NASA TM-83214

NASA Technical Memorandum 83214

NASA-TM-83214 19820003987

SEL AND EPNL NOISE DURATION COEFFICIENTS FOR THE 747 AND T-38 AIRCRAFT

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SEPTEMBER 1981

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Summary

Duration coefficients are calculated for Boeing 747 and T-38 airplanes for Sound Exposure Level (SEL) and Effective Perceived Noise Level (EPNL) scales. The measured SEL duration coefficients were 8.4 for the Boeing 747 and 5.5 for the T-38. The T-38 result was in good agreement with a previous result for a similar F-5 airplane. In EPNL, the duration coefficients were 7.2 for the Boeing 747 and 5.7 for the T-38. The difference in the results between the two airplanes is believed to be due to their different engine noise source spectra. The difference in the Boeing 747 results in the two different metrics is due to the different frequency weighting of A-weighted Sound Pressure Level (LA), used in SEL, and tone-corrected Perceived Noise Level (PNLT), used in EPNL, when applied to the 747 spectra.

Introduction

As an observer is positioned farther away from the flight track of an airplane, the shape of the airplane's overall acoustic time history broadens. With this broadening of the time history comes an increase in the duration, or the time above a chosen threshold, of the aircraft noise signature. Values of time-integrated noise metrics, such as Sound Exposure Level (SEL) or Effective Perceived Noise Level (EPNL), are influenced by these changes in signal duration. Noise contouring programs, like NOISEMAP (ref. 1) and INM (ref. 2), have assumed that the duration of a noise signal doubles for each doubling of propagation distance or slant range, based on considerations of only spherical divergence. Therefore, these programs have incorporated a duration correction term which is proportional to 10 times the logarithm of the ratio of slant ranges. The factor 10 is referred to as the duration coefficient.

A recent experimental program measured the duration coefficients of eight military airplanes (ref. 3). The measured SEL duration coefficients for the eight airplanes ranged from 5.1 for an F-15 to 7.1 for an A-10. The average experimentally determined duration coefficient was 5.9. On the basis of the experiment of reference 3 a duration coefficient of 6, rather than 10, was recommended for use in noise contour programs such as INM and NOISEMAP. However, since the experiment did not include high-bypass ratio engined airplanes, the question arises as to the applicability of the test results to the commercial aircraft fleet.

Reference 4 describes a lateral attenuation experiment using a Boeing 747 in which propagation data were collected from which duration coefficients can be calculated for this high-bypass ratio engined airplane. Therefore, values of duration coefficient applicable to both SEL and EPNL have been calculated using the Boeing 747 lateral attenuation data and are reported in this paper. Duration coefficients are also reported from a similar lateral attenuation experiment using a T-38 airplane (ref. 5) and compared to results of reference 3 for a similar F-5 airplane as well as to results for the Boeing 747 airplane.

Results and Discussions

Duration coefficient is the slope of the straight line defined by a regression analysis of a plot of duration correction as a function of the logarithm of closest approach slant range. Duration correction is defined as the difference between the SEL and maximum A-weighted Sound Pressure Level (maximum LA) or the difference between the EPNL and the maximum tone-corrected

Percieved Noise Level (maximum PNLT) values for a particular 1/3-octave band time history at a fixed slant range.

Both the Boeing 747 and the T-38 experiments were designed to study lateral attenuation. In the experiments, the airplanes were flown at low altitudes over the ends of microphone arrays. Acoustic data were collected for long slant ranges and small elevation angles. At these conditions, lateral attenuation was maximized and had a large influence on the measured data. For purposes of studying duration coefficients, the extremely long slant range and small elevation data were not used thus eliminating the data with the poorest signal to noise ratios.

Calculated duration corrections as a fuction of slant range are given for the Boeing 747 and the T-38 in the SEL scale in figures 1 and 2, respectively. Results in the EPNL scale are given in figures 3 and 4. In the figures, the duration coefficient is the slope of each regression line. The measured duration coefficients for both airplanes in both scales are given in table 1. Sigma (σ) is the standard deviation of the data from each line. The Boeing 747 results are for the 1.2 m microphones positioned over grass. For the lowest altitude runs, results are given for only the closest microphones. As the altitude of the runs increases, results are included for microphones positioned further from the flight track until, for the highest altitude runs, results are given for all 9 microphones. Results are given for the T-38 for the 1.2 m microphones positioned over grass for 14 runs for slant ranges less than 640 m. The slant range restriction was used to insure adequate signal to noise ratios The T-38 was flown with a single engine at low altitudes (the highest altitude flown was 135 m).

