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VIBROACOUSTIC STUDY OF THE NASA GODDARD SPACE FLIGHT CENTER OSS-1 PAYLOAD

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Contract NAS5-25156

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16. Abstract

A database management and prediction system named VAPEPS (Vibroacoustic Payload Environment Prediction System) has been developed for the vibration and acoustic data obtained from Space Shuttle payload components. The software of this database management system is used to predict the environment of a Shuttle payload. This prediction is then compared with empirical observations made during an acoustic ground test. The study includes an investigation of previous findings to the effect that flight induced random vibration response is more severe than that which occurs during ground testing.

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PREFACE

This report evaluates the possibility that the Shuttle payload flight vibration environment can exceed the corresponding environment induced during an acoustic ground test. Included is a study of an analytically predicted versus the empirically observed random vibration response of a shuttle payload; this study makes use of the software provided by the VAPEPS (Vibroacoustic Payload Environment Prediction System) database management system.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont)

ILLUSTRATIONS

TABLES

1.0 INTRODUCTION

This report presents a comparative evaluation of Shuttle liftoff and ground test random response data that was obtained from the Office of Space Science -1 (OSS-1) pallet payload (Figure 1.1) flown in the cargo bay of STS-3. This study was initiated by NASA Goddard Space Flight Center (GSFC) to evaluate the possibility that the payload flight vibration response can exceed that occurred during an acoustic ground test when the ground test acoustic excitation is normalized to the flight acoustic environment. Included in this study is a comparison of a VAPEPS (Reference 1) predicted environment for the OSS-1 payload with respect to that observed during ground test.

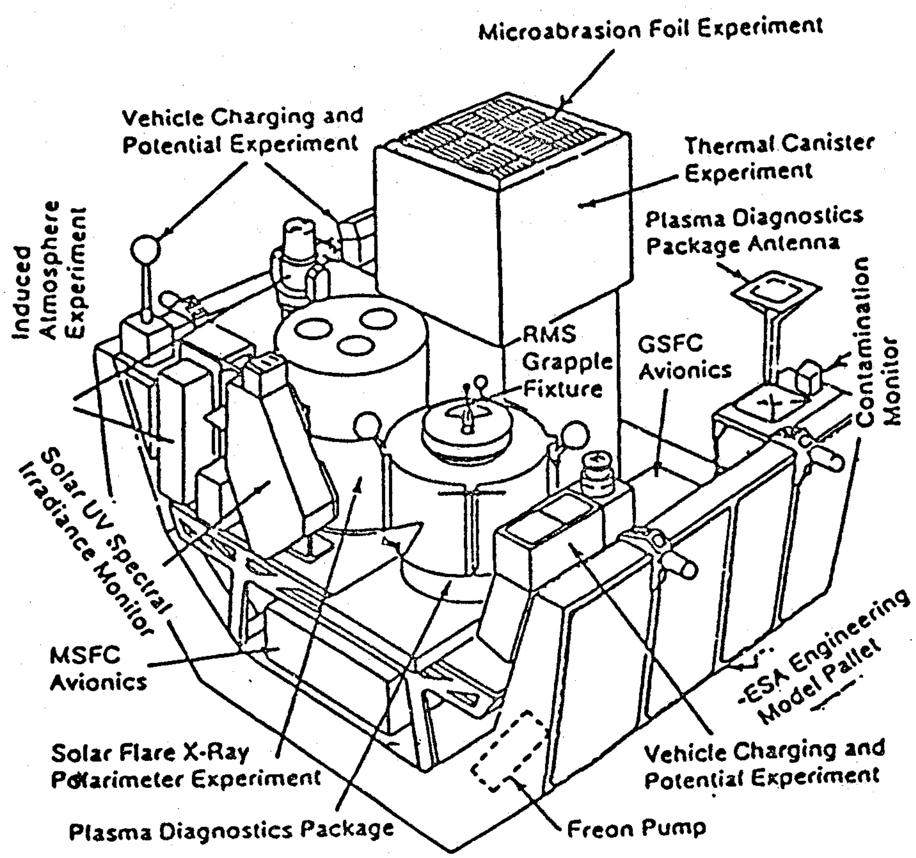


Fig. 1.1 OSS-1 Payload Configuration

2.0 A STUDY OF OSS-1 RANDOM VIBRATION RESPONSE DURING LIFTOFF AND GROUND TEST

This section of this report presents the results of an investigation into the possibility, first noted in an earlier study (Reference 2) that: (1) Shuttle payload components may be receiving a significant amount of mechanically transmitted energy that appears to be originating at the orbiter-payload interface and (2) If an exact simulation of the Shuttle Cargo Bay acoustic spectrum is used during a ground test performed in a reverberant chamber, the acoustic induced random vibration response of payload components will be more severe in flight than the corresponding response induced during the ground test. This later situation is contrary to expendable launch vehicle experiences. Further, it is undesirable with respect to existing ground test philosophy that ground tests should induce payload/component responses at least equal to that experienced during service. Recommendations are made as to how a test program could be structured to partially accommodate this test philosophy.

Included in this study is the result of a similar and confirming experience of another payload flown on the Shuttle. While there exists a considerable degree of uncertainty concerning the Shuttle vibroacoustic environment, making it difficult to set perceptive tailored payload and payload component design and test requirements, the experience to date does not suggest that this environment is any more severe than that typically encountered by expendable launch vehicle payloads.

2.1 Comparisons of Liftoff and Ground Test Data

The liftoff and ground test random vibration data used in the study were the data from one-third octave band analyses as processed and supplied by GSFC. The ground test acoustic data were also similarly processed and supplied by GSFC, the Shuttle flight data, however, was processed and supplied by Lockheed Missiles and Space Co. (LMSC).

During data processing it was noted that the signal to noise ratio of the data on the Shuttle flight tapes was very low at frequencies above approximately 800 Hz. Corrections were made. However, because uncertainties still remained, this high frequency data was not used.

The ground test acoustic spectrum used in this study is the spatial average of the data obtained from the six microphones that controlled the reverberant chamber in which the ground test was performed, see Reference 2 for details. The Shuttle flight acoustic spectrums that were used are the spatial average and maximum values of the data obtained from microphones located in the immediate vicinity of the payloads flown on Shuttle flights STS-2 thru STS-4.

Figure 2.1 is typical of the twelve one-third octave data sets that were received from GSFC for analysis. Clearly there are a number of points within the frequency spectrum between 31.5 Hz and 2000 Hz where the measured flight data is higher than that measured during the ground test. It should be noted that the flight and ground test measurements were made at identical locations on the OSS-1 structure. The corresponding acoustic excitation that produced this response is presented in Figure 2.2. An examination of the figure indicates that the spatial average ground test acoustic excitation levels are at least 5dB higher than the corresponding excitation encountered in flight. In fact, the maximum acoustic excitation believed to have been experienced in flight by the OSS-1 payload is significantly less than the spatial average value of the ground test reverberant chamber acoustic field. This latter statement is true except between 50 Hz and 100 Hz where these acoustic spectrums are about the same value. Based on these comparisons it appears that an exact simulation of the Shuttle cargo bay acoustic field during a ground test would not produce the desired random vibration response and would represent an under test with respect to the flight condition. The question then is, just how much of an under test does testing with a reverberant acoustic field represent; and, knowing this, how should test requirements be specified to cater to this situation?

