George C. Marshall Space Flight Center
Science and Engineering
Contract NAS8-40836

# GROUND TEST OF THE URINE PROCESSING ASSEMBLY FOR ACCELERATIONS AND TRANSFER FUNCTIONS

## SVERDRUP PRESENTATION NO.: MG-01-677

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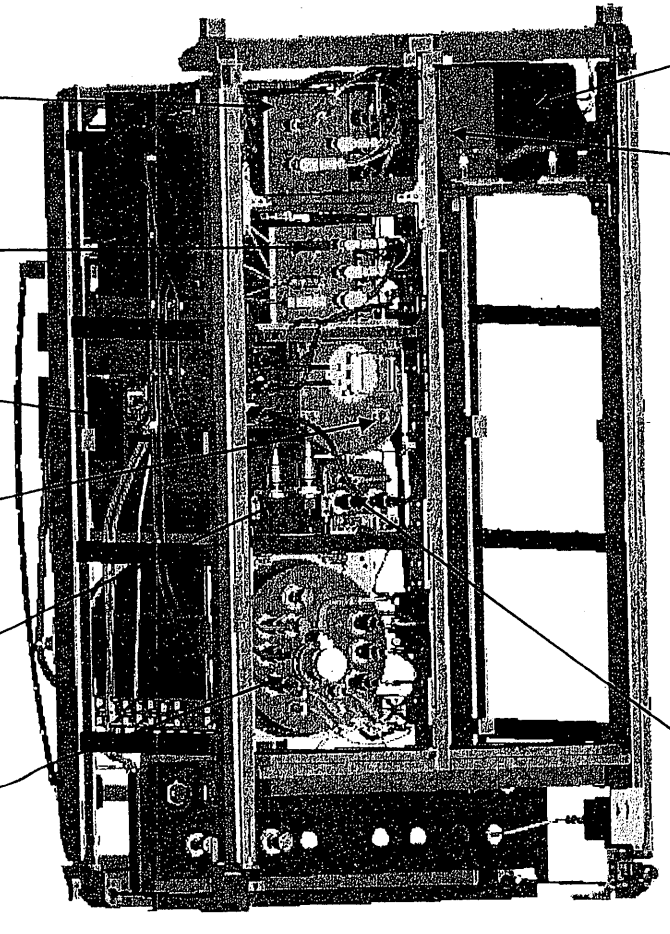
# AGENDA

- NODE 3 WATER RECOVERY RACK #2
- TEST DETAILS
- TEST DATA
- DATA ANALYSIS METHODOLOGY
- RESULTS
- CONCLUSIONS

# NODE 3 WATER RECOVERY RACK #2



UPA PRESSURE CONTROL AND PUMP ASSEMBLY (PCPA)

UPA FLUIDS CONTROL AND PUMP ASSEMBLY (FCPA)

REMOTE POWER CONTROLLER MODULE (RPCM)

UPA RECYCLE FILTER TANK ASSEMBLY (RFTA)

UPA WATER STORAGE ASSEMBLY (WSA)

UPA DISTILLATION ASSEMBLY (DA)

INTERNATIONAL STANDARD PAYLOAD RACK (ISPR)

UPA POWER MODULE (PM)

UPA DATA MODULE (DM)

UPA SEPARATOR PLUMBING ASSEMBLY (SPA)

