COMMUNITY NOISE TECHNOLOGY NEEDS BOEINGS PERSPECTIVE

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COMMUNITY NOISE TECHNOLOGY NEEDS
BOEING PERSPECTIVE

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AIRPORT COMMUNITY ACCEPTANCE

Airport community acceptance of HSCT noise levels will depend on the relative noise levels to airplanes flying at the time of introduction. The 85 dBA noise contours for the range of large subsonic airplanes that are expected to be in service in the early 21st century are shown as a shaded area. A certifiable HSCT noise contour, as shown, would be somewhat wider along the runway but about the same in the residential areas downrange. An HSCT noise rule should insure this noise capability.

COMMUNITY NOISE

85 dBA FOOTPRINTS

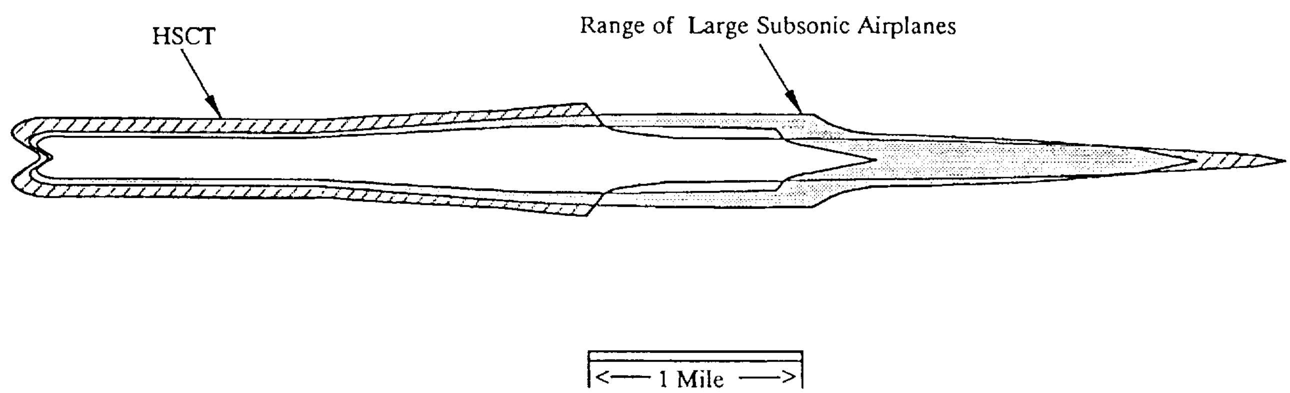

FIGURE 1

COMMUNITY NOISE SOURCES

Jet noise is the primary noise source at the sideline measuring point but at the downrange and approach measuring points burner noise is also important In addition turbine and air-frame noise are important sources during approach. Prediction accuracy for all of the sources and for noise reduction features, such as the jet exhaust noise suppression nozzle, will have a major impact on design features such as engine sizing.

