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MEASUREMENT OF THE RELATIVE AND ABSOLUTE MICROGRAVITY ENVIRONMENT OF SPACE PLATFORMS, RECENT FLIGHT RESULTS AND DETERMINATION OF THE SPATIAL MICROGRAVITY FIELD

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ABSTRACT

Microgravity materials processes in space, such as crystal growth, require specific and accurate knowledge of the very low frequency, very low level microgravity. This means knowledge of absolute microgravity levels.

Most acceleration measurement systems for space platforms only measure "microvibrations", the measurement of the absolute microgravity level being severely corrupted by bias errors, temperature hysteresis, non-linearity by-products and bias changes due to launch vibrations.

An advanced system was developed incorporating a fixed 3-axes acceleration measurement system with improved signal conditioning and Invertible Accelerometers for absolute measurements. The higher sensitivity channels have lower frequency low pass filtering to meet crystal growers demands for recording of low level/low frequency disturbances. Also included is a pre-flight bias adjustment feature.

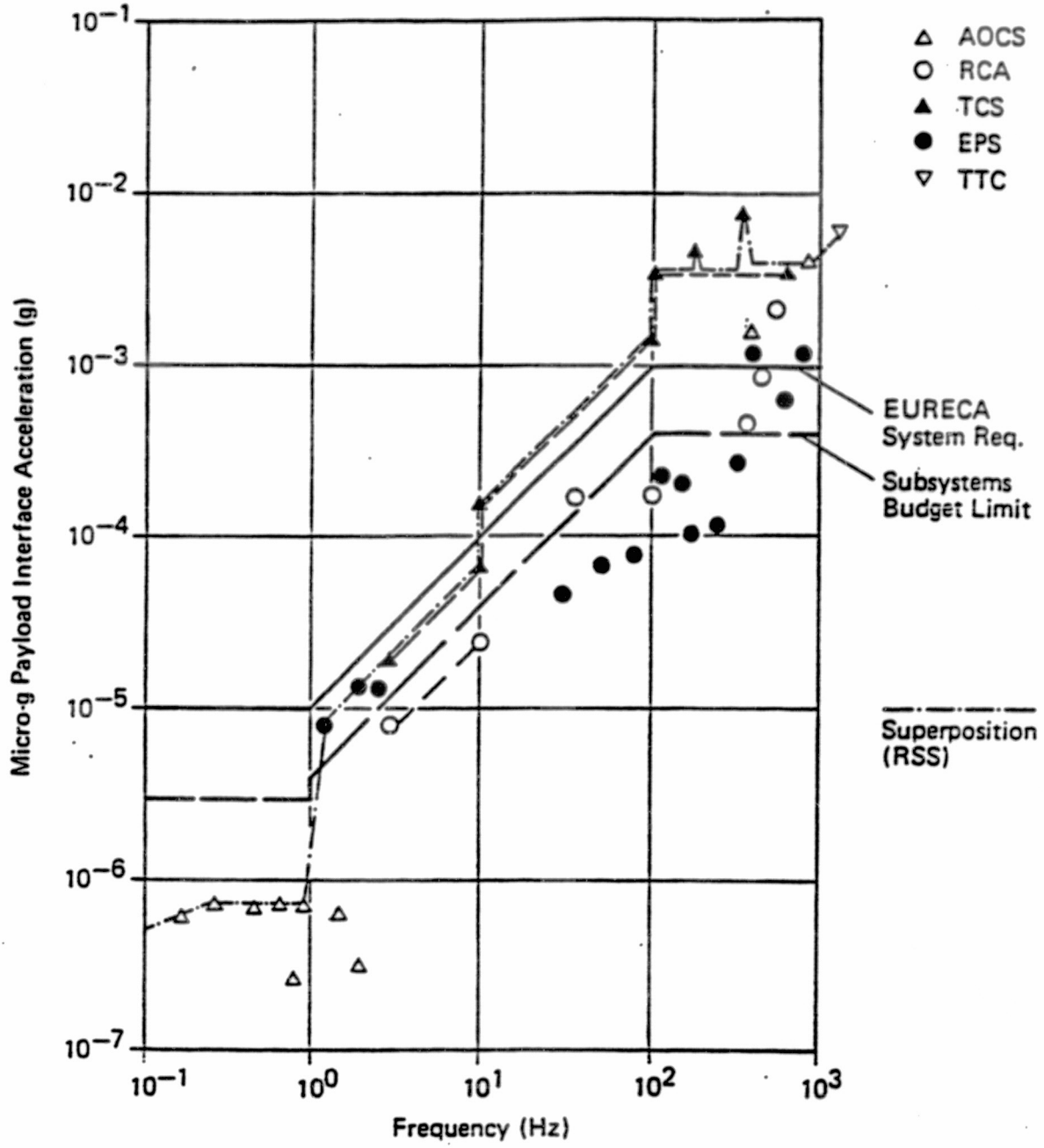
The Invertible Accelerometers invert the accelerometer sensitive axis over 180° at regular intervals permitting determination of both the in-space bias error and the residual absolute microgravity level.