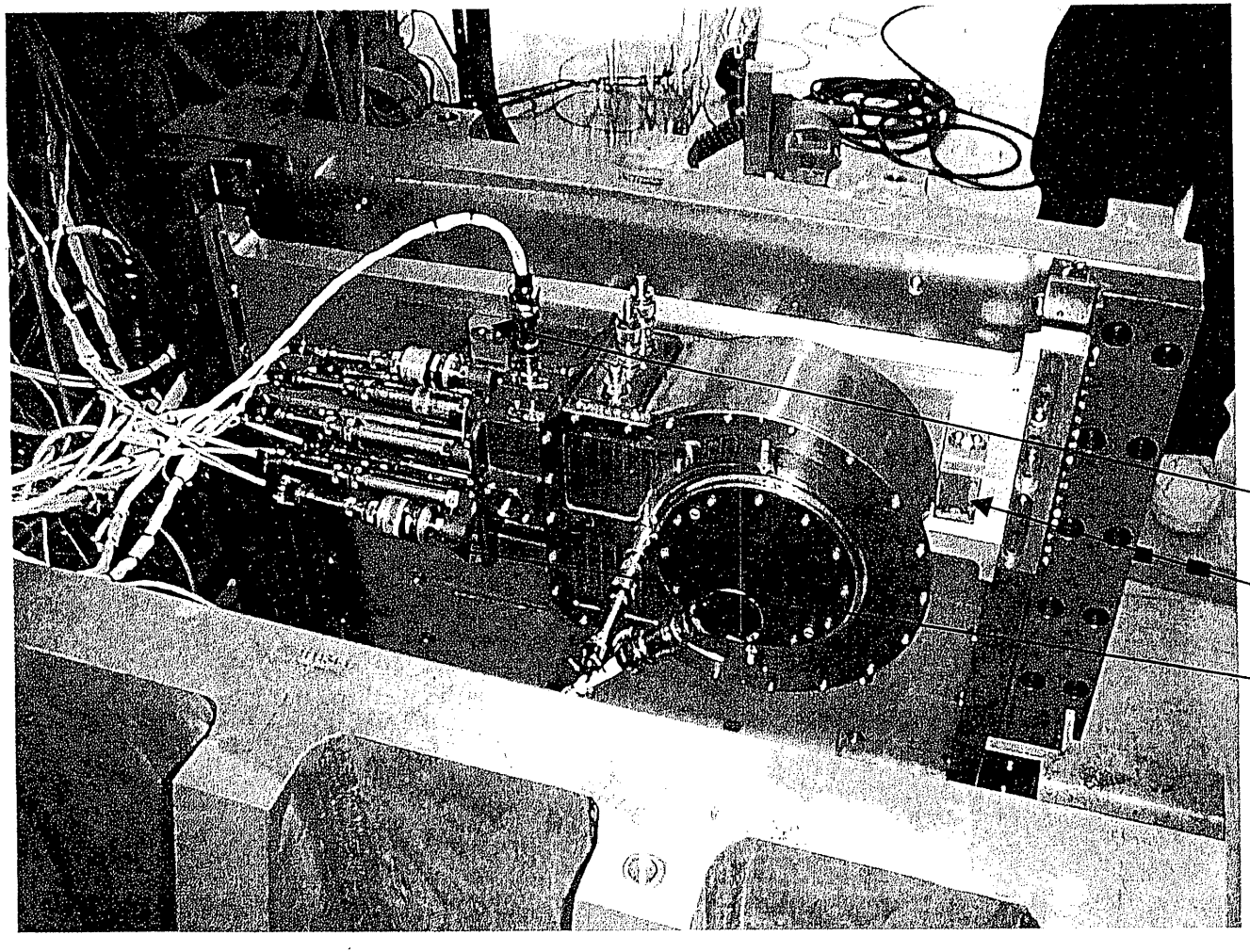
# TEST DETAILS: SETUP

## •ACTUALLY TWO TESTS WITH MULTIPLE CASES

- <u>FCPA PUMP</u>
  - –AMBIENT CASE - Background noise acquisition
  - –IMPACT CASE - Obtain transfer functions (FRFs)
  - –OPERATIONAL CASE - Obtained acceleration/force power spectral density (PSDs)

- <u>PCPA PUMP</u>
  - –AMBIENT CASE - Background noise acquisition
  - –IMPACT CASE - Obtain transfer functions (FRFs)
  - –OPERATIONAL CASE - Obtained acceleration/force power spectral density (PSDs)
    - •TWO ADDITIONAL SUBCASES
      - –Loop Only
      - –Pump Only