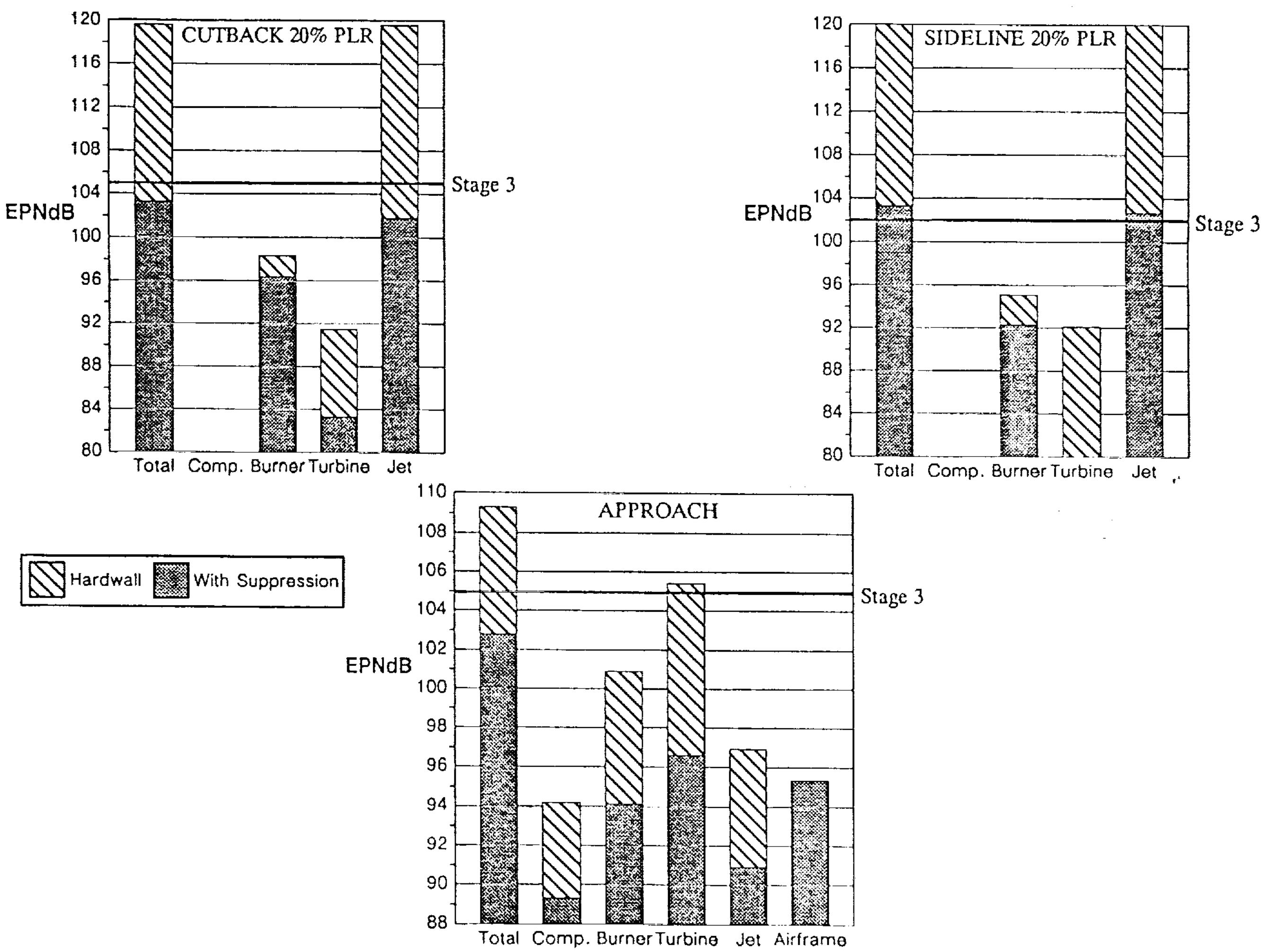

Figure 2 Noise Components Turbine Bypass Turbojet Engine

JET NOISE PREDICTION TECHNOLOGY

CURRENT PROCEDURES ARE :

* EMPIRICAL
* PREDICT UNSUPPRESSED JET ; ie, R–C
* PREDICT SPECIFIC SUPPRESSION CONFIGURATIONS

IDEAL PROCEDURE :

* ANALYTICAL PROCEDURE THAT PREDICTS ABSOLUTE LEVELS
* FLEXIBLE SUCH THAT SUPPRESSION DEVICES CAN BE SCREENED
* USES PREDICTABLE FLOW PARAMETERS OR RESULTS OF CFD MODELING

FIGURE 3

NFM NOZZLE PREDICTION VERSUS DATA

The basic low bypass ratio jet noise prediction program at Boeing is empirical and is for a round convergent (RC) nozzle. This program was used to predict externally generated noise based on the fully mixed stream and the internal noise from one of the primary nozzles using the aspirated flow as the free stream. The predicted noise levels are then added. Shock cell noise predicted for the primary nozzle is reduced by 7 dB to account for the convergent-divergent (CD) expansion of the primary nozzle.

