A COMPILATION OF SPACECRAFT LOADS DATA
FROM
FOUR TITAN CENTAUR LAUNCH VEHICLE FLIGHTS
VOLUME II

VIBRATION POWER SPECTRAL DENSITY ANALYSIS
OF LAUNCH AND MAX Q FLIGHT

Compiled by George Kachadourian

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This report is a compilation of PSD analyses processed by the Langley Research Center Analysis and Computation Division under the direction of the Viking Project Office. This volume contains time histories and Power Spectral Density (PSD) analyses of vibration and acceleration measurements on the spacecraft from the 1st, 3rd and 4th Titan Centaur launchings, TC-1, TC-4 and TC-3 respectively. Summary plots are also presented.
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ABSTRACT

The payloads carried by the first four Titan Centaur Launch Vehicle Flights were, a Viking Spacecraft Dynamic Simulator, the Helios-1 Spacecraft and the two Viking Spacecraft. A wealth of dynamic loads data was accumulated by the NASA Viking Project Office from these four flights for application to the Viking Spacecraft. This report contains a compilation of that data and is presented for reference and information. The data has been compiled into the following five Volumes:

Volume I - Acoustic Data (NASA CR-144944)
Volume II - Vibration Power Spectral Density Data (NASA CR-144945)
Volume III - Shock Spectra of Transients (NASA CR-144946)
Volume IV - Titan Stage I and Centaur Burn Oscillation (NASA CR-144947)
Volume V - Time History Plots (NASA CR-144948)

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<td>Bus</td>
<td>Major structural assembly of Viking Orbiter - see Figure 3.1</td>
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<td>Max Q</td>
<td>Period of launch flight of maximum dynamic pressure</td>
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<td>PSD</td>
<td>Power spectral density, vibration, g²/Hertz</td>
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<td>VDS</td>
<td>Viking Dynamic Simulator, TC-1 payload</td>
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<td>Viking Lander Capsule</td>
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<td>VLCA</td>
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VOLUME II

VIBRATION PSD OF LAUNCH AND MAX Q FLIGHT DATA

SECTION I

SUMMARY DATA

Volume II presents Power Spectral Density analyses of vibration measurements made on the spacecraft section of the first, third and fourth launch flights of the Titan Centaur Launch Vehicles. The spacecraft carried were the Viking Dynamic Simulator (VDS), and the first and second Viking Spacecraft. The data is for two locations on the spacecraft: (1) the center of gravity of the Viking Lander Capsule, and (2) several points on the Viking Orbiter Bus. The Viking Lander Capsule c.g. data was obtained through transformations of adapter strain gage measurements and contains data in the 0-40 Hertz frequency band. The Bus data is from both crystal and servo accelerometers and provides data in the 0-2000 Hertz range. The Bus is the primary structural assembly of the Viking Orbiter and the data is more representative of structure response rather than component response. All of the data was telemetered on IRIG Proportional Subcarrier Bands, however nonstandard filtering was used in playback to enhance the frequency content of the data.

Volume II is contained in four sections.

Section 1 summarizes all of the data into composite and envelope PSD plots.

Section 2 contains individual PSD plots and associated time histories from the first launch, carrying the Viking Dynamic Simulator.

Section 3 and 4 contain the individual data from the two Viking Spacecraft.

Measurement locations, telemetry channel assignments, filter usage and measurement identification notations are contained in Sections 2, 3 and 4 with the respective spacecraft.

All of the data processing contained in this report was performed at the Langley Research Center by the Analysis and Computations Division and their contractors. The computer program used for the PSD is the NASA Langley Signal Analysis Program (Reference 1). The program uses Blackman-Tukey-Fast Fourier Transform techniques.