# TEST DETAILS: FCPA WITH TEST FIXTURE

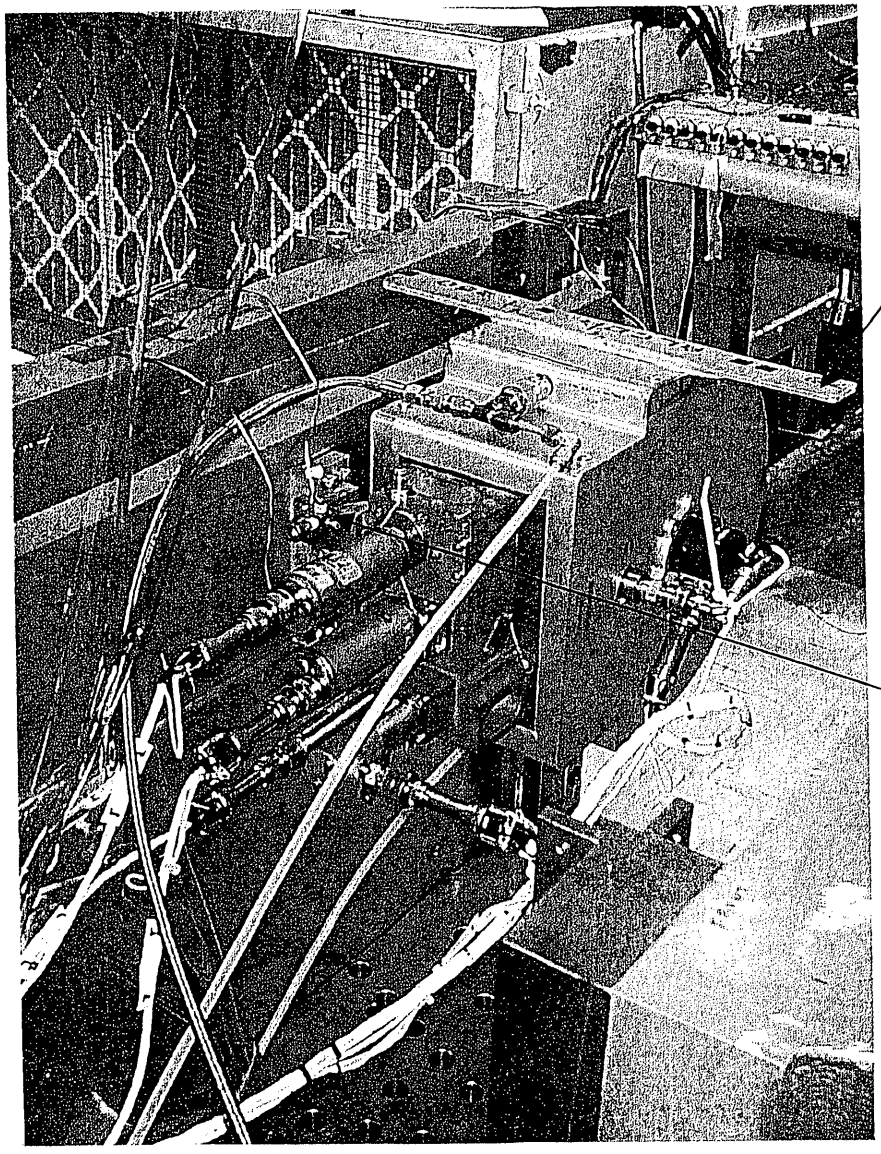


MASS ~100 lbs
MOTOR RPM: 800 RPM
PUMP RPM: 8 RPM

<u>Response Accelerometers</u>
Located at 3 Point Attachment of Pump to Attach Bracket

1. Upper Rear Interface
2. Front Interface
3. Lower Rear Interface (not visible)

# TEST DETAILS: PCPA WITH TEST FIXTURE



MASS ~100 lbs
MOTOR RPM ~2500 RPM
PUMP RPM ~25 RPM

- DUE TO LIGHTWEIGHT HOUSING: Stiffener was affixed to PCPA housing with dental cement