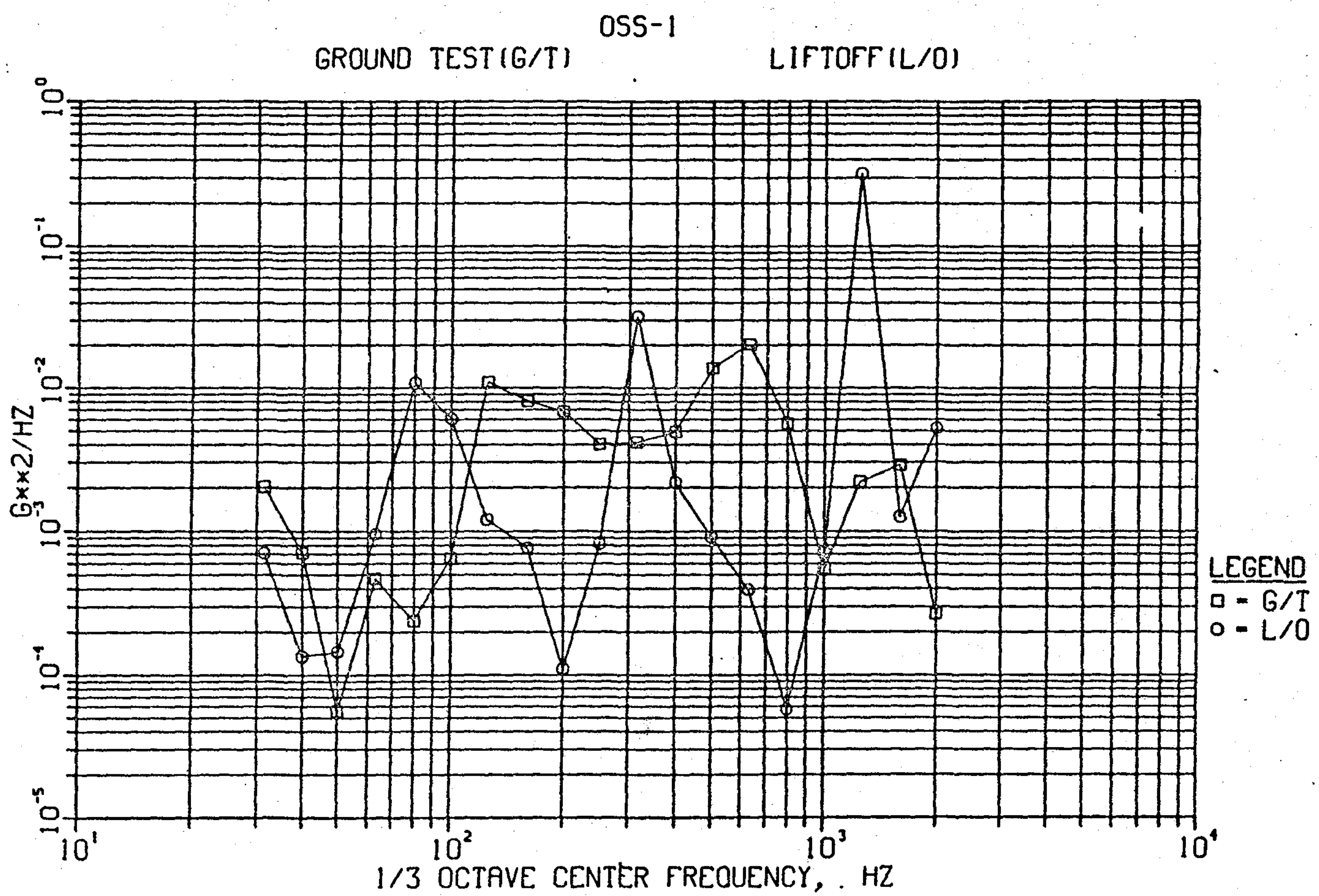


Fig. 2.1 Ground Test and STS Vibration Comparisons

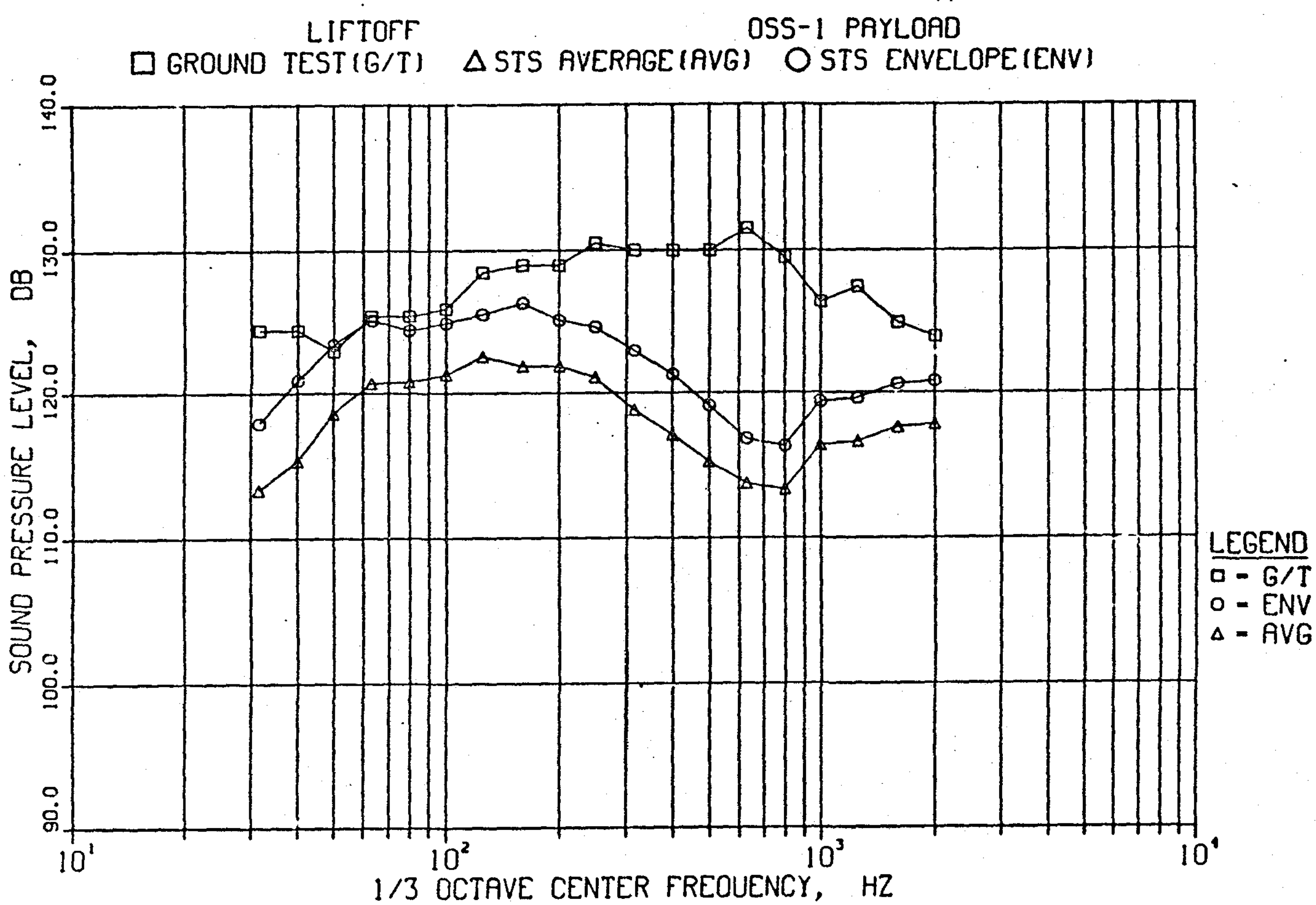


Fig. 2.2 Ground Test and STS Acoustic Comparisons

2.2 Evaluation Of Liftoff And Ground Test Data Discrepancies

The magnitude of the under test described above was quantified in the following manner: (1) The ground test one-third octave response spectra processed from each random vibration measurement was normalized to account for the differences between the acoustic ground test spatial average acoustic levels and the corresponding spatial average levels of flight. (2) A flight to normalized-ground-test ratio was then obtained for each one-third octave reponse spectrum value. This was done for each measurement made. This operation resulted in twelve such ratios for each one-third octave value between 31.5 Hz and 800 Hz. (3) The average value of these one-third octave ratios was then obtained and expressed as a dB value; a positive value indicates the magnitude of the under test involved. The results one obtains concerning the magnitude of this under test does depend on the acoustic spectrums used to normalize the response data. Therefore, to obtain a measure of the minimum discrepancy between liftoff and ground test reponse values, the above operation was repeated by normalizing to the maximum acoustic excitation believed to have been encountered in flight by the OSS-1 payload. The results obtained from these analyses are shown in Figure 2.3. Presented in Figure 2.4 are the results of a corresponding analyses performed on another payload.