Systems flew on the "CONSORT" Sounding Rockets in 1989, '90 and '91. A system has been assembled for flight on STS-46 for absolute measurement of the force on the orbiter from a tethered satellite and for the COMET satellite. A triple system is under construction for SPACEHAB-01 for flight in 1993.

An advanced display and analysis computer program was developed for unambiguous correlation with disturbing events from other experiments and

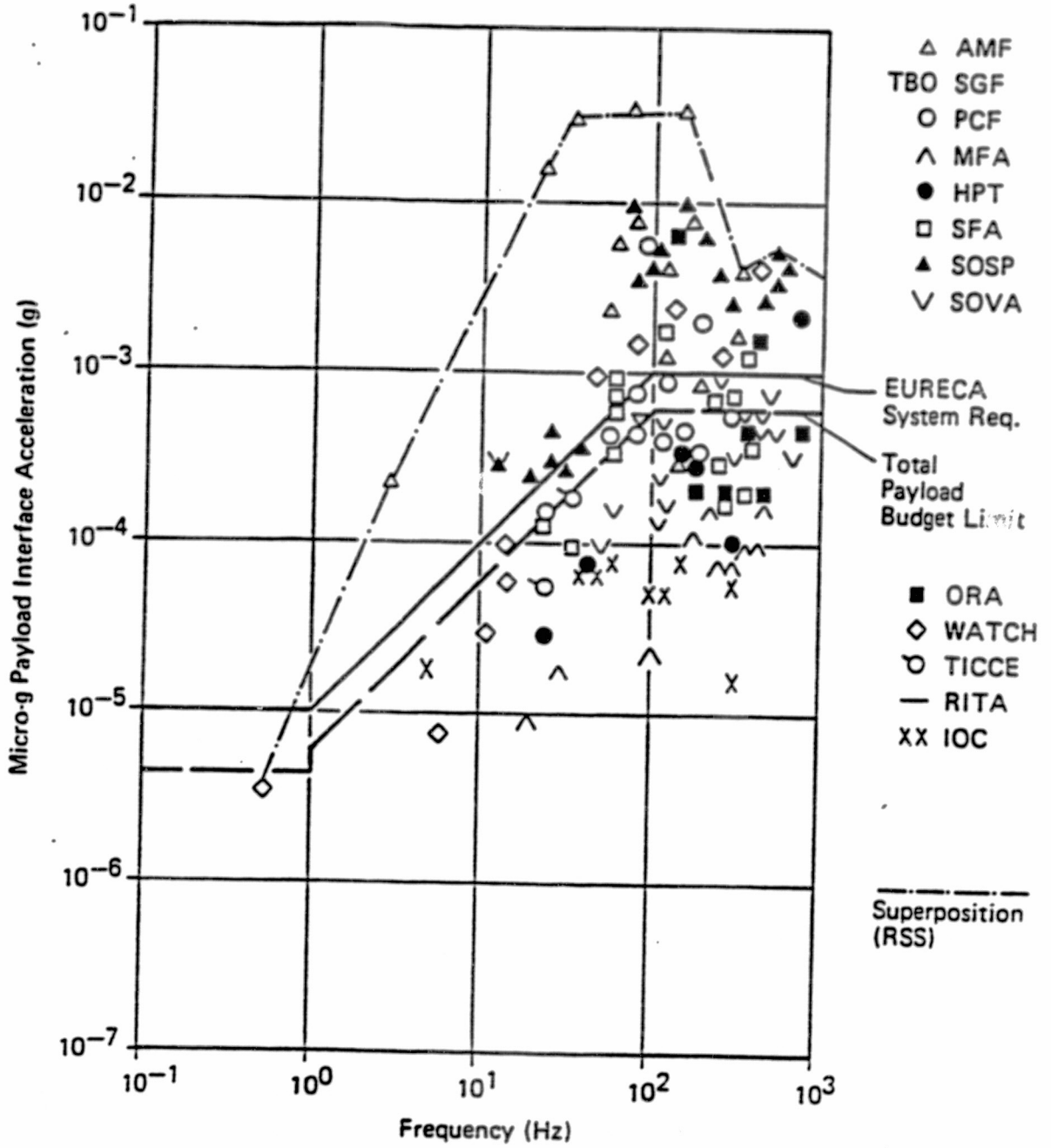
subsystems. Typical results on determining absolute microgravity levels and on the correlation between weak disturbances and events such as solenoid-and camera-operations will be shown. Full correlation between events and disturbances was obtained.