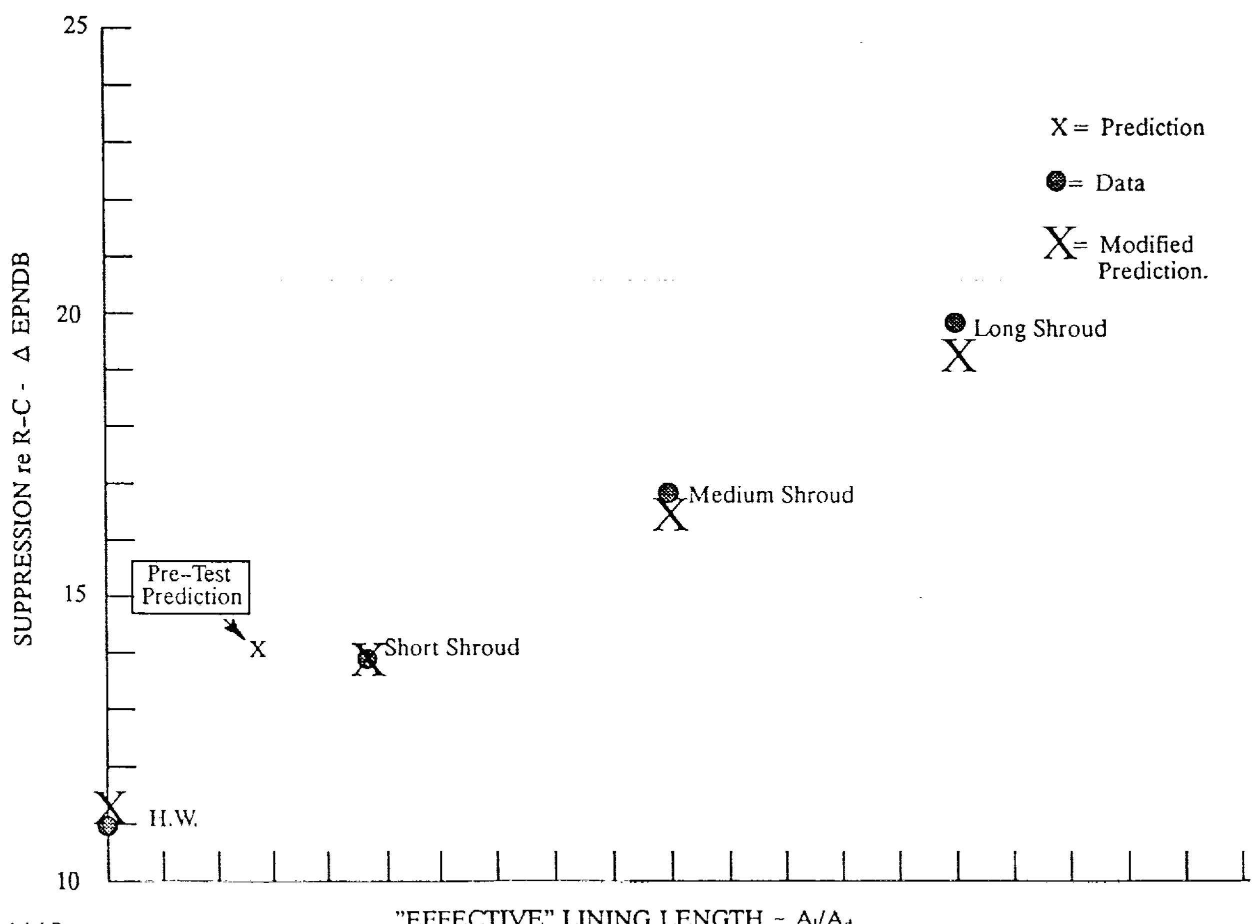

FIGURE 4. NFM NOZZLE PREDICTION VS DATA

JET NOISE PREDICTION PROCEDURE DEVELOPMENT

A computer prediction program is being developed at Boeing incorporating the recent nozzle test data modeling externally generated mixing noise, internally generated mixing noise and internal shock cell noise components. A status comparison to test data in the forward and aft arc are shown.