Figure 1.1 Summary of Bus Acceleration PSD's
Figure 1.4 TC-1 VDS Data - Envelopes of Bus Accelerometers
TC-1 VDS Summary Data - Bus Accelerometers

Figure 1.4 Envelopes of Stage 0 Ignition PSD's
TC-1  VDS Summary Data - VLC-cg Acceleration

Figure 1.7 Envelopes of Stage 0 Ignition PSD's
TC-1 VDS Summary Data - Bus Accelerometers

Figure 1.8 Envelopes of Max Q PSD's
TC-1 VDS Summary Data - VLC cg Accelerations

Figure 1.9 Envelopes of Max Q PSD's
POWER SPECTRAL DENSITY

$P_{SD} \text{ CY1840}$

$G$ (G SQ / HERTZ)

$10^{-2}$

$10^{-3}$

$10^{-4}$

$10^{-5}$

$10^{-6}$

$10^{-7}$

$10^0$ $10^1$ $10^2$ $10^3$

FREQUENCY (HERTZ)

$T+0 - T+2$

$T+2 - T+4$

$T+4 - T+6$

$T+0 - T+5$

$sF = .500$

TC-1 / VDS DATA (LRC-3A) STAGE O IGN CY1840

Figure 1.12
POWER SPECTRAL DENSITY

This data at 8192 sps

Roll-off due to 1024 sample rate

$\delta F = 0.500$

TC-1  VOS DATA (LRC-3A)  STAGE O IGN  CY1850

Figure 1.13
Figure 1.14

POWER SPECTRAL DENSITY

FREQUENCY (HERTZ)

PSD (G SQ / HERTZ)

ΔF = 0.500

TC-1 / VOS DATA (LRC-3A) STAGE 0 IGN XDDL

NASA-LANGLEY SIGNAL ANALYSIS PROGRAM 07/23/75

Figure 1.14
POWER SPECTRAL DENSITY

FREQUENCY (HERTZ)

PSD ZOOL

(G SQ / HERTZ)

ΔF = .500

TC-1 / VDS DATA (LRC-3A)

STAGE D IGN

ZOOL

HIGH-LANGLEY SIGNAL ANALYSIS PROGRAM  07/23/75

Figure 1.16
POWER SPECTRAL DENSITY

$\Delta f = 0.500$

TC-1 / VDS DATA (LRC-3A)  STAGE 0 IGN  ZDDB

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Figure 1.22 TC-1 VDS Summary Data --- Max Q --- XDDL
Figure 1.23 TC-1 VDS Summary Data --- Max Q --- YDDL

POWER SPECTRAL DENSITY

FREQUENCY (HERTZ)

PSD YOOL (6 SG0 / HERTZ)
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Envelopes of Stage 0 Ignition Composites

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Envelopes of Stage 0 Ignition Composites

POWER SPECTRAL DENSITY

FREQUENCY (HERTZ)

10^{-2}  10^{-3}  10^{-4}  10^{-5}  10^{-6}  10^{-7}  10^{-8}

10^{-1}  10^{0}  10^{1}  10^{2}  10^{3}

PSD

(650 / Hertz)
Envelopes of Stage 0 Ignition Composites

Figure 1.53 TC-3 Viking B Summary Data, VLC cg Accelerations
Envelopes of Max Q Composite Plots

Figure 1.54 TC-3 Viking B Summary Data - Bus Accelerometers
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Figure 1.64 TC-3 Viking B Max Q Summary - CY1820
Figure 1.66 TC-3 Viking B Max Q Summary - CY1840
Figure 1.67 TC-3 Viking B Max Q Summary CY1850

POWER SPECTRAL DENSITY

FREQUENCY (HERTZ)

10⁻³  10⁻⁴  10⁻⁵  10⁻⁶  10⁻⁷  10⁻⁸  10⁻⁹  10⁻¹  10⁻²

T+35 - T+37
T+37 - T+39
T+41 - T+43
T+43 - T+45
T+45 - T+47

(650 to 7050) Hz

PSO CY1850
Figure 1.68 TC-3 Viking B Max Q Summary - XDDL
Figure 1.69  TC-3 Viking B Max Q Summary  YDDL
Figure 1.70  TC-3 Viking B Max Q Summary - ZDDL