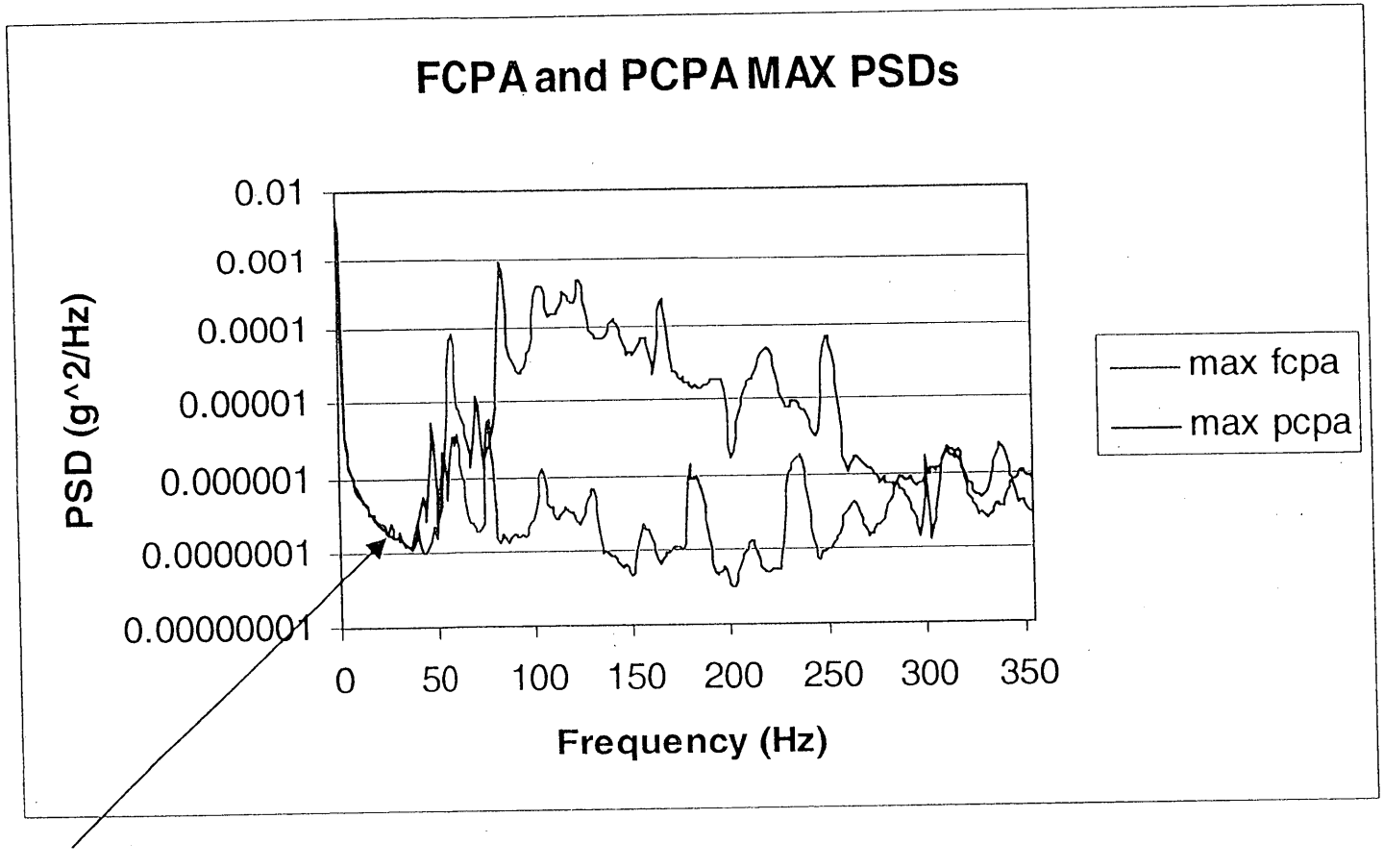
- DIFFERENT HAMMER

<u>Response Accelerometers</u>

Same 3 Locations as FCPA Pump

Triaxial Accelerometer attached to Upper Rear Interface

# TEST DATA: PSDs




**Typically, in the range from 0-33 Hz, the max ambient (not shown) is greater than the max fcpa and max pcpa.**

# DATA ANALYSIS: ASSUMPTIONS

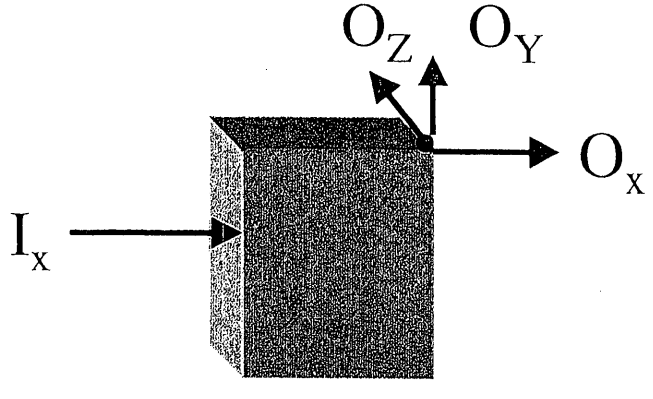
**THE GOAL: DETERMINE THE FORCING FUNCTION, I, OF THE PUMP THAT IT OUTPUTS DURING OPERATION**

**THE 1ST ASSUMPTION: THE COMPONENT C.G. IS THE SOURCE OF THE FORCE**

**THE 2ND ASSUMPTION: RIGID LOAD PATH FROM IMPACT LOCATIONS TO C.G.**

# DATA ANALYSIS: METHOD

- DISCARDED SINGLE INPUT/SINGLE OUTPUT MODEL
  - METHOD DID NOT TAKE INTO ACCOUNT TRI-AXIAL NATURE OF INPUT AND RESPONSE
- APPLIED SINGLE INPUT/MULTIPLE OUTPUT MODEL
  - ACCOUNTS FOR IMPACT, I, IN X DIRECTION HAVING OUTPUT, O, RESPONSES IN X, Y, Z DIRECTIONS
- WHERE O IS THE ACCELERATION DUE TO THE FORCE, I, AND THE TRANSFER FUNCTION, H




$$[O] = [H][I]$$

# DATA ANALYSIS: EQUATIONS

•ACCELERATION, O, IS A RANDOM VARIABLE AND IS THEREFORE RESPRESENTED BY A POWER SPECTRAL DENSITY, $G_O$

$$G_o = F(OO^*)$$

•LIKEWISE, FORCE, I, IS A RANDOM VARIABLE AND IS THEREFORE REPRESENTED BY A POWER SPECTRAL DENSITY, $G_I$

$$G_i = F(II^*)$$

•SPECIFIC EXAMPLE: OUTPUT RESPONSE ACCELERATION AT OUTPUT 5 DUE TO INPUT FORCES, [I], AT 1X, 2 Y, AND 3Z

$$O_{5X} = H_{5X1X}I_{1X} + H_{5X2Y}I_{2Y} + H_{5X3Z}I_{3Z}$$

$$O_{5Y} = H_{5Y1X}I_{1X} + H_{5Y2Y}I_{2Y} + H_{5Y3Z}I_{3Z}$$

$$O_{5Z} = H_{5Z1X}I_{1X} + H_{5Z2Y}I_{2Y} + H_{5Z3Z}I_{3Z}$$

# DATA ANALYSIS: EQUATIONS CONTINUED

- MULTIPLYING BY THE CONJUGATE, O*, IGNORING THE CROSS TERMS AND SOLVING FOR $G_O$ YIELDS

$$[G_o] = [H^2][G_i],$$

$$[G_i] = [H^2]^{-1}[G_o]$$

- ACCELERATION POWER SPECTRAL DENSITY IS IN $G^2/HZ$ UNITS
- SOLVING FOR THE FORCE, I WHERE $\Delta f$ IS THE FREQUENCY RESOLUTION

