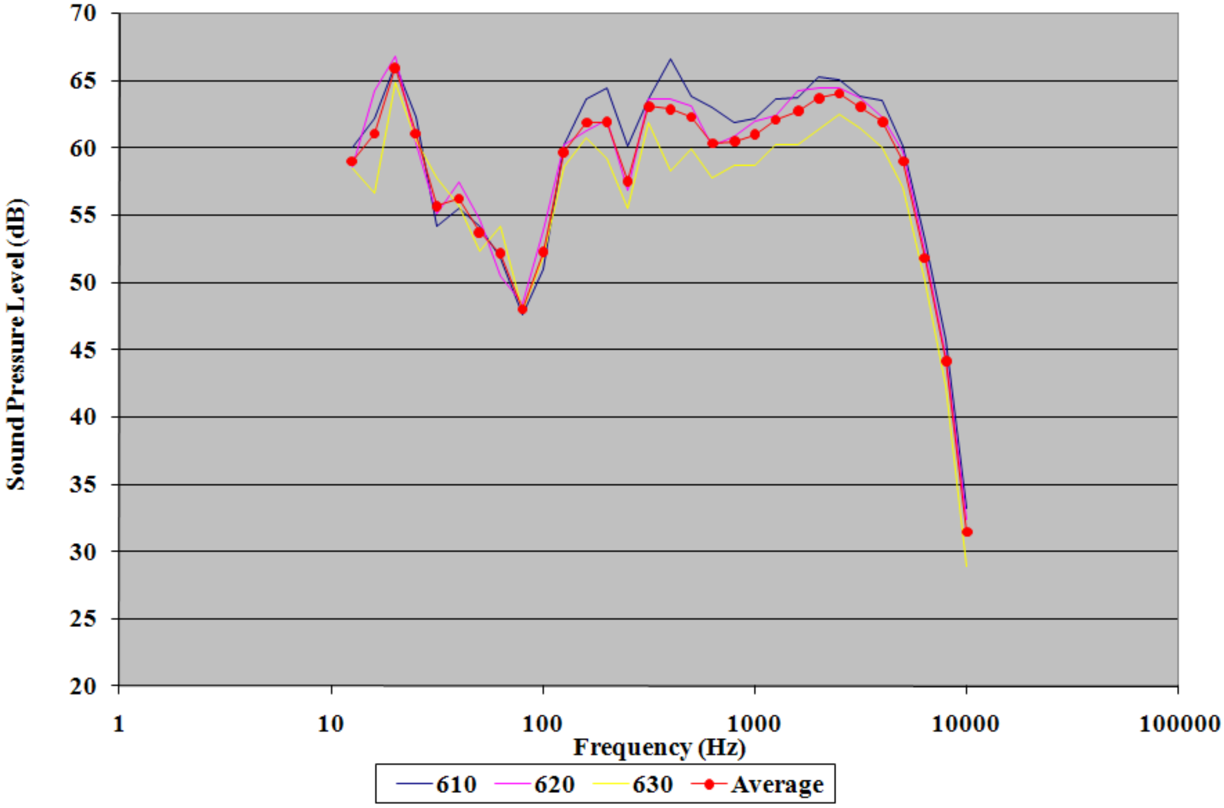

Figure 51. Phase II Sideline Series 600 Spectra

APPENDIX E: AIRCRAFT ENGINE POWER SETTINGS

Appendix E presents the test aircraft engine power settings, N1 (%), that were used during measurements for each of the three AlliedSignal TFE731-3-1C engines, including the average value of all three engines. Similar to the TSPI data provided in Appendix B, the N1 values shown represent the setting used during the time at L_{ASmx} for each event. Note that only data for events that passed the Quality Assurance test outlined in Section 9 are provided.