HSCT JET NOISE

SEMI-EMPIRICAL COMPONENT MODELLING TO GUIDE NOZZLE / AIRPLANE DEVELOPMENT

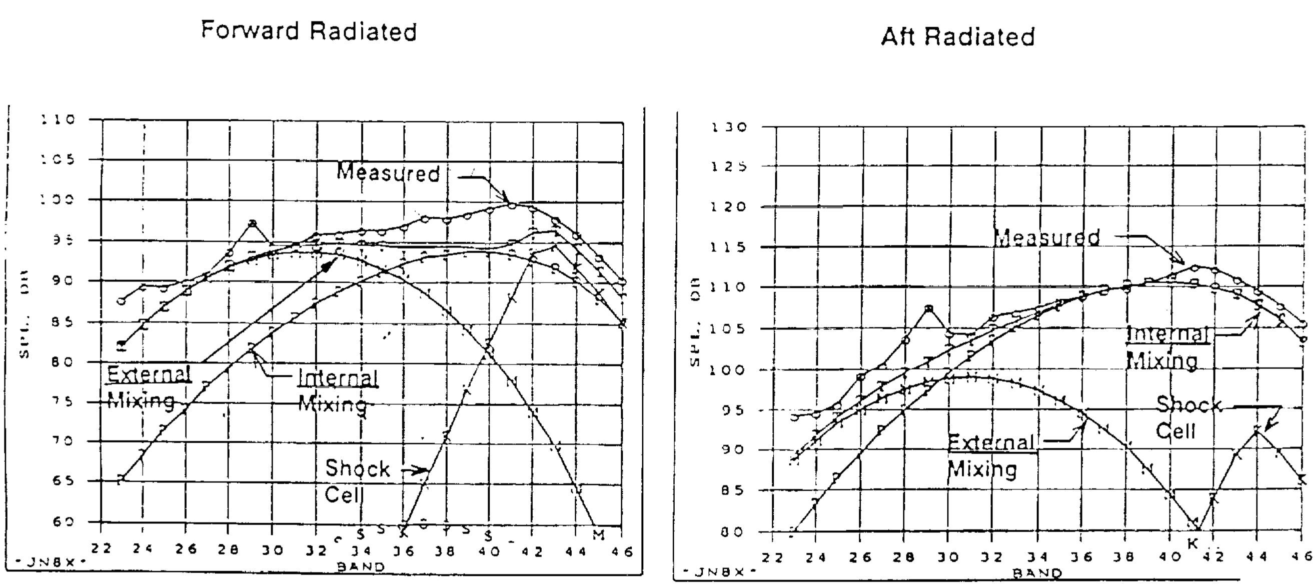

FIGURE 5

CROSS-CORRELATION STUDIES

Techniques are being studied to cross-correlate internal fluctuating jet velocities with far field sound pressure. If this is successful, noise source locations and their frequency characteristics can be determined inside the ejector. This would be useful in improving the mixer nozzle and ejector lining designs.

BOEING

APPLICATION OF CROSS CORRELATION TECHNIQUES

Present Opportunities for Better Understanding of Internal Noise Sources

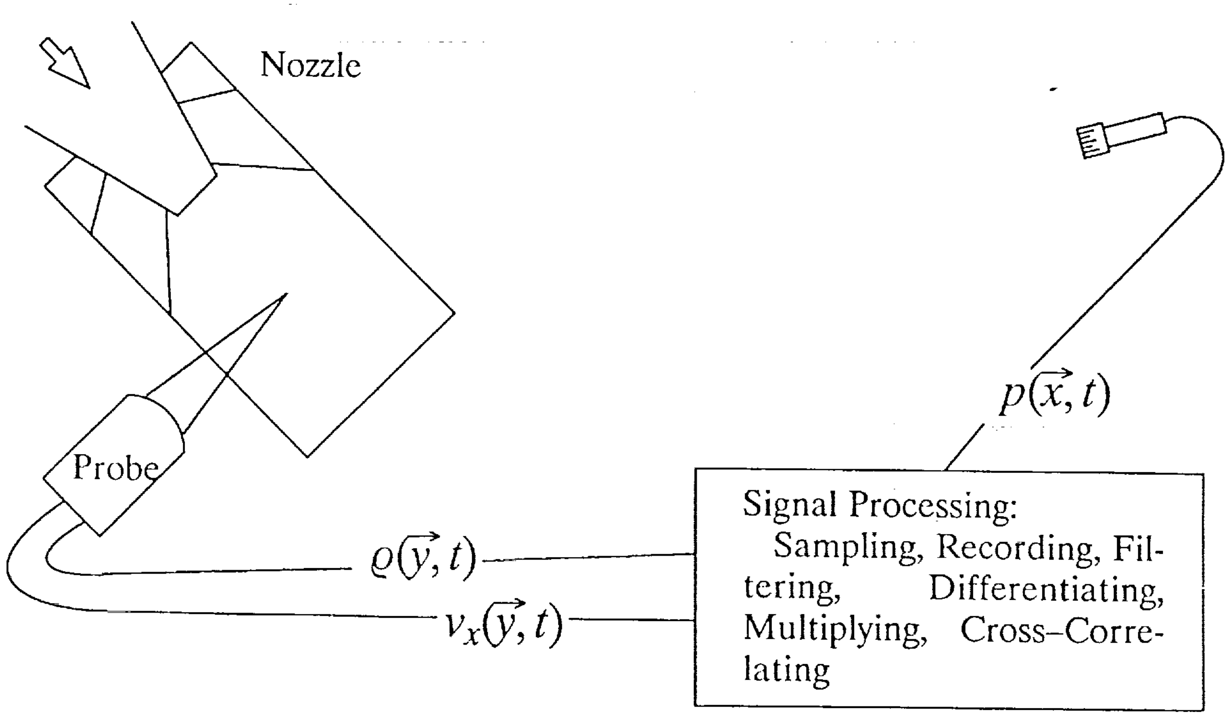

FIGURE 6

SIMULATED CROSS-CORRELATION RESULTS

In order to determine the number of samples (proportional to processing time) needed to obtain useful cross-correlation functions, a digitally simulated random test signal was buried in a noise signal and delayed. Resulting cross-correlations between the second derivative of the original test signal and the test and noise signal combination, are shown where the signal to noise ratio is about 10. The reducion in the variance in the correlation with increasing number of samples is evident. Frequency characteristics are obtained by fourier transforming the cross correlation.