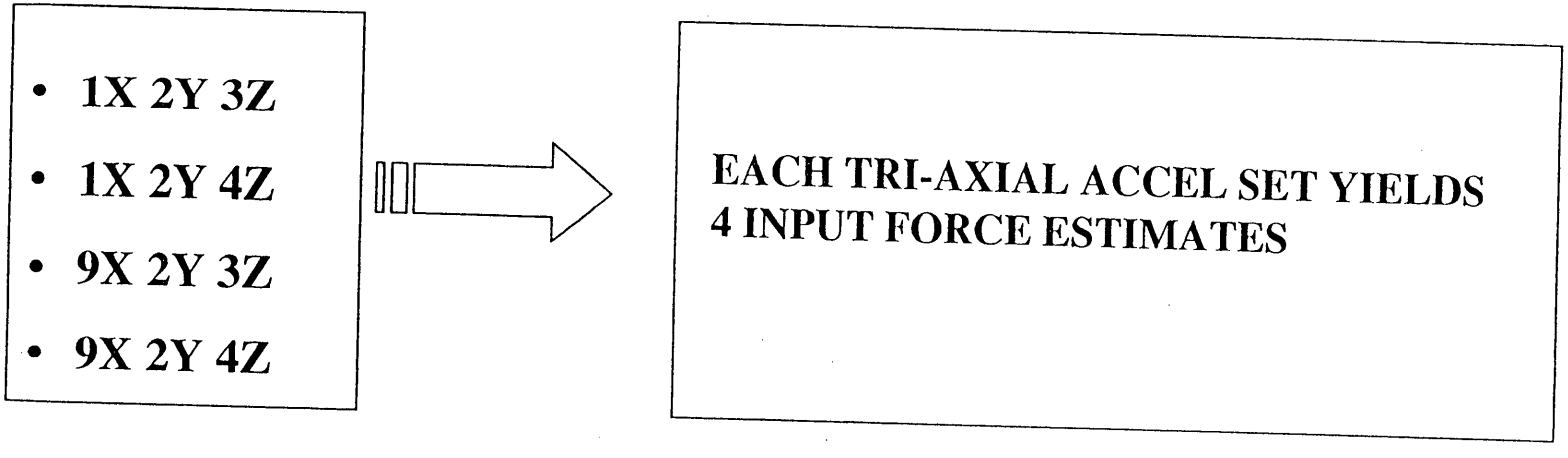
$$[I] = \sqrt{\Delta f [G_i]}$$

- COMBINING THESE IN A WORST CASE SCENARIO YIELDS

$$I = \sqrt{I^2_{MAX\_X} + I^2_{MAX\_Y} + I^2_{MAX\_Z}}$$

# DATA ANALYSIS: COMBINATIONS

- DURING TEST, FOUR TRI-AXIAL ACCELEROMETERS
- IMPACT DIRECTIONS: 1X, 9X, 2Y, 3Z, 4Z
  - IMPACT COMBINATIONS FOR EACH LOCATION




- 4 TRI-AXIAL ACCELS =TOTAL 16 FORCE ESTIMATES EXAMINED FOR EVERY FREQUENCY

# DATA ANALYSIS: COMBINATIONS

- WHICH IS THE BEST "WORST" CASE?
  - QUALITY OF FORCE ESTIMATES WAS "WEIGHTED BY" COHERENCES OF THE FRFS
    - GOOD/BAD COHERENCE CUTOFF = 0.7 FOR EACH FRF
    - EACH FORCE ESTIMATE IS ASSIGNED A VALUE EQUAL TO THE NUMBER OF COHERENCES IN THE MATRIX THAT ARE <0.7
  - THE BEST FORCE ESTIMATE IS THAT WITH THE LOWEST NUMBER OF POOR COHERENCES
  - IF TWO FORCE ESTIMATES HAVE THE SAME "COHERENCE SCORE" THEN THE MAX FORCE IS THE "BEST" ONE

# DATA ANALYSIS: COHERENCE

- "GOOD" COHERENCE MATRIX

$$\begin{vmatrix} 0.7 & 0.8 & 0.9 \\ 0.9 & 0.8 & 0.9 \\ 0.9 & 0.9 & 0.9 \end{vmatrix}$$