The data shown in Figures 2.3 and 2.4 confirm the general finding of the Reference 2 study; namely, an exact simulation of the Shuttle cargo bay acoustic field during a ground test will not excite a response of payload structure/components as high as that expected to be encountered in flight. The reason(s) for this situation is not well understood at present. It could be due in part to differences in the coherence characteristics between the two acoustic fields; or, possibly due in part to mechanical energy being transmitted from the side rails and trunnion fittings of the Shuttle. This latter energy source was not simulated in either of the ground test studied; and therefore, at the present time is considered the most likely source of the noted discrepancies. Whether the source of this energy is due to the

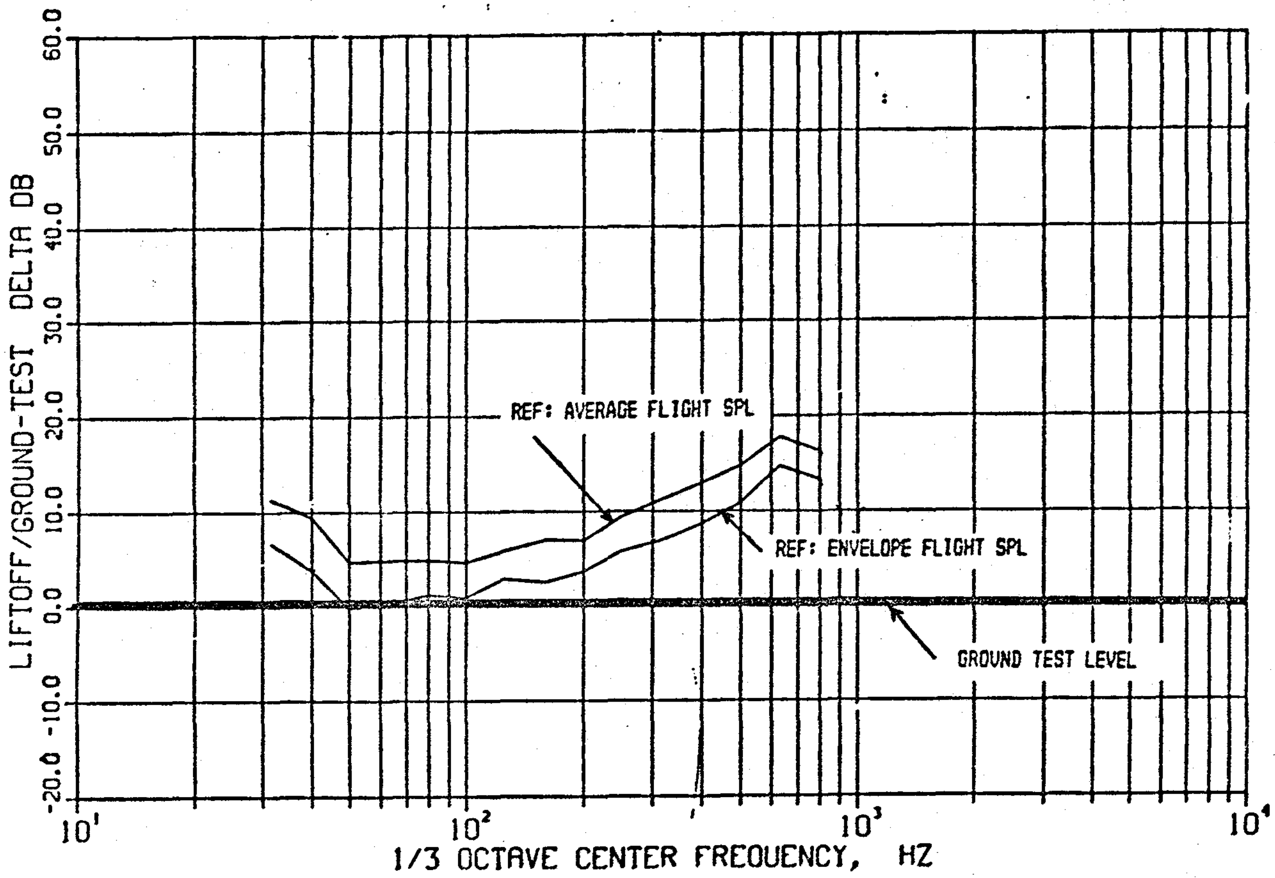


Fig. 2.3 Comparison of STS-3 Flight and Ground Test Data, OSS-1 Payload

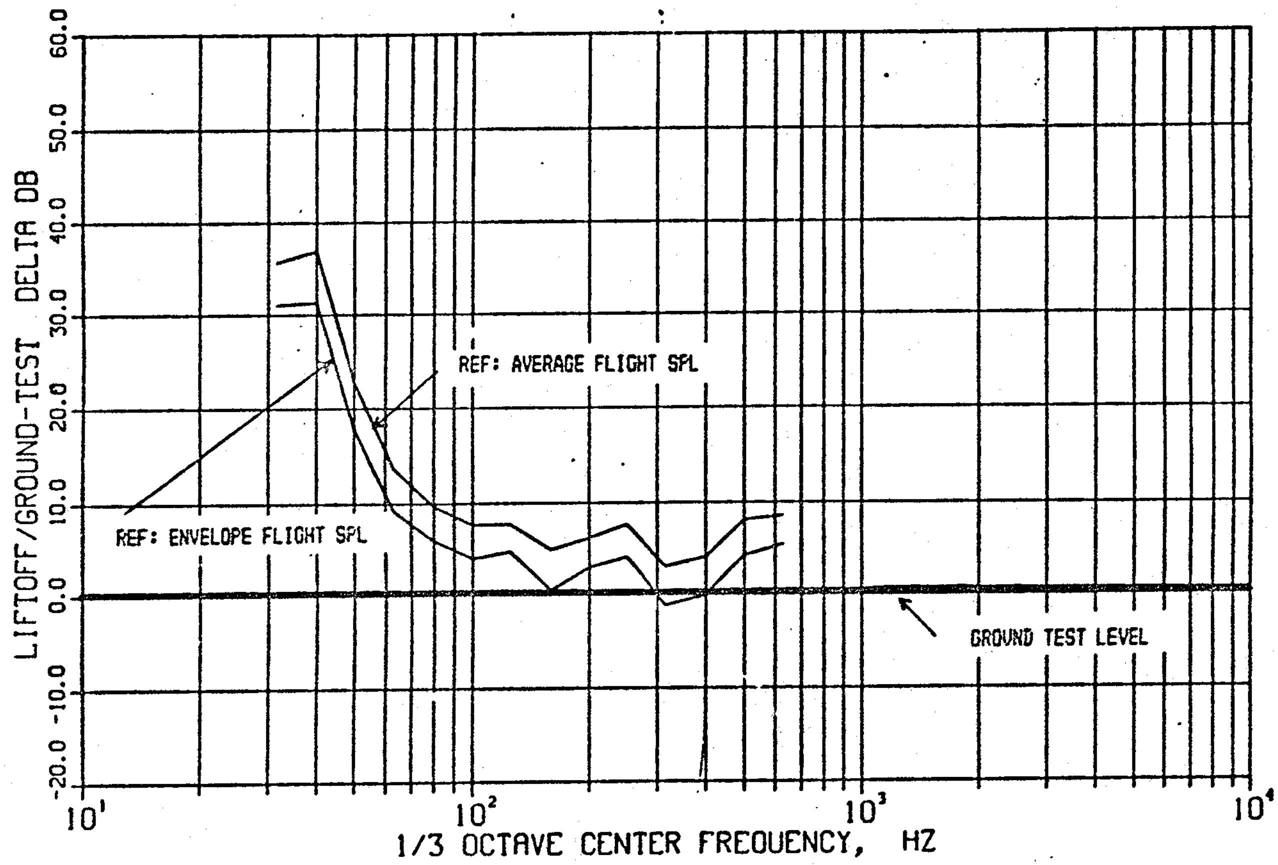


Fig. 2.4 Comparison of Flight and Ground Test Data, Another Payload

liftoff inertial loads, or the external acoustic field coupling with the cargo bay structure/skins, and then mechanically transmitting this energy to the payload was not and could not have been investigated as part of this study using the data supplied. However, because of the launch time period at which most of this data was obtained, it is believed that the response due to the liftoff inertia excitation has decayed to an insignificant value. Therefore, the response data used in this study represents that due to acoustic coupling of one form or another.