The experimentally determined duration coefficient for the SEL scale was 8.4 for the Boeing 747 and 5.5 for the T-38. The T-38 SEL result is close to the value of 5.8 measured in reference 3 for an F-5 and supports the conclusion of the author for similar engined airplanes. The EPNL results were 7.2 for the Boeing 747 and 5.7 for the T-38. The difference between the Boeing 747 results and the T-38 results for the same scales is due to the difference in their source spectra. The Boeing 747 source spectra have considerablely more low frequency energy than the T-38 source spectra and the Boeing 747 source spectra have a strong fan tone component. The difference in the two Boeing 747 results is due to the different frequency dependence or weighting of LA, used in SEL, and PNLT, used in EPNL, when applied to the 747 source spectra.

Concluding Remarks

The data from two lateral attenuation experiments have been used to determine duration coefficients for additional aircraft to add to the data base of Speakman (ref. 3). Results from one test on a T-38 compare well with his previous results. Results from the other test using a Boeing 747 airplane expand this data base to include a high-bypass ratio engined airplane.

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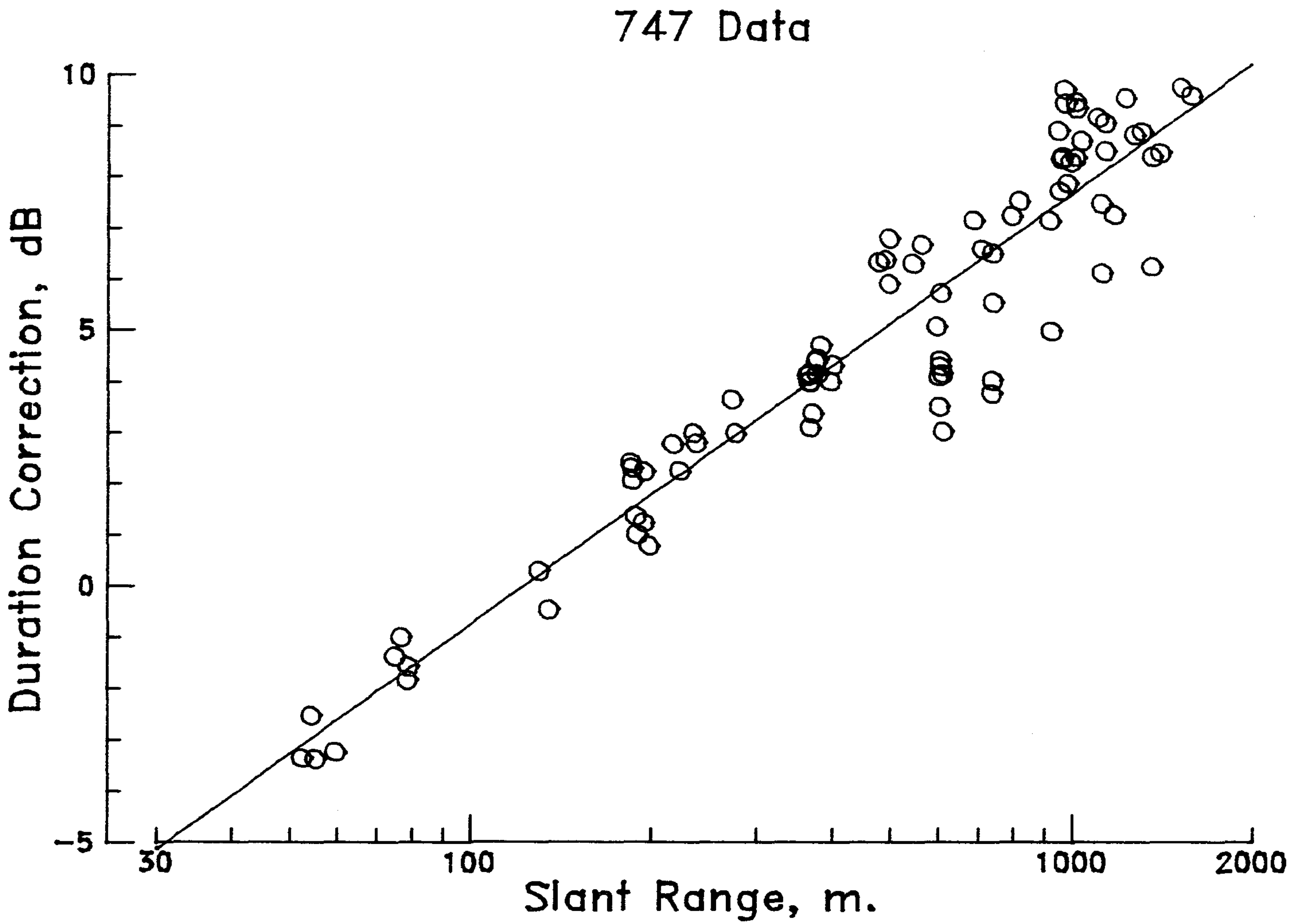
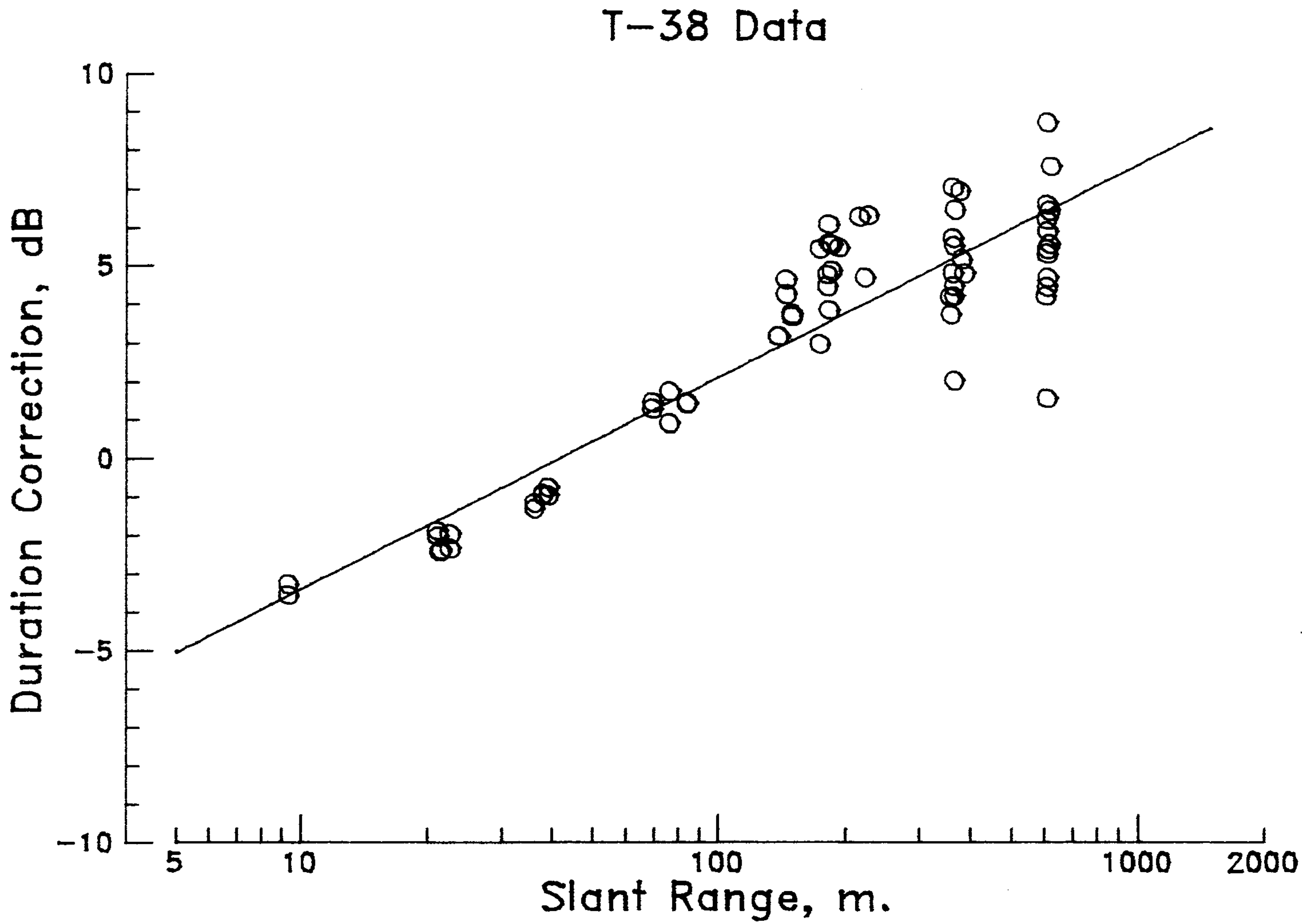
Table 1. Measured Duration Coefficients