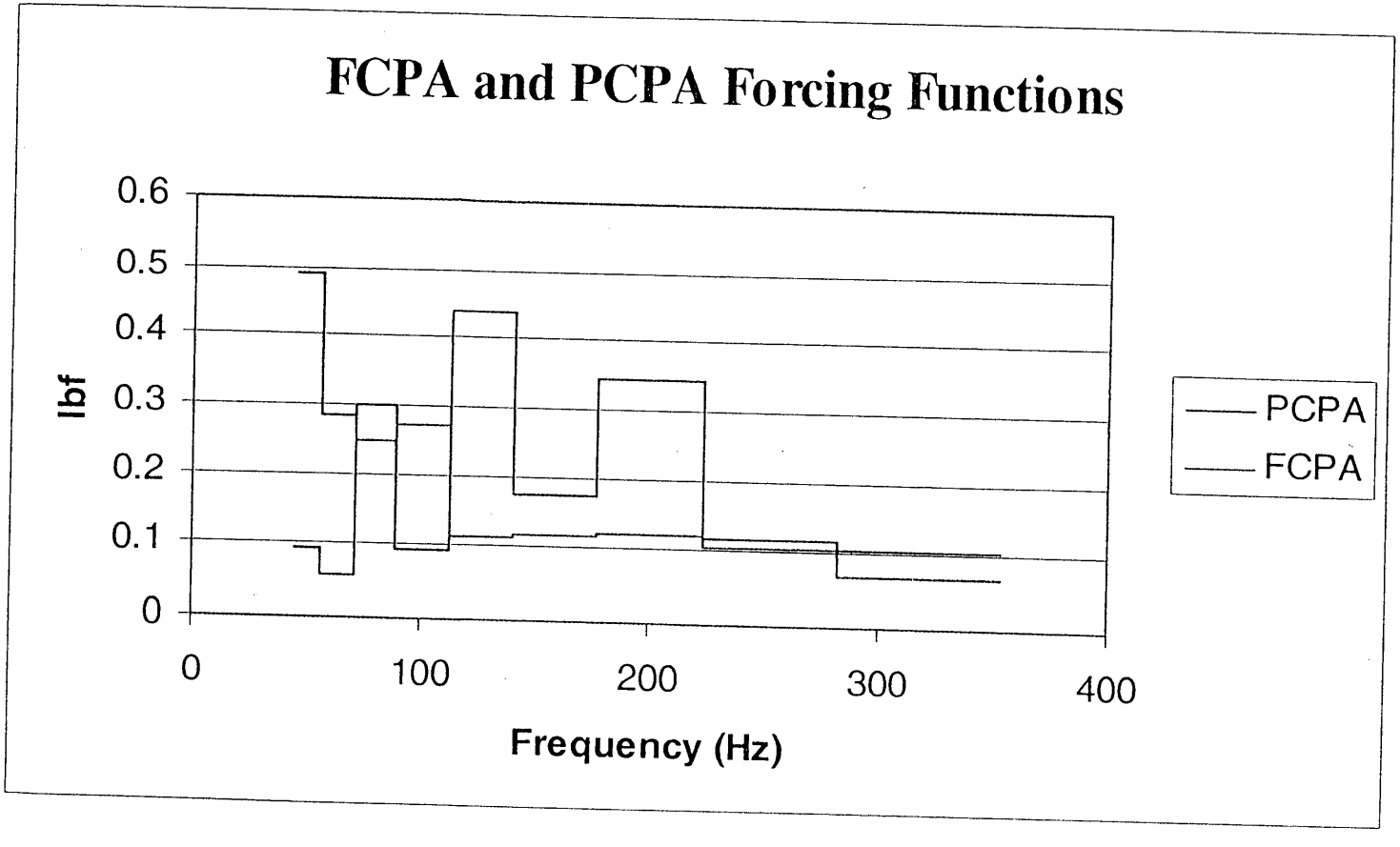
COHERENCE SCORE = 0

- "NOT SO GOOD" COHERENCE MATRIX

$$\begin{vmatrix} 0.7 & 0.8 & 0.9 \\ 0.4 & 0.5 & 0.6 \\ 0.5 & 0.4 & 0.3 \end{vmatrix}$$