It is observed in Figures 2.3 and 2.4 that while all the data is positive, indicating an under test, the general magnitude and trends of the data are not really that similar. Not enough was known about the dynamic characteristics, among other things, of the two payloads to account for the differences shown. Also, it should be noted that other than being positive, the OSS-1 trends shown in Figure 2.3 are not too similar to the corresponding trends reported in Reference 2. As previously mentioned, the results one obtains regarding the magnitude of the discrepancies between flight and ground test acoustic induced random vibration response will depend on the flight spectrum used to normalized the ground test data. The approach used in this and the referenced study was not quite the same which probably accounts for the difference in trends. The appropriate normalization procedure would depend on understanding the acoustic versus mechanical coupling characteristics within the OSS-1 payload which was not sorted out in either study.

2.3 Design And Test Recommendations

It is recommended that system level ground acoustic tests be performed using the best simulation possible of the internal cargo bay acoustic field expected to be encountered in flight. Trying to account for the higher response levels expected in flight by increasing the system level ground test acoustic levels is not recommended for the following reason. At present it is suspected that it is the mechanical energy being transmitted by the cargo bay side rails that is causing the higher response levels observed in flight. If so, then the payload structure/component response characteristics due to this type of excitation will appear as due to a distributed inertia loading. The response due to distributed inertial loads can be totally different from the forced loading of an acoustic pressure field. Therefore, acoustic ground test where the excitation levels have been arbitrarily increased to try to account for the higher response levels expected in flight may cause unwarranted problems with payload structure/components only susceptible to direct acoustic excitation.

Reference 3 is a study to develop a procedure accounting for the structural borne vibration received by Shuttle payload components. This study found that this excitation could be accounted for by keeping payload component random vibration design and test requirements at or above .03 G**2/Hz below 180 Hz. It is recommended that payload components be designed and tested accordingly except that the heavier payload components/ subassemblies, approximately 50 lbs or heavier, be assumed to have a response limit of .1 G**2/Hz. This response limit value is considered appropriate based on a review of the data provided in Reference 3.

The above recommendations pertain to low frequency structural borne vibration which may be generated at the Shuttle side-rails/trunnion fittings and transmitted to payload components. How to account for the higher frequency aspects of this environment, even if it is necessary at all, remains to be established. Also, added to the random vibration levels given above should be the payload dependent environment due to direct coupling with the internal acoustic field of the cargo bay.

2.4 Future Studies

Studies are required to develop a measurement program that will provide data to understand the differences observed between the random vibration induced in Shuttle payloads during ground test and the corresponding environment observed in flight. These studies must first include the development and investigation of analytical models of one or more plausible physical situations that would support the phenomenon observed. Such studies are necessary to: (1) determine the appropriate/best location of the acoustic and vibration transducer used in any measurement scheme and (2) support the interpretation of data obtained from these measurements. An empirical program without such analytical support will not provide data to understand the phenomenon, except to know what occurred on a given flight, on a given payload, etc. The desired extrapolation to other Shuttle flights and payloads will not be possible. This is the situation that the aerospace community now finds itself in with respect to the Shuttle vibroacoustic measurement program as it has been structured to date.

3.0 OSS-1 PAYLOAD VIBRATION - PREDICTION VERSUS MEASUREMENT

The OSS-1 payload has been modelled for Statistical Energy Analysis (SEA). The SEA computation is performed with the VAPEPS prediction software. The predicted vibration are compared with the measured data obtained during the system level acoustic tests performed in the 40,000 cubic foot test chamber at the NASA/GSFC in Greenbelt, MD (Ref 4 and 5). The comparison are made for different zones on the payload, as defined by Ref 2.

3.1 Payload Modelling

Figures 3.1 and 3.2 show the OSS-1 payload configuration. Various experimental hardwares are mounted on the pallet. During the system level acoustic test, the pallet is suspended in the air with cables from an overhead crane. There is no mechanical energy transmitted into the pallet payload. The acoustic field around the payload is the only energy source. The pallet is a structure with a frame and face panels. It is a good acoustic energy receiver. Appropriate SEA models are made for different "zones" of the pallet payload in order to make meaningful comparison with the measurement. The zones are classified in page 15 of Ref 2. Zone 1 is defined as the payload primary structure within the proximity of the payload-orbiter vehicle separation plane. Zone 2 is the payload primary and secondary structure (exclusive of mounting brackets) not included in zone 1. Zone 3 is the payload structures specifically designed for mounting of components such as shelving, platforms, or brackets. Zone 4 is the payload large surface area, lightweight structures at outboard areas which respond primarily to acoustic pressure forces. Due to the availability of structural parameters, Zone 2 and Zone 4 are modelled as shown in Figure 3.3. Because the random response predictions are made in the normal direction, only normal measurements of high-frequency accelerometers are of interest.