Above activities are also intermediate steps to a full system for determining the complete spatial microgravity field from data from a fixed number of accelerometers with different characteristics mounted on fixed locations on a space platform such as a space station.



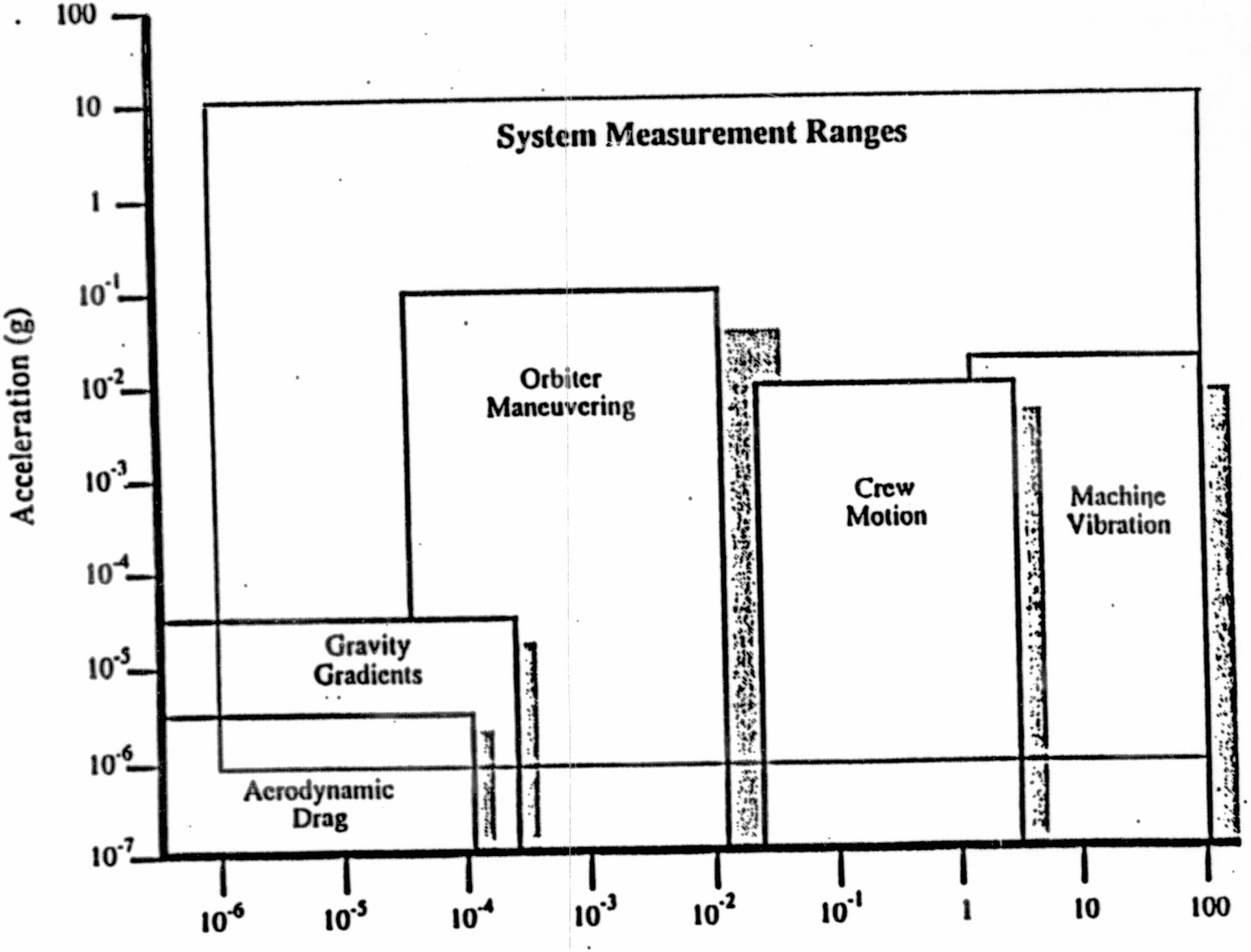