SIMULATED CROSS-CORRELATION

Results – Time Domain – Noise > Signal

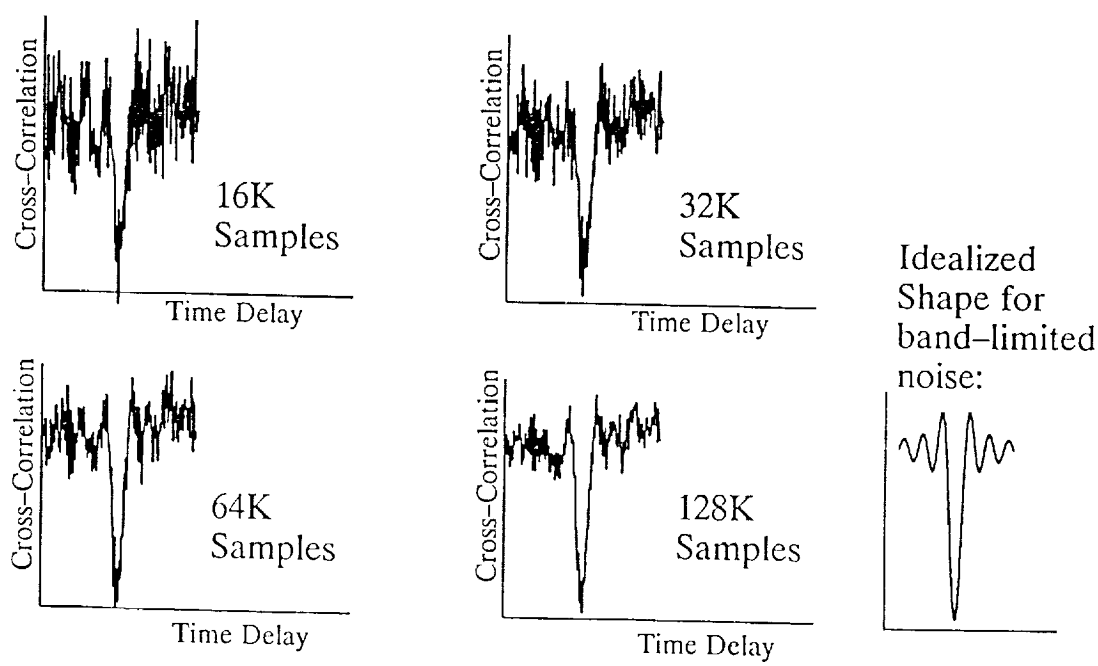

FIGURE 7

CFD AND NOZZLE DESIGN

Computational Fluid Dynamics (CFD) has the potential of being a very useful tool in nozzle design. Currently CFD is used to evaluate new designs, prior to fabrication, in order to find potential flow problems. Data gathered during wind tunnel testing is used to validate CFD modeling increasing confidence in the CFD results.