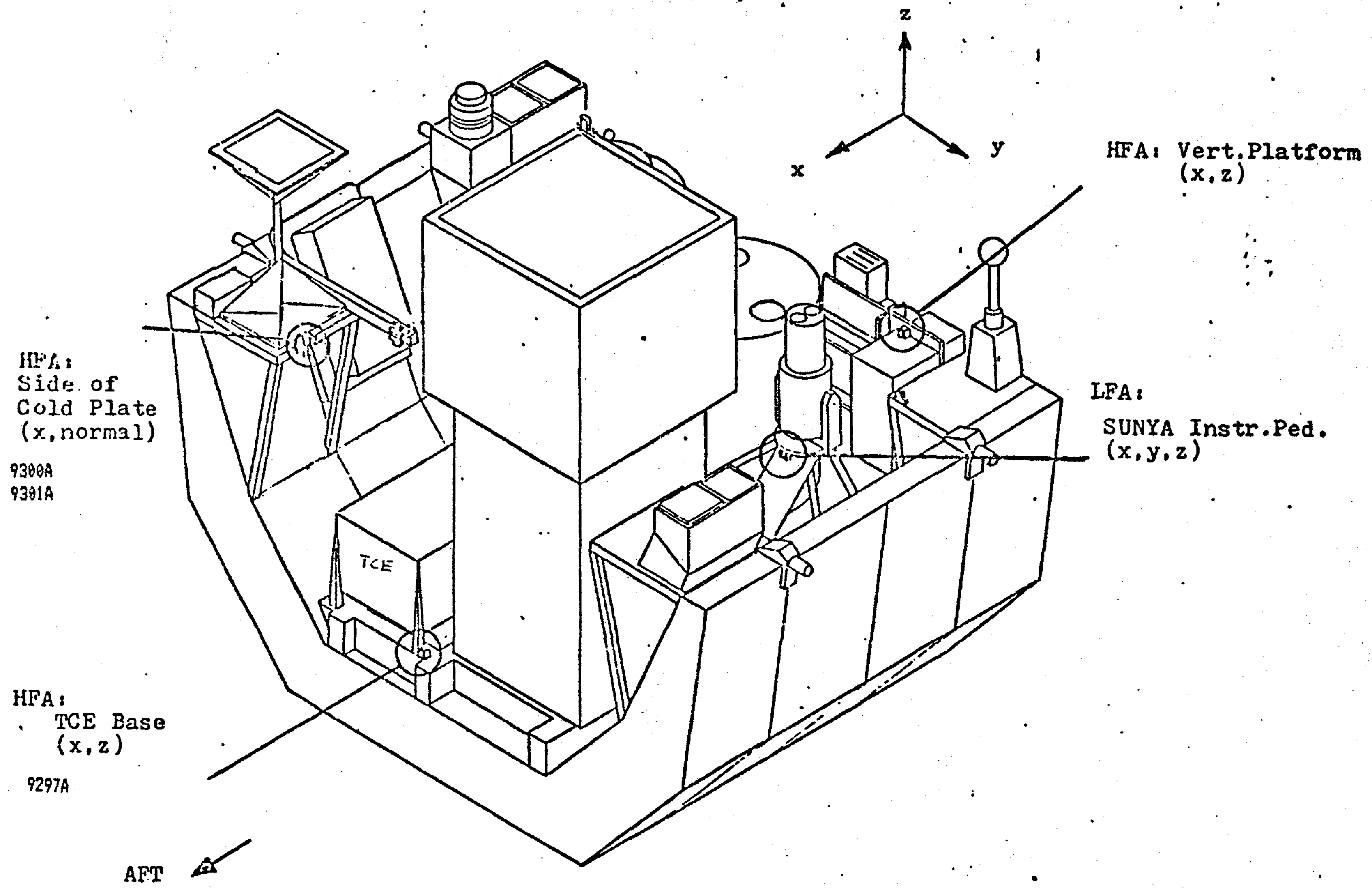


Fig. 3.1 OSS-1 Pallet Payload Transducer Locations

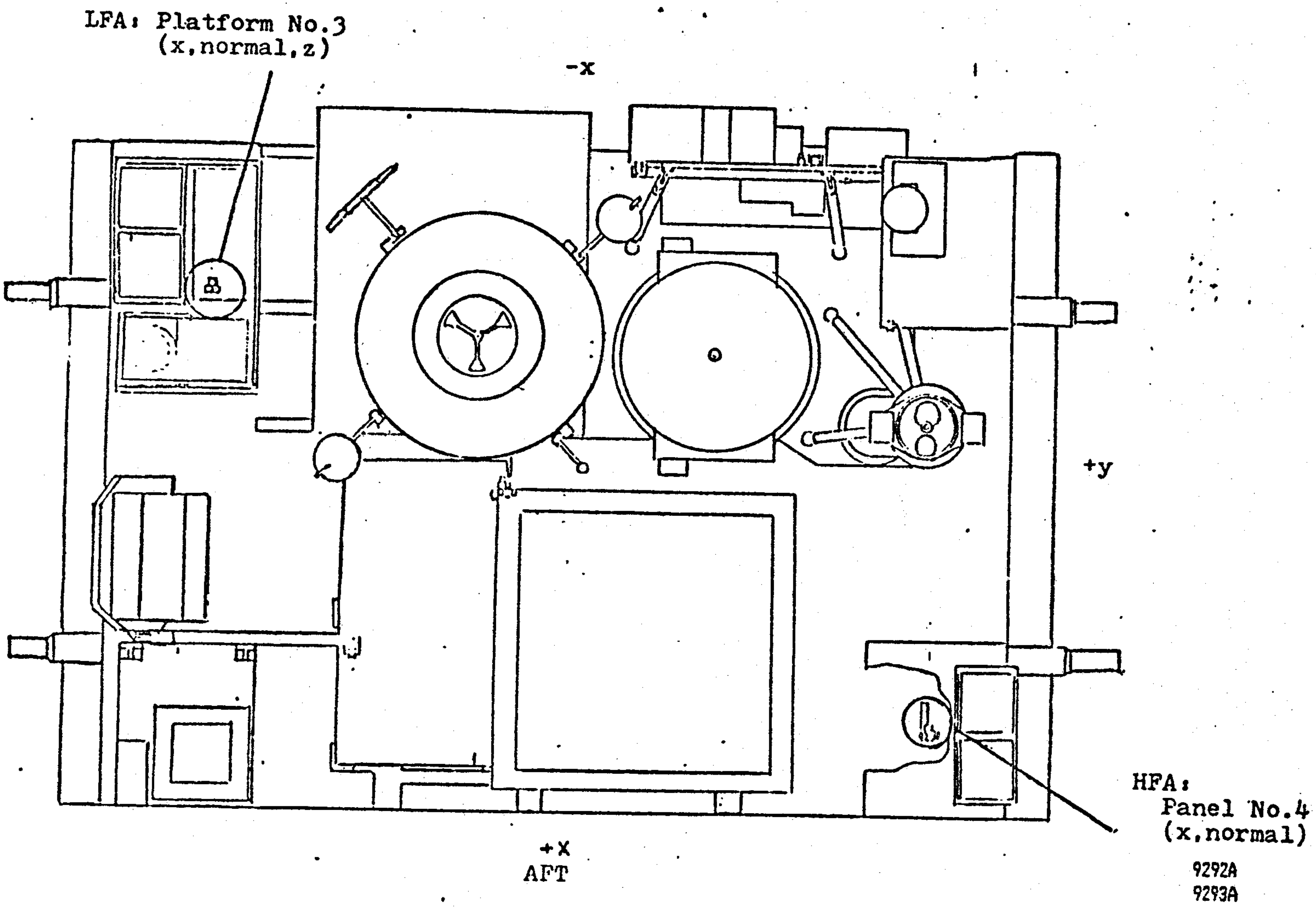


Fig. 3.2 OSS-1 Pallet Payload Transducer Locations (Plan View)