COHERENCE SCORE = 6

# ANALYTICAL RESULTS

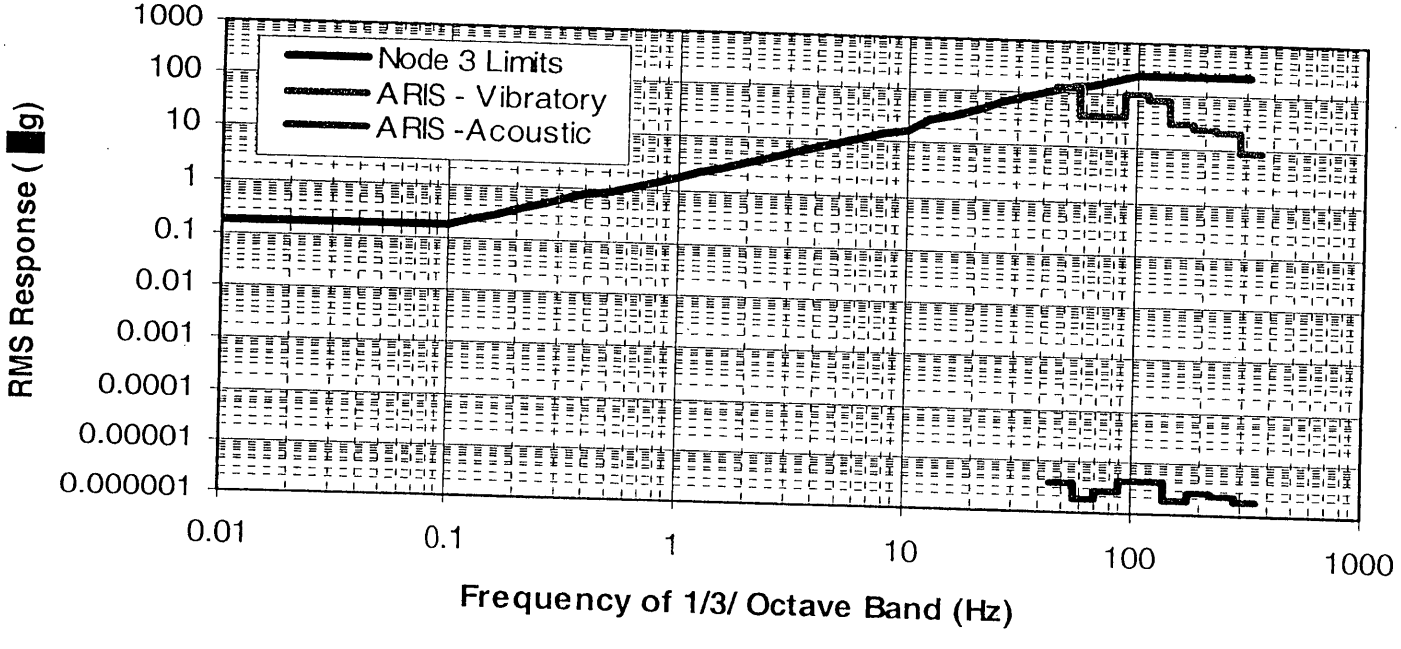


# MICROGRAVITY ASSESSMENT

- METHODOLOGY
  - NEED TRANSFER FUNCTION (FROM MICROGRAVITY CONTROL PLAN) FOR NODE 3
  - NEED FORCING FUNCTION OF MICROGRAVITY DISTURBER
  - ACCELERATION = TRANSFER FUNCTION * FORCING FUNCTION
  - MICROGRAVITY ENVIRONMENT = RSS OF ACCELERATIONS