COURTESY : DR ANDRESEN, ESA

Figure 6.1: Acceleration Response Spectrum due to Subsystem Equipment

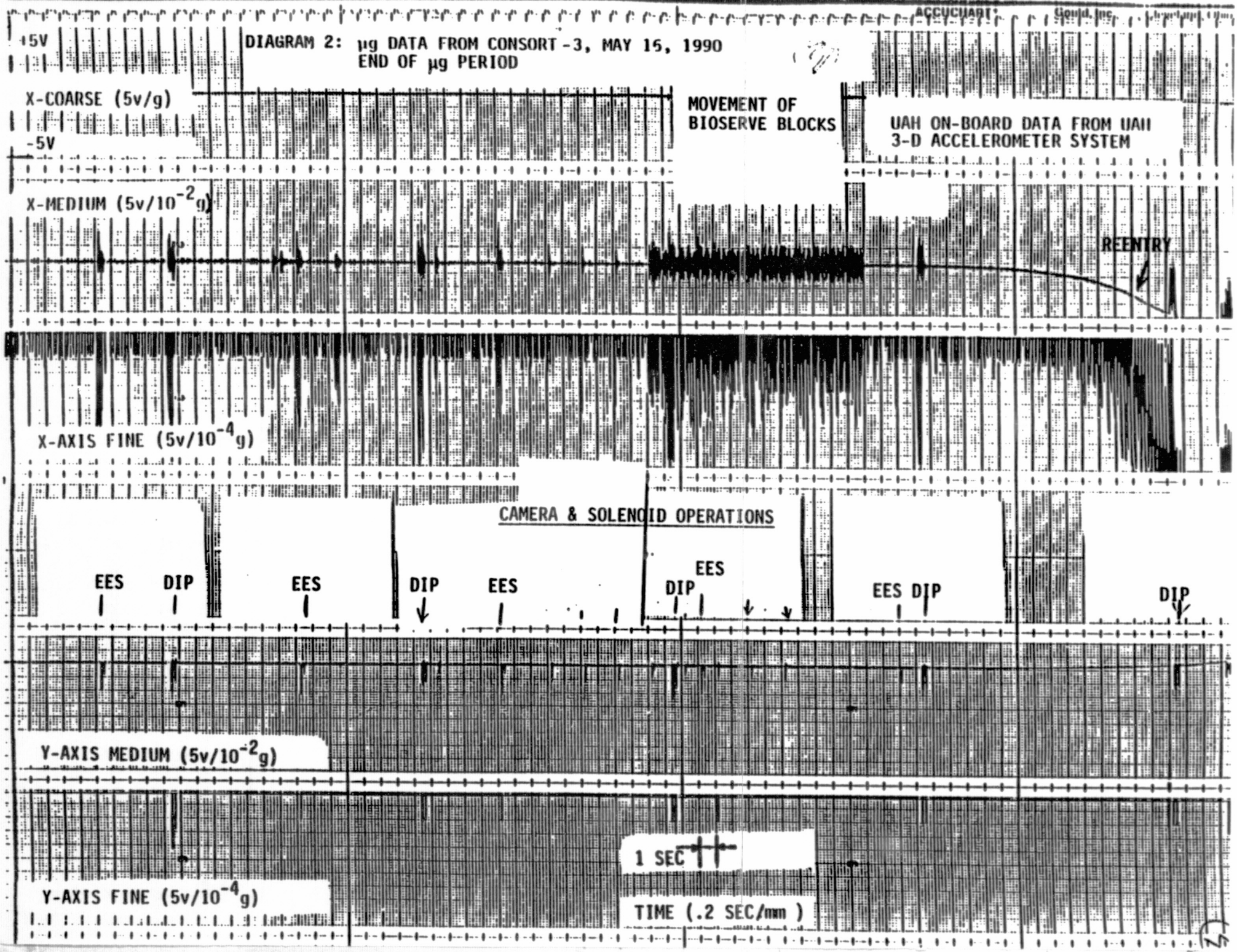


COURTESY DR ANDERSEN, ESA

Figure 6.2: Acceleration Response Spectrum due to Operating Facilities/Instruments of the EURECA Payload