	Scale	
	SEL	EPNL
Boeing 747	8.4	7.2
T-38	5.5	5.7



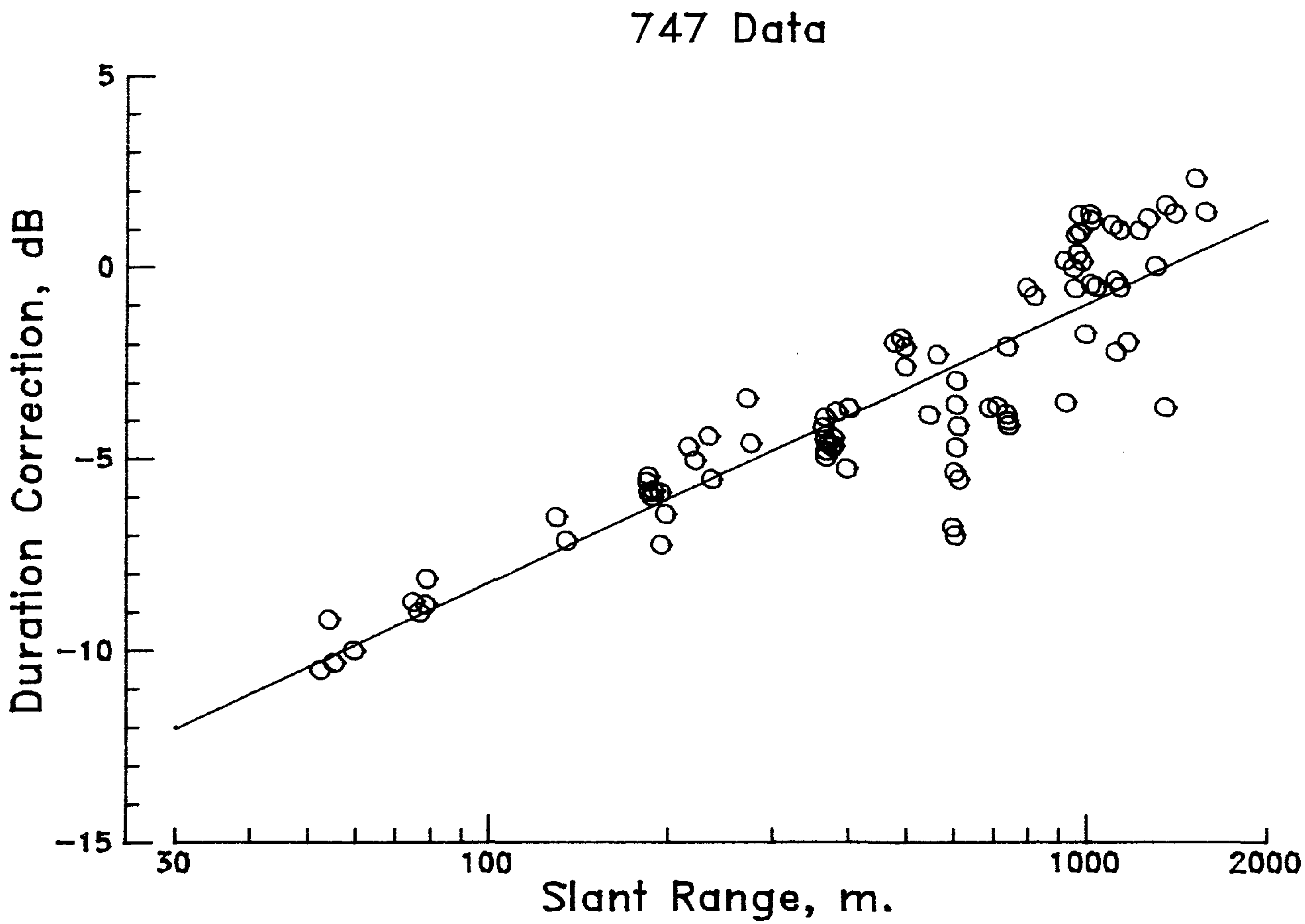
Slope = 8.4, σ = 1.1

Figure 1. 747 SEL results.



