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MODELING LATERAL ATTENUATION OF AIRCRAFT FLIGHT NOISE

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Airbase and/or airport noise prediction models such as the Air Force NOISEMAP computer program are used to forecast the long term noise exposure from aircraft flight and ground activity at a facility. Noise contour maps from these calculations are used to assess the potential adverse effects such noise may have on the environ and to assist nearby communities in performing compatible land use planning. To calculate the noise exposure at any specified ground position located to the side of a flight path, a variety of noise attenuation mechanisms must be accounted for if the model is to predict levels that are in reasonable agreement with field noise measurements. For such locations, the attenuation effects are usually grouped as being due to: (1) wave divergence (spherical spreading), (2) atmospheric absorption, and (3) lateral attenuation (the combined attenuation due to ground, meteorological, forward flight, and engine/airplane installation effects). Because of the complexity of the frequency dependent interaction of these phenomena affecting lateral attenuation, most attempts in recent years (Ref 1,2,3,4,5,6) to improve the technical basis of the simplified algorithms used in airbase/airport noise models have defined lateral attenuation as a function of elevation angle in terms of a variety of single event measures such as the Sound Exposure Level.

For civil aircraft the lateral attenuation model developed by the Society of Automotive Engineers, Inc. A-21 Committee on Aircraft Noise (Ref 5) is commonly used. Since it was derived mainly from measured lateral attenuation data on civil aircraft, the predicted results generally show good agreement when compared with actual measurements. However, the

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frequency spectra of the noise from most military aircraft is often quite different from that associated with civil transports. A series of field experiments was conducted to develop a data base of sufficient size (853 points at elevation angles ranging from 1.9 to 90 degrees) to accurately model the lateral attenuation associated with military flights near airbases and especially along Military Training Routes where the aircraft fly at low altitude (150 m or less) and at high subsonic airspeeds. Those tests (Ref 7) confirmed the need for a different model of lateral attenuation for typical United States military versus civil aircraft flight operations.

A companion paper, A Prediction Model for Noise From Low-Altitude Military Aircraft, describes recent tests performed in the United Kingdom (Ref 8,9). Two of the aircraft (F-15 and F-16) were common to the tests performed in the United States and the United Kingdom. This paper merges the 182 data points at very low elevation angles (1.3 to 6.8 degrees) from the UK tests, adds 154 more USAF data points at low to moderate elevation angles (3 to 45 degrees) and derives an improved model for lateral attenuation associated with military aircraft.

DISCUSSION

The tests in both countries involved having the aircraft fly at various (constant) altitudes at stable engine power setting conditions over an array of microphones positioned perpendicular to the planned flight track. Analog or digital tape recordings at each microphone site were made while simultaneously tracking the aircraft position using radar, laser, or photographic equipment. In the United States, data were collected on attack/fighter aircraft (A-10A, F-4D, F-5E, F-15, F-16, and F-18); bomber aircraft (B-1, B-52G, B-52H and FB-111); cargo/tanker aircraft (C-18, C-141, KC-10A, KC-135A, and KC-135R); and special purpose aircraft (C-21 and E-3A). The United Kingdom tests provided data on Tornado, Jaguar, Harrier, Hawk, F-15, and F-16 aircraft.

Computation of the lateral attenuation as a function of elevation angle in terms of the Sound Exposure Level (SEL) was done for each individual flyover event as follows: (1) The ambient background corrected one-third octave band SPL spectrum measured at a site directly under the aircraft flyover (elevation angle of 90 degrees) at the time of maximum noise was extrapolated to long distances. Losses due to atmospheric absorption were accounted for using the SAE 866A coefficients (Ref 10) and for spherical spreading; (2) A-weight the resulting spectra to

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obtain a computed function of maximum A-weighted Sound Level versus propagation distance and estimate the Sound Exposure Level as a function of distance by adding a sound duration correction factor based on six (6) times the logarithm of the propagation distance (Ref 11) to the measured SEL at the reference distance; and (3) The lateral attenuation at other elevation angles is simply the difference between this SEL computed for the minimum slant distances to the other microphone sites and the SEL measured at those sites for that flyover event.

Since the test altitudes for low flying operations are usually limited from 35m to 305m above the ground, there are real advantages in using this technique to derive a model of the lateral attenuation. No normalizing adjustments are required to account for differences between flyover events for engine power setting, airspeed, or steep gradients in the atmospheric absorption or refraction effects due to vastly different aircraft altitudes. The disadvantage is that a "measured" value of the lateral attenuation is not obtained by direct comparison of the SEL values measured at the same propagation distance where only the elevation angle varies, which can be done by using different flyover events at different altitudes (provided the aircraft operating conditions are identical and there are no dramatic variations in the atmosphere at the higher altitudes).

RESULTS

Consistent with earlier findings (Ref 11) in the USA and with the methodology used herein, linear regression of the UK "Luce Belle" field measured Sound Exposure Level and Maximum A-weighted Level data yielded a sound duration coefficient of six.