COURTESY | DR E. STUHLINGER
HUNTSVILLE, AL


ACCUCHART Gould Inc.
DIAGRAM 2: µg DATA FROM CONSORT-3, MAY 15, 1990
END OF µg PERIOD
+5V
X-COARSE (5v/g)
-5V
MOVEMENT OF
BIOSERVE BLOCKS
UAH ON-BOARD DATA FROM UAH
3-D ACCELEROMETER SYSTEM
X-MEDIUM (5v/10^-2 g)
REENTRY
X-AXIS FINE (5v/10^-4 g)
CAMERA & SOLENOID OPERATIONS
EES
DIP
EES
DIP
EES
EES
DIP
EES DIP
DIP
Y-AXIS MEDIUM (5v/10^-2 g)
1 SEC
Y-AXIS FINE (5v/10^-4 g)
TIME (.2 SEC/mm)

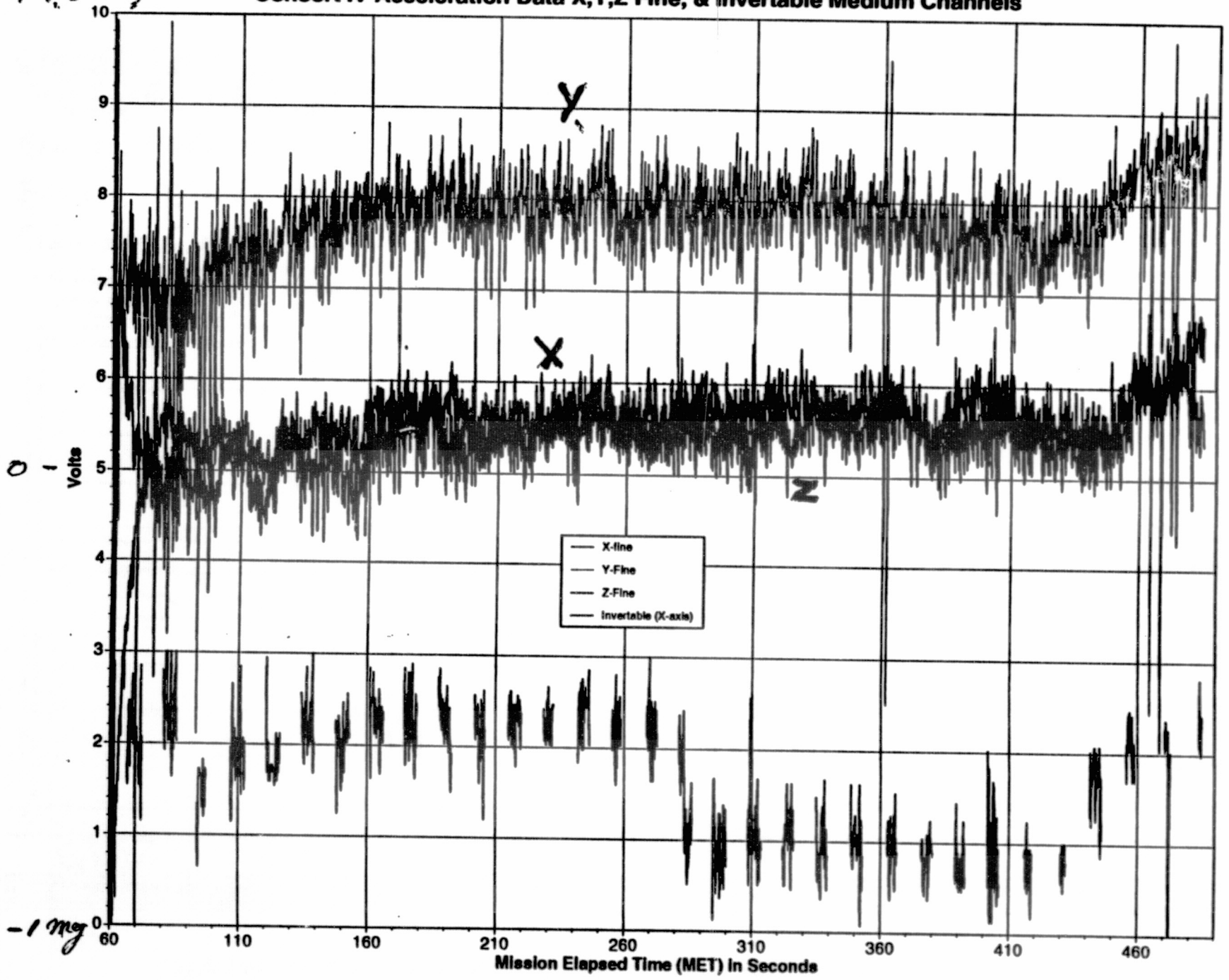
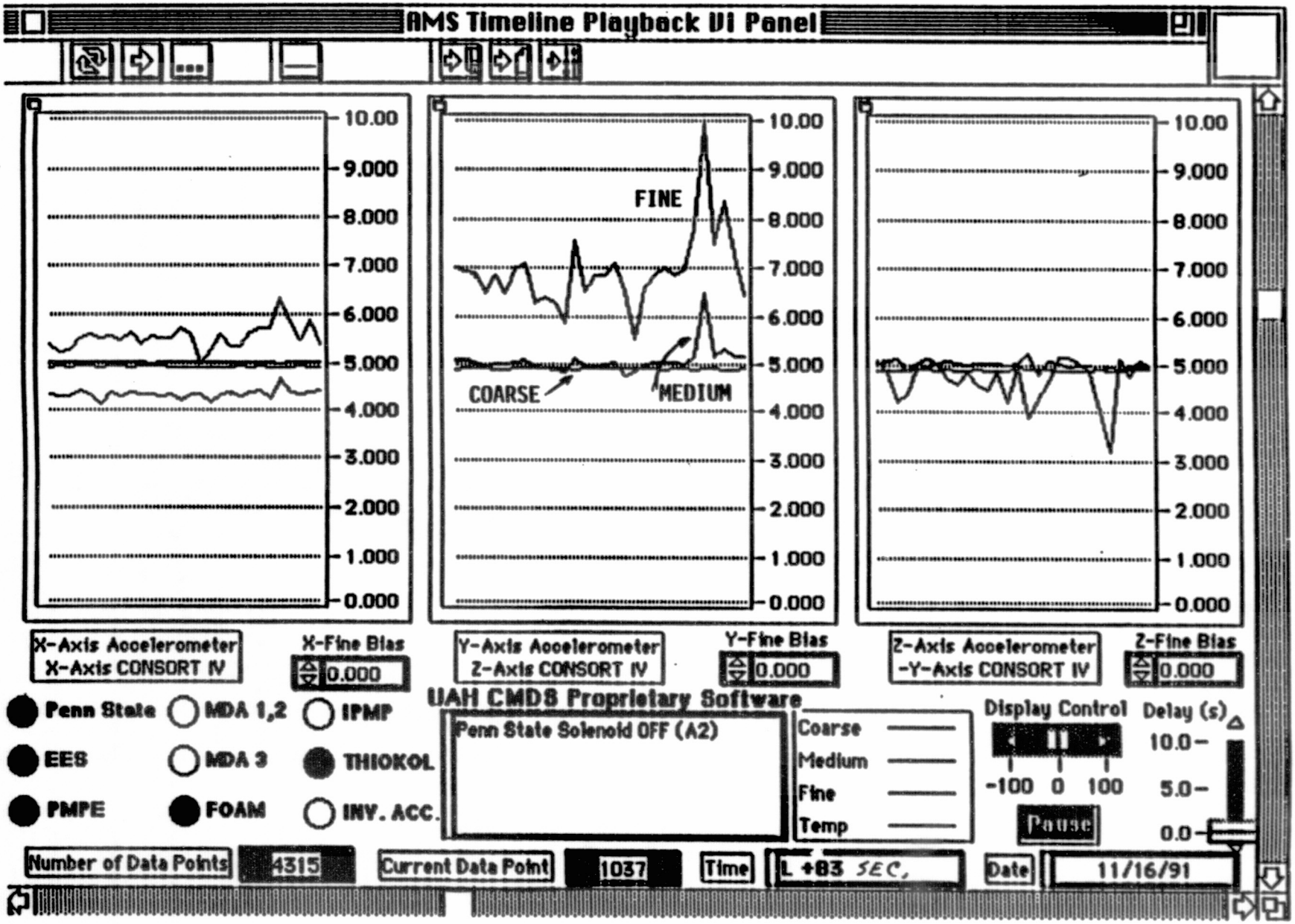
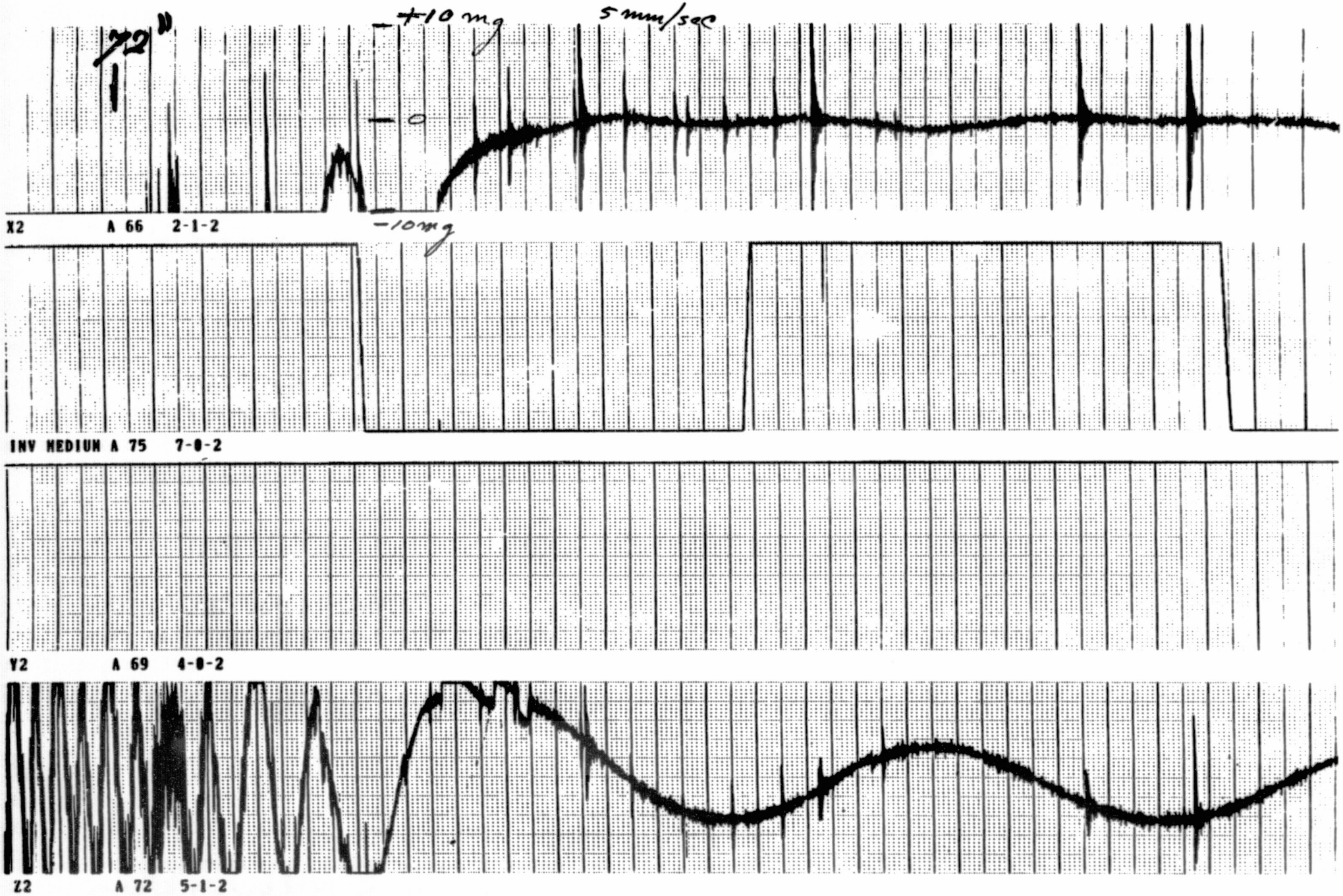