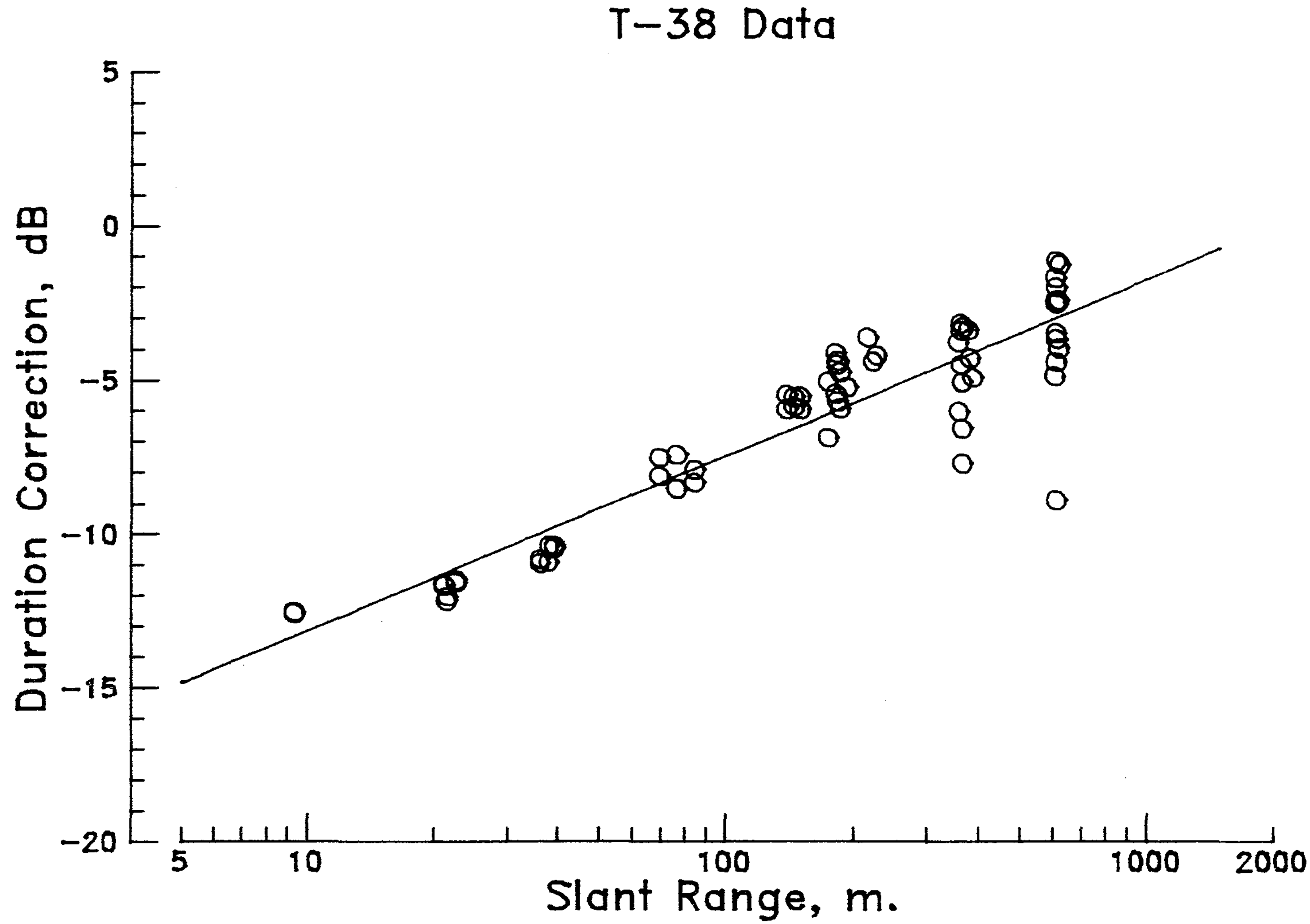
Slope = 5.5, σ = 1.3

Figure 2. T-38 SEL results.



Slope = 7.2, σ = 1.4

Figure 3. 747 EPNL results.



Slope = 5.7, σ = 1.3

Figure 4. T-38 EPNL results.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM 83214		

4. Title and Subtitle	5. Report Date
SEL and EPNL Noise Duration Coefficients for the 747 and T-38 Aircraft	September 1981
	6. Performing Organization Code 505-32-03-01
7. Author(s) William L. Willshire, Jr.	8. Performing Organization Report No.
9. Performing Organization Name and Address NASA Langley Research Center Hampton, VA 23665	10. Work Unit No.
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546	13. Type of Report and Period Covered Technical Memorandum
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

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17. Key Words (Suggested by Author(s))	18. Distribution Statement
Acoustic propagation Duration coefficient Aircraft noise	Unclassified - Unlimited Subject Category 71

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	11	A02

N-305

For sale by the National Technical Information Service, Springfield, Virginia 22161