Comparison of Coarse and Fine Grid Pressure Contours

Flow Conditions: PR1=3.5, TR1=1.01, PR2=1.16, TR2=1.01, M_∞=0.24

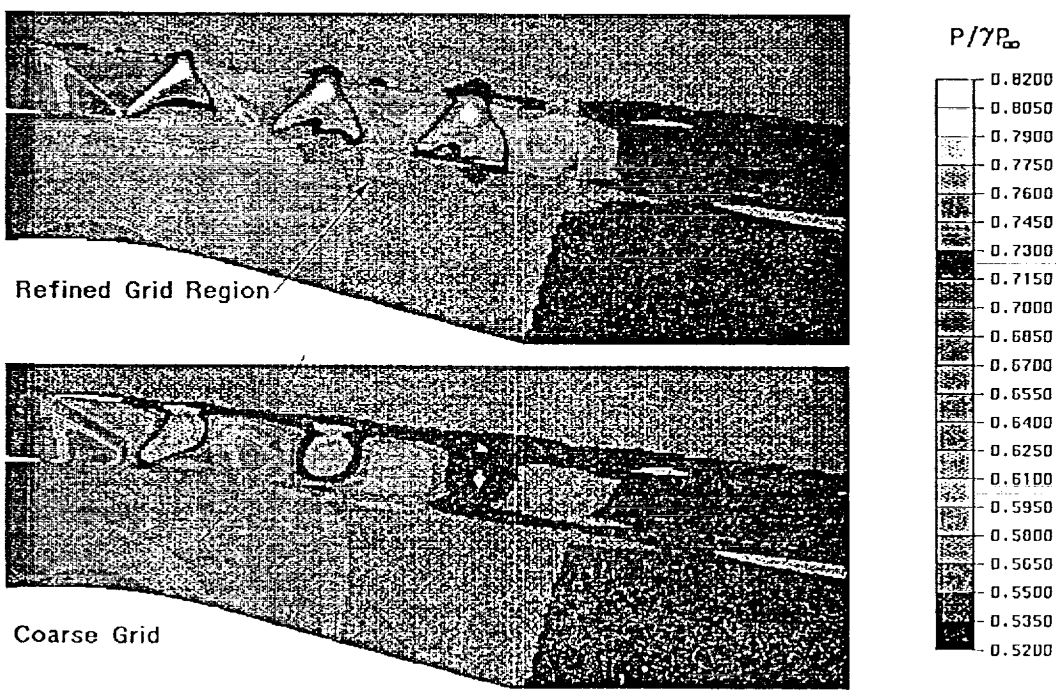

FIGURE 8

OTHER PREDICTION TECHNOLOGY NEEDS

SIDELINE SHIELDING AND GROUND REFLECTION / ATTENUATION

* CURRENT METHODS ARE BASED ON HBPR ENGINES AND SUBSONIC AIRPLANE CONFIGURATIONS

INSTALLATION EFFECTS

* EFFECT ON SUPPRESSION SYSTEM
* NOISE REFLECTION, ETC.

OTHER NOISE SOURCES

* TURBOMACHINERY
* BURNER NOISE (LOW EMISSION BURNERS)
* AIRFRAME NOISE

FIGURE 9

SIDELINE SHIELDING PREDICTION

Current sideline shielding prediction programs were developed using sideline noise measurements of 747 and 767 airplanes with the same engines. The shielding is then for high bypass ratio engines mounted off of the leading edge of the wing and with many configuration differences from current HSCT designs. There is currently little capability to accuratly predict shielding sensitivities to configuration layout changes.