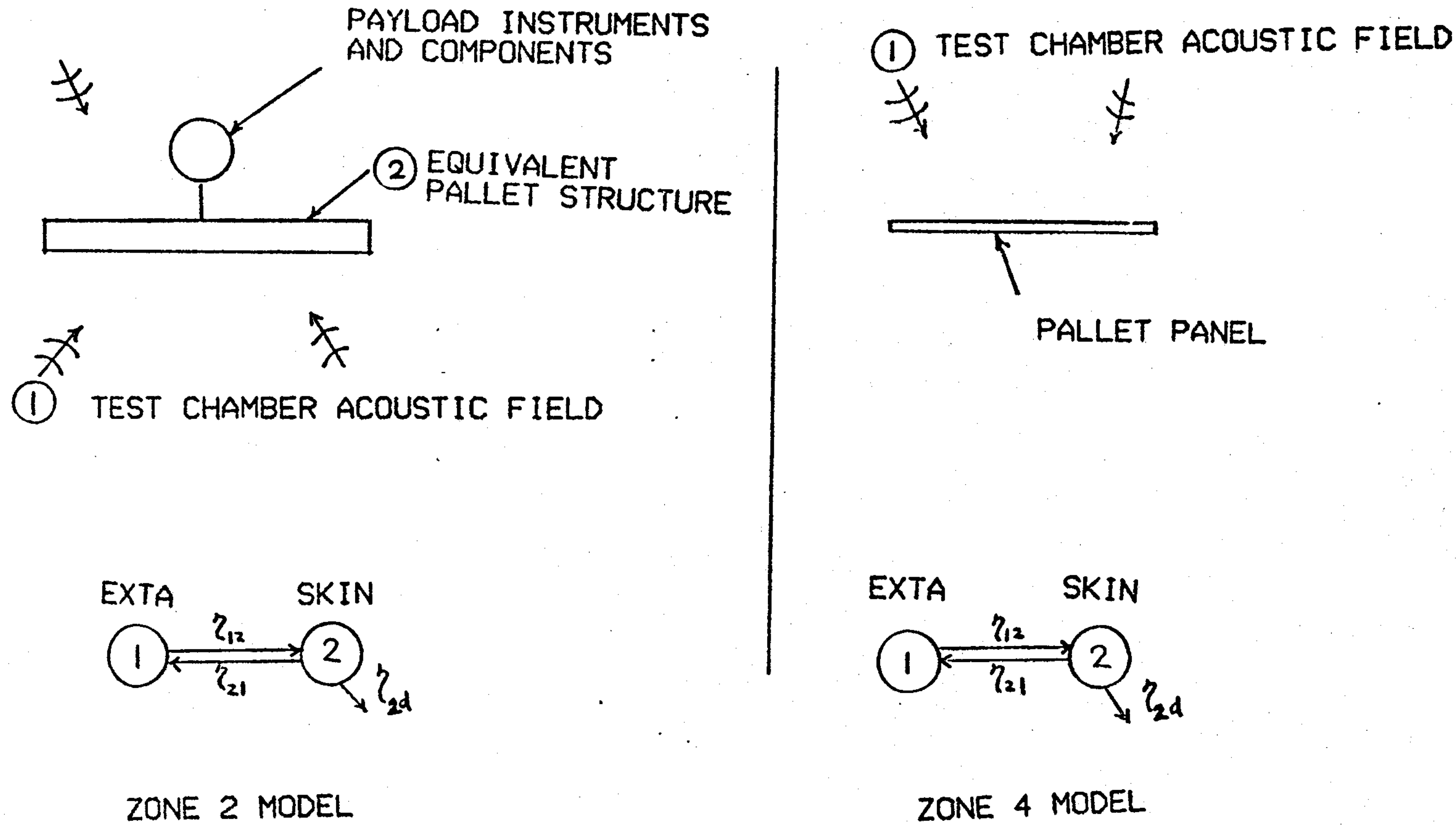


Fig. 3.3 Statistical Energy Analysis Model of Zone 2 and Zone 4

Zone 2 Model

The overall pallet payload is modelled as an equivalent plate with all payload experiments as the non-structural mass loading. The pallet structure consists of inner panels, outer panels and many stiffeners in-between. The equivalent plate has the same surface width and length, structural stiffness (EI), surface mass density, and structural longitudinal wavespeed, as those of actual pallet. The critical frequency is therefore matched. The derivation of equivalent plate is obtained by using the computer program PLATE which is a part of VAPEPS software (Ref 1). The derived equivalent pallet properties are shown in Table 1.

There are 24 inner panels of the pallet. The average dimension of each panel is 38.1 inch by 27.5 inch. It is of honeycomb construction with aluminum face sheets. Table 2 shows the structural parameters of the honeycomb panel and those of the equivalent panel. From Table A-2 of Ref 4, the total weight of pallet primary fittings, secondary fittings, hardpoints and keel fittings are 290 lbm. If we assume this weight is non-structural mass uniformly distributed on all 24 inner panels, then the surface mass density of equivalent panel is increased from original 1.382×10^{-5} to 4.369×10^{-5} $lb_f - sec^2/in^3$. Based on this value and other equivalent parameters listed in Table 2, the panel fundamental frequency with simply supported boundaries is calculated to be about 90 Hz. This is the (split) frequency in our model. Below this frequency, the whole pallet structure vibrates as a unit. The equivalent pallet parameters in Table 1 should be applied. Above this frequency, the individual panel of pallet vibrates independently with the stiffeners as the boundaries. The parameters of the inner panel in Table 2 are used as the pallet parameters in this frequency range.

All payload instruments and components are modelled as non-structural mass attached to the equivalent pallet. From Table A-2 of ref 4, the total integrated pallet weight is 6807 lbm. From Table 1 of this report, the total mass of the equivalent pallet structure is 418 lbm. The difference of 6389 lbm is considered as non-structural mass.

Table 1 STRUCTURAL PARAMETERS OF EQUIVALENT PALLET STRUCTURE

size = 228.6 inch x 110.0 inch

ρ_m = 2.025×10^{-6} lb_f $-sec^2/in^4$

H = 20.01 inch

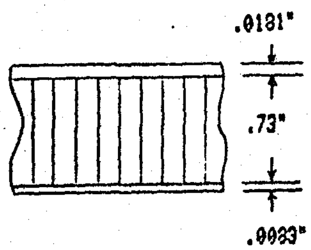
ρ_s = 4.052×10^{-5} lb_f $-sec^2/in^3$ (skin and stiffeners)

ρ_s = 2.821×10^{-5} lb_f $-sec^2/in^3$ (skin only)

E = 7.820×10^4 psi

Total mass = 418 lbm

Table 2 STRUCTURAL PARAMETERS OF PALLET INNER PANELS



Face sheet

$E = 10^7$ psi
$\rho_m = 2.59 \times 10^{-4}\ lb_f - sec^2/in^4$

Honeycomb

$E = 0$
$\rho_m = 9.562 \times 10^{-6}\ lb_f - sec^2/in^4$

Equivalent parameters

$\rho_m = 1.644 \times 10^{-5}\ lb_f - sec^2/in^4$
$H = .8409$ inch
$\rho_s = \rho_m \times H = 1.382 \times 10^{-5}\ lb_f - sec^2/in^3$
$E = 6.346 \times 10^5$ psi

The sound pressure level (SPL) around the OSS-1 pallet payload is measured by the control microphones. The averaged SPL in 1/3-octave bands can be found in ref 2 and listed in Table 3. During the acoustic test, both inner panels and outer panels of the pallet structure are exposed to the acoustic field. Double-sided excitation must be applied to the equivalent pallet structure.

The VAPEPS prediction software is applied in response calculation. A two-element Statistical Energy Analysis (SEA) model is used, with the test chamber acoustic field as the EXTA-element and the equivalent pallet structure as the SKIN-element (see Figure 3.3). The parameters of both elements are listed in Table 4. The pallet damping loss factor is assumed to be inversely proportional to frequency, with value of 0.1 at 250 Hz. Because the VAPEPS software assumes the EXTA-element to be coupled with the SKIN-element on a single side, the coupling loss factor between these two elements must be doubled to account for double-sided excitation.

Zone 4 Modeling

The pallet inner panels are modeled as the SKIN-element in the SEA model for Zone 4 (see Figure 3.3). Both equivalent pallet parameters in Table 1 and inner panel parameters in Table 2 are still applicable for the frequency range below and above 90 Hz, respectively. Because the accelerometers used for comparison are on panels, we cannot apply all the non-structural mass used in Zone 2 to these panels. As a matter of fact, only the actual items mounted on these panels should be considered. Based on the information available to us, either none or very little mass are mounted. Therefore zero non-structural mass is assumed in VAPEPS calculation.

During the acoustic test, only one side of pallet panel is exposed to the full test chamber SPL. The acoustic level on the other side is much lower and assumed to be negligible. No double-sided excitation is required in this Zone 4 calculation.