Table 106. Phase I N1 Engine Power Settings

Event	Event Description	Time at L_{ASmx}	E1 N1 (%)	E2 N1 (%)	E3 N1 (%)	Average N1 (%)
120	LFO: Normal Cruise @ 500 ft	10:29:21	64.98	61.21	67.46	64.55
130	LFO: Normal Cruise @ 500 ft	12:43:50	73.27	71.19	74.44	72.96
140	LFO: Normal Cruise @ 500 ft	12:49:07	72.78	69.55	70.55	70.96
320	DEP: Standard	11:48:35	98.88	100.76	99.97	99.87
340	DEP: Standard	12:01:29	99.15	100.94	100.10	100.06
350	DEP: Standard	12:07:35	99.19	100.97	100.13	100.09
410	DEP: Cruise Climb	12:13:26	96.18	96.07	97.34	96.53
420	DEP: Cruise Climb	12:19:01	97.05	97.07	97.53	97.22
430	DEP: Cruise Climb	12:24:35	97.05	96.50	97.47	97.01
530	APP: Flaps 20 Degrees, Gear Up	10:47:47	68.06	64.58	67.40	66.68
550	APP: Flaps 20 Degrees, Gear Up	11:00:57	64.19	63.49	67.72	65.13
570	APP: Flaps 20 Degrees, Gear Up	12:38:21	58.89	57.22	60.78	58.97
620	APP: Flaps 48 Degrees, Gear Down	11:15:09	75.19	73.37	79.13	75.90
630	APP: Flaps 48 Degrees, Gear Down	11:21:46	78.42	74.03	78.21	76.89
640	APP: Flaps 48 Degrees, Gear Down	11:28:41	75.42	73.82	78.85	76.03
650	APP: Flaps 48 Degrees, Gear Down	11:35:40	80.39	77.32	82.60	80.10

Table 107. Phase II N1 Engine Power Settings During

Event	Event Description	Time at L_{ASmx}	E1 N1 (%)	E2 N1 (%)	E3 N1 (%)	Average N1 (%)
120	LFO: Normal Cruise @ 500 ft	14:03:40	73.18	66.58	73.48	71.08
130	LFO: Normal Cruise @ 500 ft	14:07:59	80.74	74.27	78.50	77.84
320	DEP: Standard	14:36:22	93.89	93.44	93.92	93.75
330	DEP: Standard	14:40:45	93.67	94.25	94.75	94.23
420	DEP: Cruise Climb	15:00:09	96.25	94.63	96.16	95.68
430	DEP: Cruise Climb	15:05:19	95.80	95.73	97.00	96.18
440	DEP: Cruise Climb	15:13:53	95.98	95.13	96.25	95.79
510	APP: Flaps 20 Degrees, Gear Up	15:23:27	48.05	40.85	47.28	45.40
530	APP: Flaps 20 Degrees, Gear Up	15:40:22	53.50	49.66	51.66	51.61
610	APP: Flaps 48 Degrees, Gear Down	15:49:19	72.15	66.34	71.85	70.11
620	APP: Flaps 48 Degrees, Gear Down	15:57:53	69.31	64.06	68.10	67.16
630	APP: Flaps 48 Degrees, Gear Down	16:06:11	66.63	61.54	68.08	65.42

APPENDIX G: ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
AeroTEC	Aerospace Testing Engineering and Certification
AGL	Above Ground Level
Ah	Amp Hours
ANSI	American National Standards Institute
API	Aviation Partners Inc.
APP	Approach
B&K	Brüel and Kjær
BNC	Bayonet Neill-Concelman
CLM	William Fairchild International Airport (FAA identifier)
dB	Decibel
dBA	Decibel, A-weighted
DC	Direct Current
DEP	Departure
DGPS	Differential Global Positioning System
EED	Needles Airport (FAA identifier)
EPNL	Effective Perceived Noise Level
F	Fahrenheit
FAR36	Federal Aviation Regulations Part 36
Ft	Feet
GPS	Global Positioning System
hr	Hour
Hz	Hertz
ICAO	International Civil Aviation Organization
KHz	Kilohertz
kts	Knots
LAE	Sound Exposure Level
LASmx	Maximum Time-weighted A-weighted Sound Level
lb	Pound(s)
LD824	Larson Davis model 824
LEPN	Effective Perceived Noise Level
LFO	Level Fly Over
LPNTSmx	Tone-adjusted Maximum Slow Time-weighted Perceived Noise Level
MSL	Mean Sea Level
MXSA	Maximum Time-weighted A-weighted Sound Level
MXSPNT	Tone-adjusted Maximum Slow Time-weighted Perceived Noise Level
NextGen	Next Generation air Transportation System
NOTAM	Notice to Airmen
NPD	Noise Power Distance
QA	Quality Assurance
RMSE	Root Mean Square Error

ROC	Rate of Climb
SAE-AIR-1845	Society of Automotive Engineers Aerospace Information Report No. 1845
SBD	San Bernardino International Airport (FAA identifier)
SD744T	Sound Devices model 744T
SEL	Sound Exposure Level
SPL	Sound Pressure Level
TAMS	Transportable Automated Meteorological Station
TNC	Threaded Neill-Concelman
TSPI	Time Space Position Information
USB	Universal Serial Bus
XLR	Ground Left Right

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