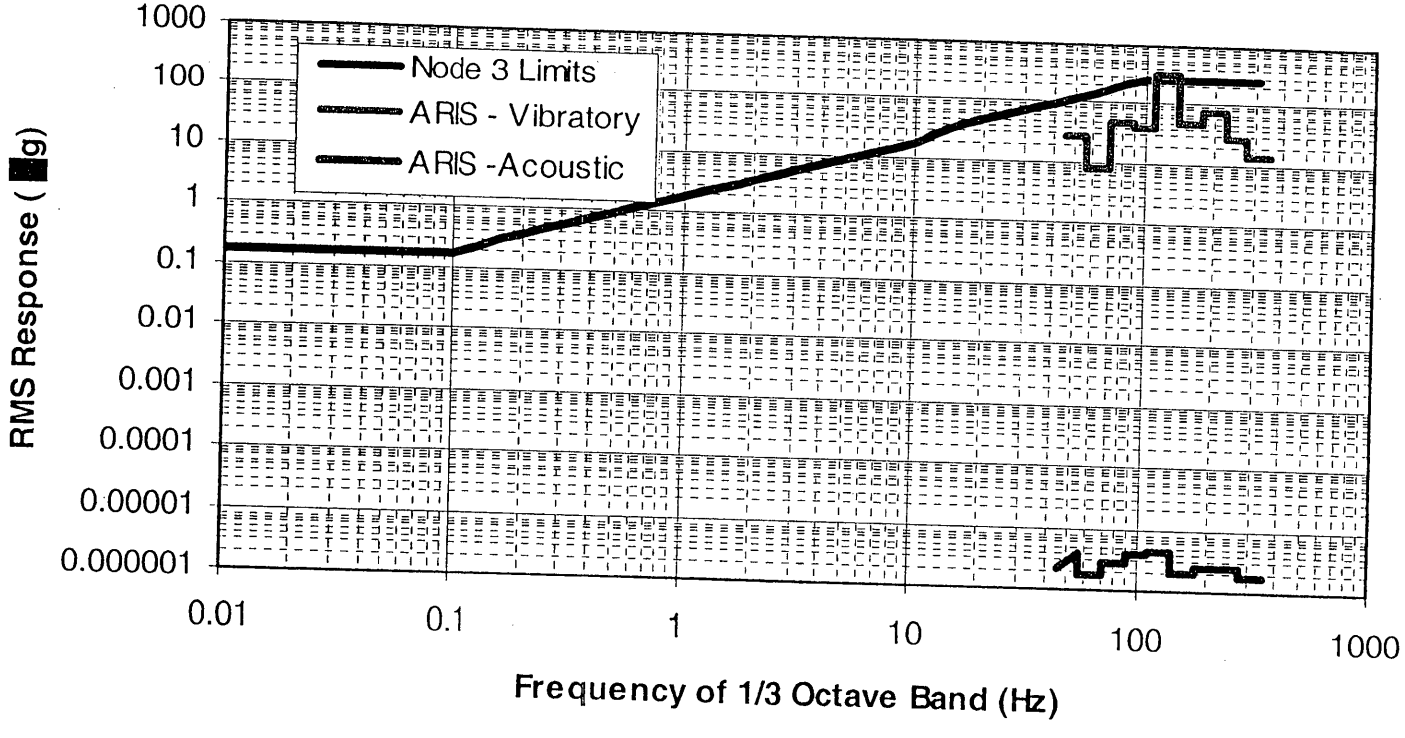
# FCPA MICROGRAVITY ASSESSMENT

**Fluids Pump**
**Urine Processor- ECLSS/WRS #2**



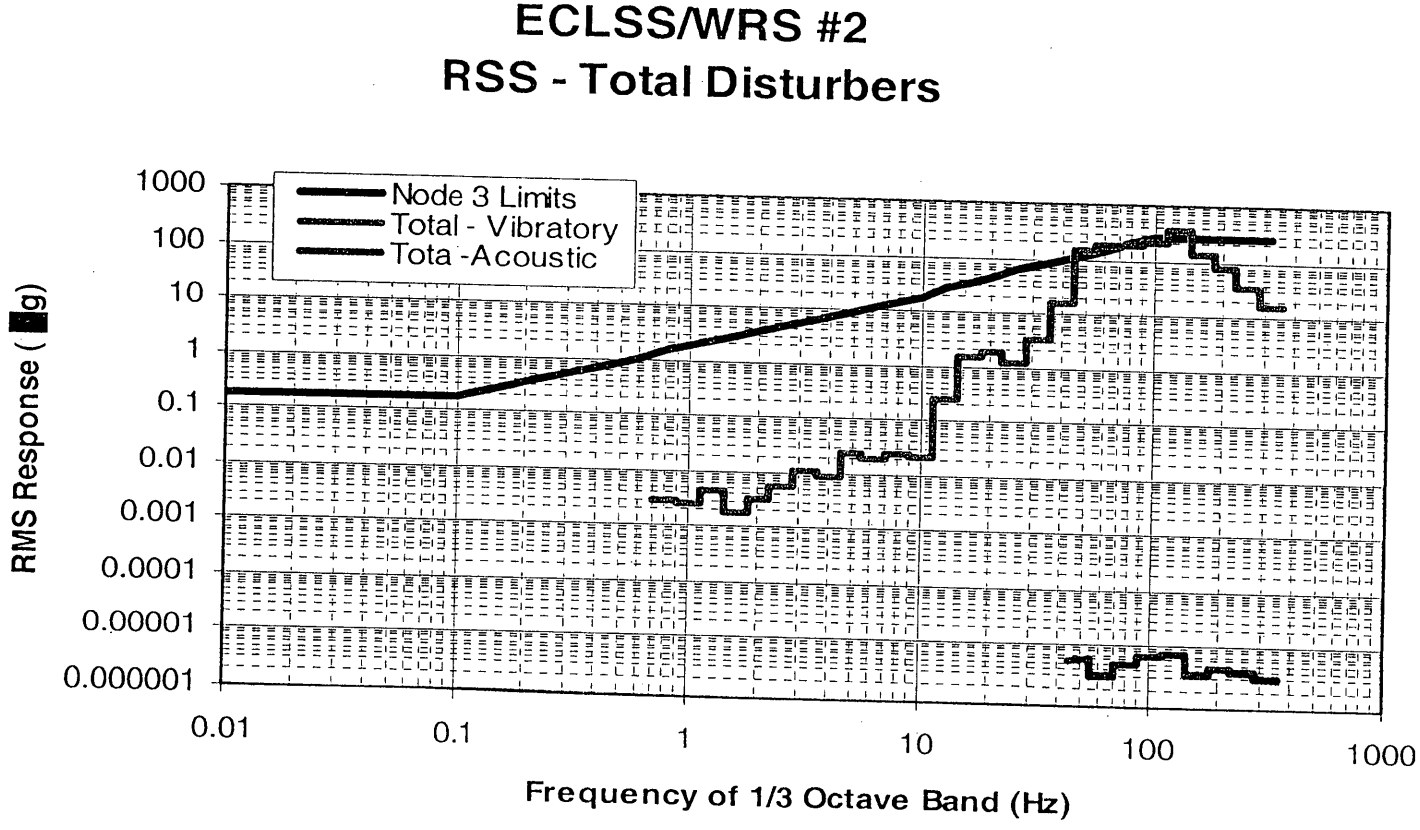
# PCPA MICROGRAVITY ASSESSMENT

## Purge Pump
## Urine Processor- ECLSS/WRS #2



# WRS#2 MICROGRAVITY ASSESSMENT

•Includes FCPA, PCPA, and (Old) DA Forcing Functions



# SUMMARY

- **WRS #2 EXCEEDANCES**

  - 23 Micro-g's at 50 HZ
  - 30 Micro-g's AT 63 HZ
  - 103 Micro-g's AT 125 HZ

POTENTIAL TO ISOLATE AT THSE PARTICULAR FREQUENCIES

  - ?? Micro-g's AT 0.01 TO 50 HZ
    - Unable to characterize the FCPA and PCPA pump disturbances from 0.01 to 50 HZ
    - This affects the result at the one-third octave band with center frequency of 50 Hz
  - At the one-third octave bands with center frequency 63 Hz, result may be high due to electrical ground loop noise

# CONCLUSIONS

- DATA ANALYSIS METHODOLOGY
  - SINGLE INPUT/MULTIPLE OUTPUT METHOD USEFUL IF DATA ACQUIRED IS BY TRI-AXIAL ACCELEROMETERS AND INPUTS CAN BE CONSIDERED UNCORRELATED
  - TYING COHERENCE WITH MATRIX YIELDS HIGHER CONFIDENCE IN RESULT
- RESULTS
  - WRS#2 RACK ORU'S NEED TO BE ISOLATED
- FUTURE WORK
  - TEST DEV DA – SPRING 2002
    - INCLUDES PLAN FOR CHARACTERIZING PERFORMANCE OF ISOLATION MATERIALS
  - RETEST FCPA AND PCPA PUMPS FOR DATA BELOW 70 HZ