Table 3 OSS-1 ACOUSTIC TEST LEVEL

1/3-Octave Center Frequency (Hz)	SPL
31.5	124.5
40	125
50	123
63	125.5
80	125.5
100	126
125	128
160	129
200	129
250	130.5
315	130
400	130
500	130.5
630	131.5
800	129.5
1000	126.5
1250	127.5
1600	125
2000	124

Table 4 VAPEPS PARAMETERS OF ZONE 2 AND ZONE 4 MODELS

EXTA	SKIN: Low Frequency (below 90 Hz)	SKIN: High Frequency (above 90Hz)
TYPE = 1	TYPE = 1	TYPE = 1
ROW = 1.12×10^{-7}	ROW = 2.025×10^{-6}	ROW = 1.644×10^{-5}
CO = 1.32×10^{4}	CL = 2×10^{5}	CL = 2×10^{5}
V = 6.912×10^{7}	H = 20.0	H = .8409
AP = 5.619×10^{5}	AP = 2.515×10^{4}	AP = 2.515×10^{4}
AAC = .02	ALX = 38.1	ALX = 38.1
	ALY = 27.51	ALY = 27.51
	DLF = .1	DLF = .1
	E = 7.820×10^{4}	E = 6.346×10^{5}
	PATA = 677.5	PATA = 6299
	ROWS = 4.05×10^{-5}	ROWS = 1.382×10^{-5}
	ASMS = 16.53 (Zone 2)	ASMS = 16.53 (Zone 2)
	ASMS = 0 (Zone 4)	ASMS = 0 (Zone 4)

3.2 VAPEPS Prediction and Comparison With Measurement

The acceleration data used to compare with the VAPEPS prediction are selected from the PSD data set obtained during the GSFC system level acoustic test (ref 5). The VAPEPS predictions represent the space-time averaged acceleration in the direction normal to the structural surfaces. To make a fair comparison, 26 normal transducer data in Zone 2 and Zone 4 are selected out of the total 158 accelerometer measurements. The DATE and Non-DATE transducers of this data set are listed in Table 5 and Table 6, respectively. The transducer numbers of these transducers are those used in refs 4 and 5. There are 20 PSD in Zone 2 and 6 PSD in Zone 4. Using these PSD data samples, the averaged PSD in G**2/Hz and its associated 95% confidence limits are calculated by using VAPEPS commands and based upon log-normal distribution. Table 7 and Table 8 list the averaged value, confidence limits, and VAPEPS prediction for Zone 2 and Zone 4, respectively. They are also plotted out in Figure 3.4 and Figure 3.5. The comparison between data and prediction are good.

Table 5 NORMAL MEASUREMENT DATE TRANSDUCERS IN ZONE 2 AND ZONE 4

Zone	Measurement Description	Measurement No.
2	Aft side of thermal canister base (Z)	V08D9297A
	Side of cold plate (normal)	V08D9301A
4	Panel No. 4 central insert (normal)	V08D9293A

Table 6 NORMAL MEASUREMENT NON-DATE TRANSDUCERS IN ZONE 2 AND ZONE 4

Measurement Description	Accel. No.	PSD No.
(Zone 2)		
Box beam at HP (Z)	V 45	71
Subsystem MSFC CPSS (PCB) base (Z)	V 74	53
Experiment CPSS (normal)	V 76	55
MSFC CPSS FMDM (Z)	V 27	19
Iowa Base	V 15	10
HP No. 6 (OL) (Z)	V106	105
HP No. 5 (OL) (Z)	V103	161
HP No. 2 (OL) (Z)	V100	99
HP No. 4 (OL) (Z)	V 51	39
HP No. 1 (OL) (Z)	V 48	36
HP No. 3 (OL) (Z)	V 21	13
Pallet HP No. 1 (OL) (Z)	V 6	61
HP No. 12 (IL) (Z)	V133	132
HP No. 7 (IL) (Z)	V109	108
HP No. 10 (IL) (Z)	V112	111
HP No. 14 (IL) (Z)	V 57	74
HP No. 8 (IL) (Z)	V 54	42
Pallet HP No. 17 (IL) (Z)	V 3	3
(Zone 4)		
Freon line, panel 19 (Z)	V 66	90
Panel 4 quarter span (normal)	V 61	75
Panel 9 (normal)	V 83	93
Panel 18 (normal)	V 63	87
Freon line standoff, panel 19 (normal)	V 68	47

Table 7 ZONE 2 PREDICTION AND MEASURED PSD DATA

1/3-Oct. Center Freq (Hz)	VAPEPS Prediction (g^2/Hz)	Measurement (Average) (g^2/Hz)	95% Confidence Lower Limit (g^2/Hz)	95% Confidence Upper Limit (g^2/Hz)
31.5	4.2382E-04	2.6648E-04	1.0819E-04	2.9495E-04
40	2.6471E-04	1.5911E-04	8.6456E-05	1.9738E-04
50	1.4234E-04	1.0933E-04	6.9462E-05	1.5502E-04
63	1.7098E-04	3.7329E-04	2.6077E-04	5.4394E-04
80	1.2756E-04	5.3594E-04	2.7977E-04	7.1936E-04
100	1.1869E-04	6.6920E-04	3.4181E-04	9.2425E-04
125	8.0557E-03	1.6281E-03	8.9242E-04	2.6228E-03
160	5.1173E-03	3.3098E-03	1.7552E-03	5.8310E-03
200	3.0525E-03	4.4911E-03	2.7830E-03	8.4395E-03
250	4.4845E-03	3.5431E-03	2.1106E-03	5.4722E-03
315	4.2983E-03	2.4716E-03	1.4250E-03	3.4823E-03
400	5.7688E-03	4.4163E-03	2.0412E-03	6.5421E-03
500	1.2929E-02	5.0606E-03	2.6198E-03	8.6557E-03
630	5.3398E-03	5.0953E-03	3.2145E-03	8.8334E-03
800	1.6979E-03	3.1511E-03	1.6260E-03	5.3292E-03
1000	6.0996E-04	2.0473E-03	9.8486E-04	3.1601E-03
1250	5.4112E-04	2.8940E-03	8.9172E-04	3.6613E-03
1600	1.9829E-04	7.3839E-04	3.6865E-04	1.1753E-03
2000	1.3619E-04	3.9656E-04	2.4573E-04	8.6464E-04

Table 8 ZONE 4 PREDICTION AND MEASURED PSD DATA

1/3-Oct. Center Freq	VAPEPS Prediction	Measurement (Average)	95% Confidence Lower Limit	95% Confidence Upper Limit
(Hz)	(g^2/Hz)	(g^2/Hz)	(g^2/Hz)	(g^2/Hz)
31.5	7.3017E-03	1.1705E-03	3.4650E-04	5.2433E-03
40	4.5606E-03	1.5445E-03	4.0243E-04	1.1471E-02
50	2.4523E-03	1.1165E-03	3.0818E-04	1.6654E-02
63	2.9457E-03	4.0249E-03	1.2279E-03	3.8768E-02
80	2.1977E-03	9.6107E-03	2.8512E-03	1.7284E-01
100	2.0448E-03	1.5852E-02	4.6532E-03	4.7497E-01
125	3.9105E-01	3.7130E-01	1.1062E-01	5.5369E+01
160	2.4841E-01	3.1660E-01	9.2616E-02	1.4213E+01
200	1.4818E-01	1.3704E-01	3.6327E-02	2.6095E+01
250	2.1770E-01	1.2622E-01	2.3454E-02	2.9895E+00
315	2.0865E-01	1.8772E-01	5.2077E-02	6.8599E+00
400	2.8004E-01	1.5196E-01	4.3191E-02	1.8248E+00
500	6.2762E-01	1.3116E-01	3.2126E-02	1.8850E+00
630	2.5921E-01	1.5309E-01	3.5525E-02	2.5003E+00
800	8.2422E-02	5.8768E-02	1.4796E-02	3.9342E-01
1000	2.9610E-02	2.7426E-02	8.1786E-03	1.2671E-01
1250	2.6268E-02	2.0523E-02	5.0739E-03	1.7428E-01
1600	9.6256E-03	9.6162E-03	2.2423E-03	1.0896E-01
2000	6.6113E-03	1.8319E-03	6.2288E-04	5.5840E-03