Size Comparison

HSCT Versus 747-400

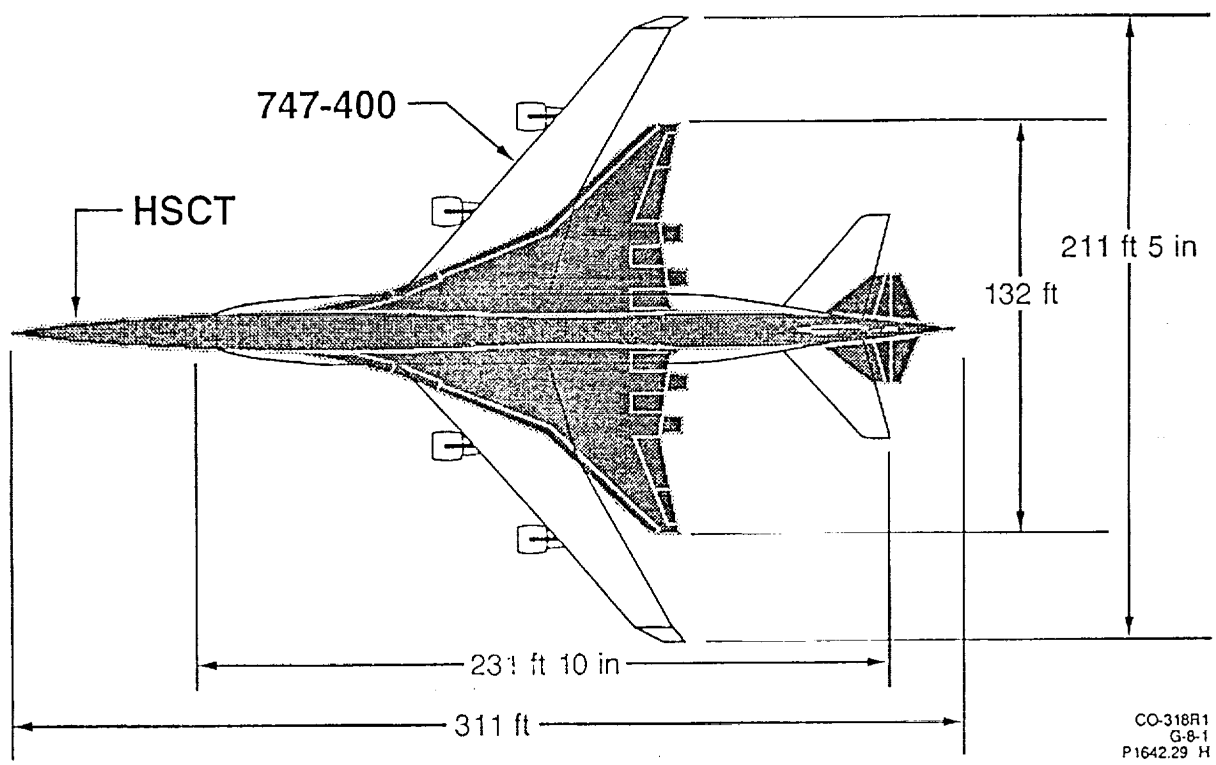

FIGURE 10

DESIGN MARGIN IMPORTANCE

A design margin on the order of 80% confidence will be required to launch an HSCT production program. The current status is less than 50% with a one sigma variation of 5. To reach 80% confidence will require improvements in the airplane, such as an improvements in the jet suppression nozzle, but will also require improved prediction capability to reduce the variation.