Figures 1 and 2, for the F-15 and F-16 aircraft, clearly show how well the data collected by the different organizations (Armstrong Laboratory in the USA and National Physical Laboratory in the UK) can be merged. Note how for the F-15, the UK data provided the information sorely needed at very low elevation angles to augment the US data acquired many years earlier under quite different flight conditions. The UK data for the F-16 overlay well with the US data even though different models with different engine configurations were measured.

Comparison of the F-15 and F-16 data show that lateral attenuation varies considerably even though both are of the same general class of small, military fighters. This finding is consistent with that previously seen in the literature for both civil and military aircraft (Ref 5,7) and is expected since

lateral attenuation is a frequency dependent interactive phenomena between the source noise, atmosphere, ground, etc. Such differences can be very important for some special purpose analyses such as acoustic detection. However, most airport or military operational scenarios involve a wide mix of aircraft types and flight/engine power setting conditions. For the more general purposes of assessing the overall impact of aircraft noise on the environment or for conducting planning studies of compatible land use, it is common practice to use a single relationship for modeling lateral attenuation for all aircraft types. Figure 3 shows all of the available SEL lateral attenuation data for military aircraft. Included is a solid line curve based on a least squares fit of these data. This function is given by:

$$\text{SEL Lateral Attenuation (dB)} = 20.49/\text{ANGLE} - 0.1818$$

It is recommended that this be used over the range of one to forty-five degrees in elevation angle. For angles less than one degree, use 20.3 dB; and use zero for angles greater than 45 degrees. Note that the data and recommended curve for use in predicting this phenomenon for military aircraft do not support that commonly used for civil aircraft.

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Figure 1
F-15 LATERAL ATTENUATION

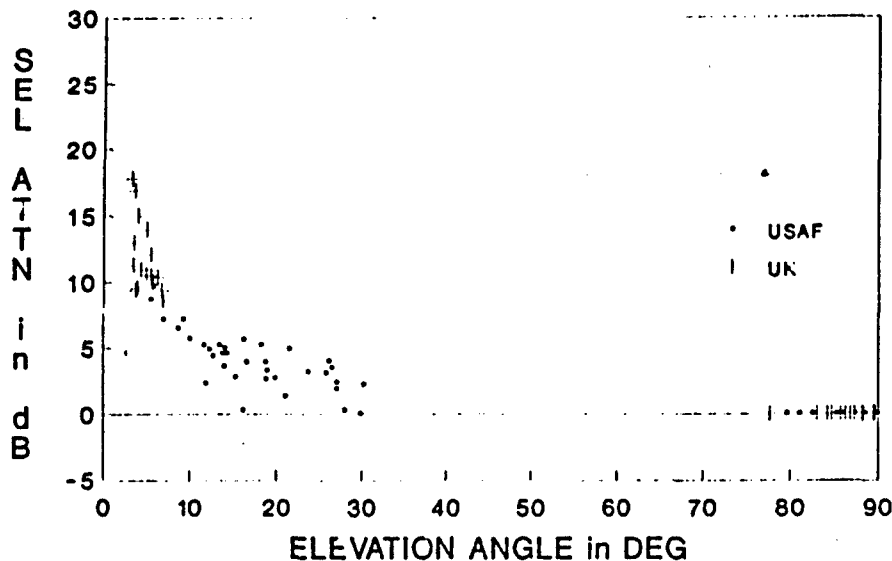


Figure 2
F-16 LATERAL ATTENUATION

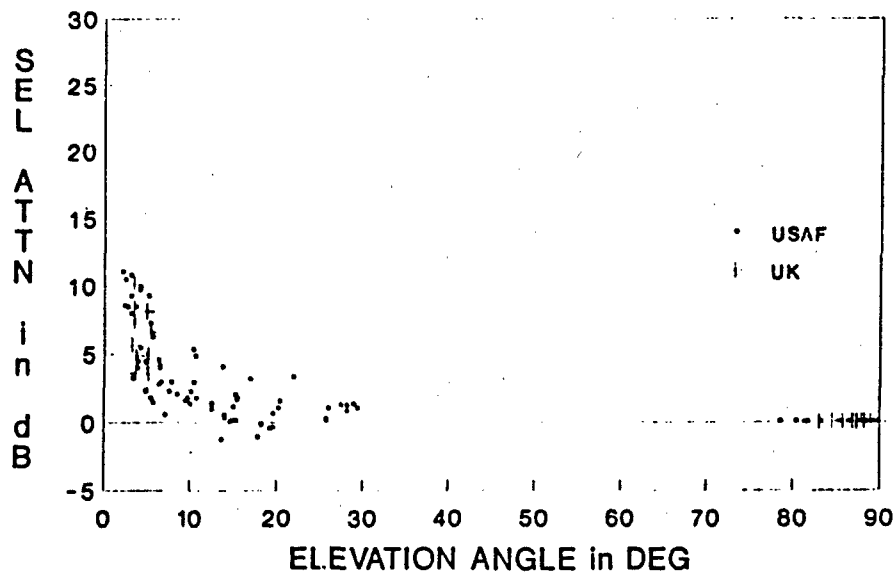


FIGURE 3
LATERAL ATTENUATION