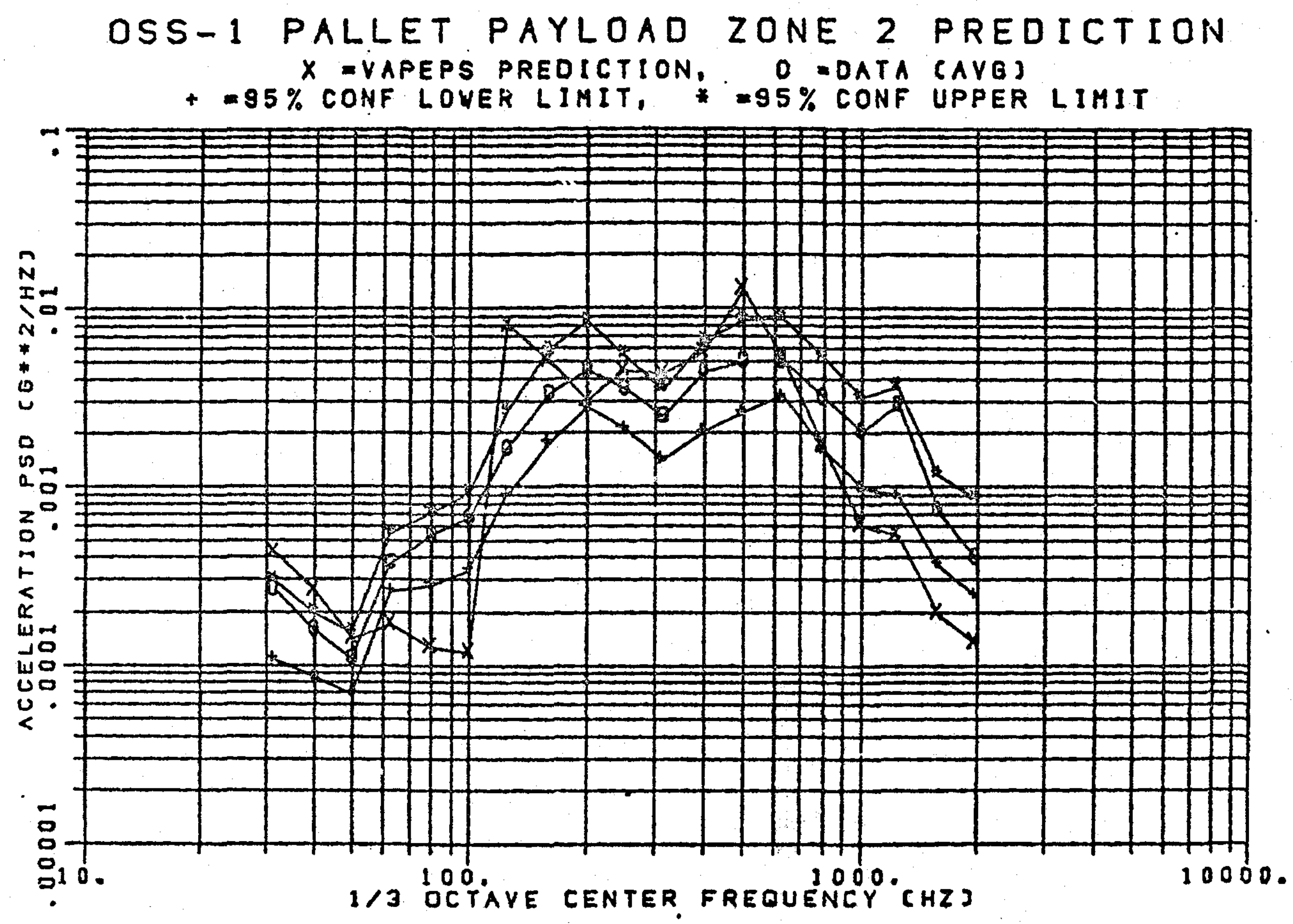


Fig. 3.4 VAPEPS Prediction and Measurement in Zone 2, OSS-1 Payload

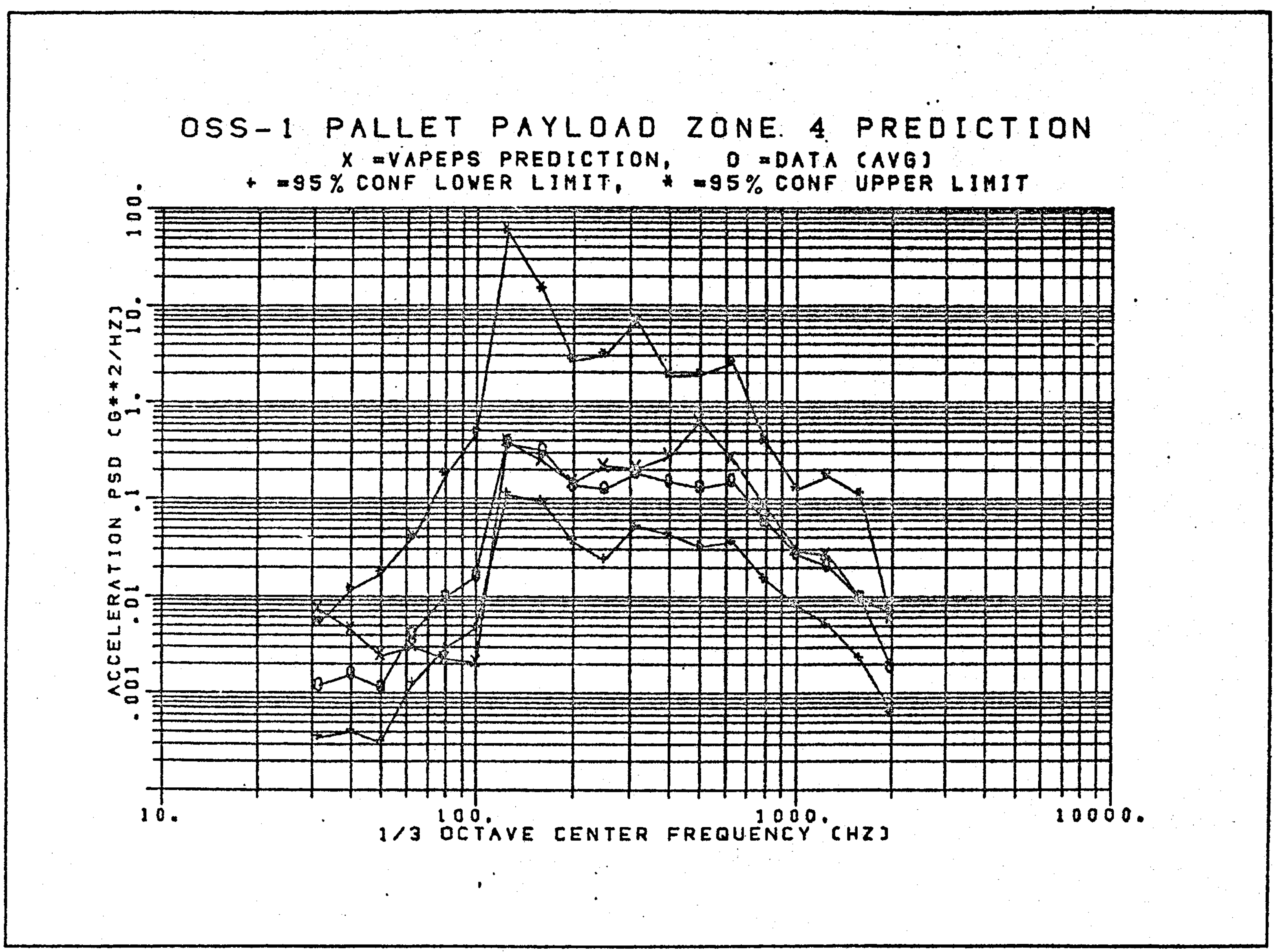


Fig. 3.5 VAPEPS Prediction and Measurement in Zone 4, OSS-1 Payload

4.0 CONCLUSIONS

An exact simulation of the shuttle cargo bay acoustic level during a ground test may not excite payload components to response as high as that can be expected to be encountered in flight. The exact reason that this situation exists is unknown. Mechanically transmitted energy from the shuttle side-rails/trunnion, which has not been simulated in any of the acoustic test performed to date, is presently considered the most likely source of this problem. If accompanied by appropriate analytical studies, it is expected that a flight measurement program could be designed that would resolve this flight versus ground test discrepancy.

Based on sample size considerations, the present VAPEPS prediction software appear to provide reasonable results. As VAPEPS is used, updated and improved by the aerospace community, it is expected to provide a very useful analytical tool for establishing the vibroacoustic environment for shuttle and expendable launch vehicle payload components.

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END

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