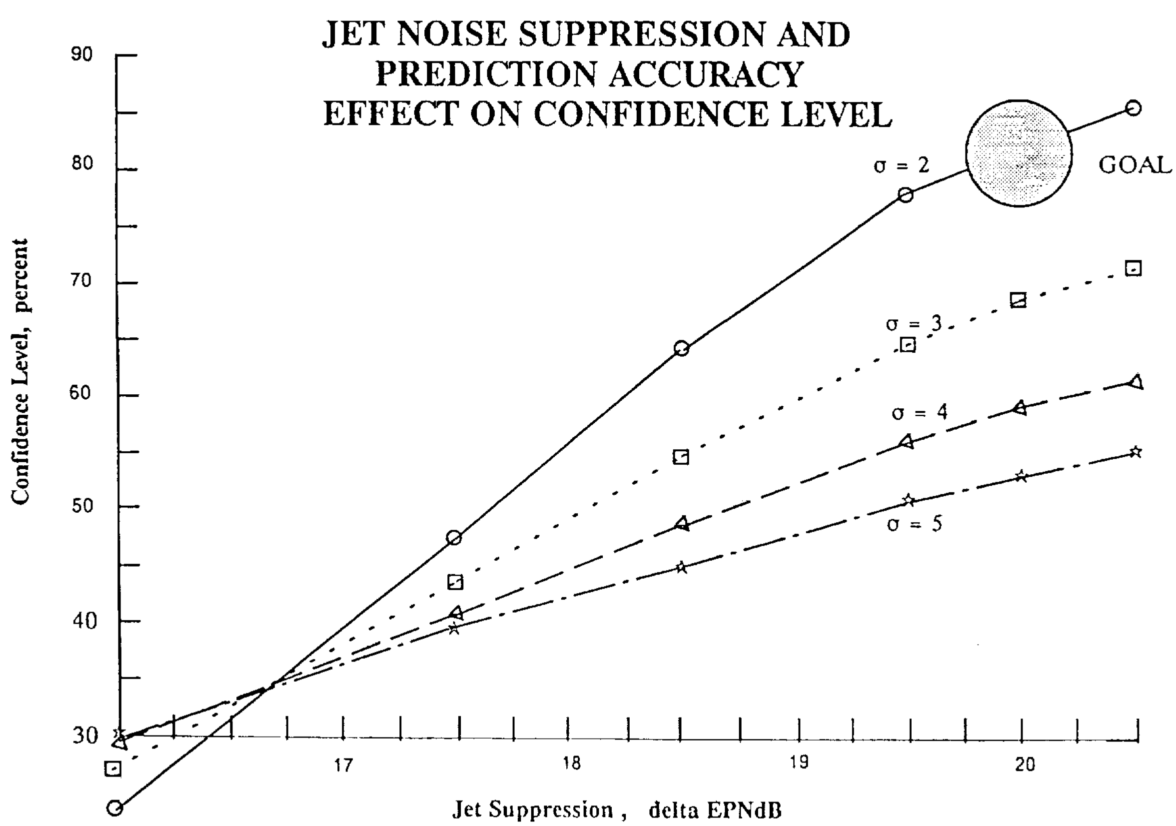

FIGURE 11

PREDICTION UNCERTAINTY SOURCES

Prediction uncertainty includes the uncertainty of each of the contributing noise sources (A–D). The total accumulated measurement variation includes (E) the single test variability (data scatter) but also (F) any true error (bias). To improve the total prediction to demonstration uncertainty (G) each noise source prediction procedure should be evaluated for accuracy and improved if possible. Improvements in prediction of propagation, installation effects, shielding, ground reflection and airplane performance will also be required.

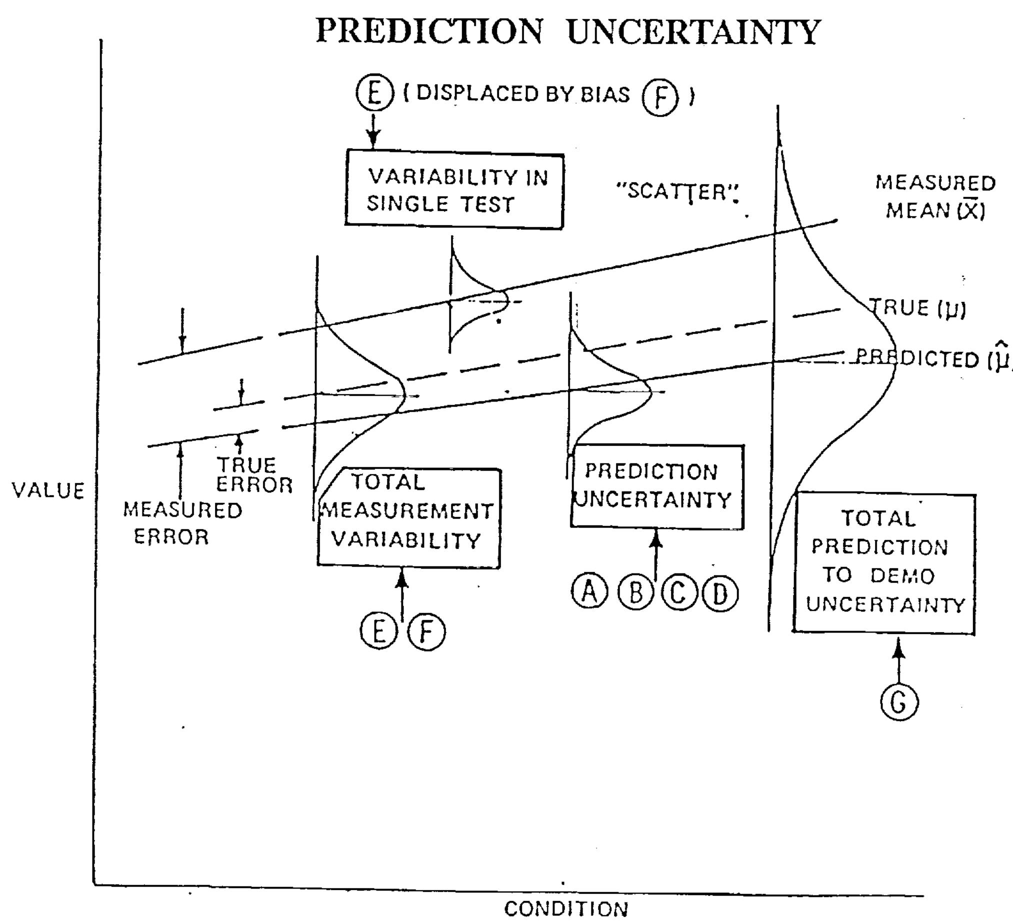

FIGURE 12

CONCLUSIONS

* JET NOISE PREDICTIONS ARE PRIMARILY EMPIRICAL AND PREDICT TESTED NOZZLE CONFIGURATIONS.

* FLEXIBLE AND MORE ANALYTICAL PREDICTION PROCEDURES ARE NEEDED THAT ACCURATELY PREDICT ABSOLUTE LEVELS.

* ALSO, IMPROVEMENTS ARE NEEDED IN PREDICTION PROCEDURES FOR THE OTHER NOISE SOURCES TOGETHER WITH IMPROVEMENTS IN INSTALLATION EFFECTS, SIDELINE SHIELDING AND GROUND REFLECTION PREDICTIONS.

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