DIAGRAM 4: CONSORT -IV ACCELERATION DATA DISPLAY & CORRELATION




+10 mg
5 mm/sec
X2 A 66 2-1-2
-10mg
INV MEDIUM A 75 7-0-2
Y2 A 69 4-0-2
Z2 A 72 5-1-2

OBJECTIVES 3-D MICROGRAVITY ACCELEROMETER PROGRAM

- MEET SPECIFIC REQUIREMENTS MATERIALS PROCESSING IN SPACE
- ACCURATE MEASUREMENT OF ABSOLUTE MICROGRAVITY LEVELS IN SPACE
- ELIMINATION OF BIAS SHIFTS CAUSED BY LAUNCH VIBRATIONS
- EMPHASIS ON LOW FREQUENCY DISTURBANCES
- NO SUPPRESSION OF CONSTANT COMPONENTS SUCH AS DUE TO DRAG,GRAVITY GRADIENT, MOMENTS.
- ELIMINATION OF DC ERRORS CAUSED BY HIGH FREQUENCY HIGH LEVEL DISTURBANCES
- CLOSE CORRELATION OF MEASURED DISTURBANCES AND ON-BOARD EVENTS

DIAGRAM 1

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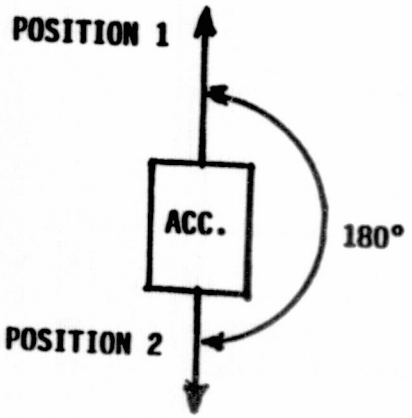
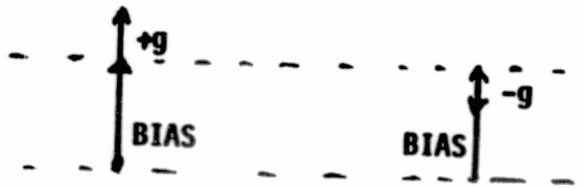
ABSOLUTE μG-MEASUREMENT

INVERTABLE ACCELEROMETER:

180° ROTATIONS BETWEEN MEASUREMENTS



- °BIAS ERROR RESULTS FROM
  - •TEMPERATURE HYSTERESIS
  - •LAUNCH VIBRATIONS
  - •NON-LINEAR RESPONSE TO HIGH LEVEL/HIGH FREQUENCY SIGNALS
- °BIAS ERROR CONSTANT WHEN ROTATED
- °G INDICATION INVERTING



{ B + g
{ B - g

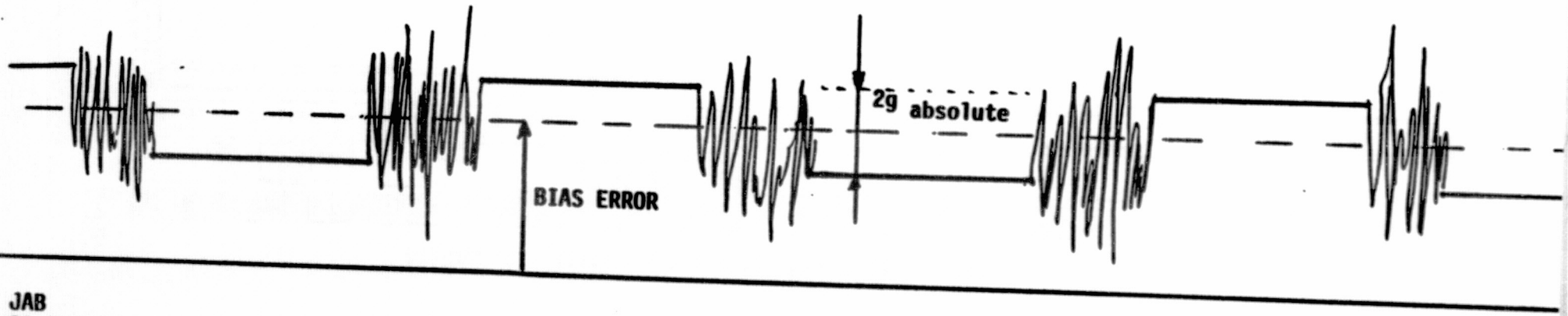


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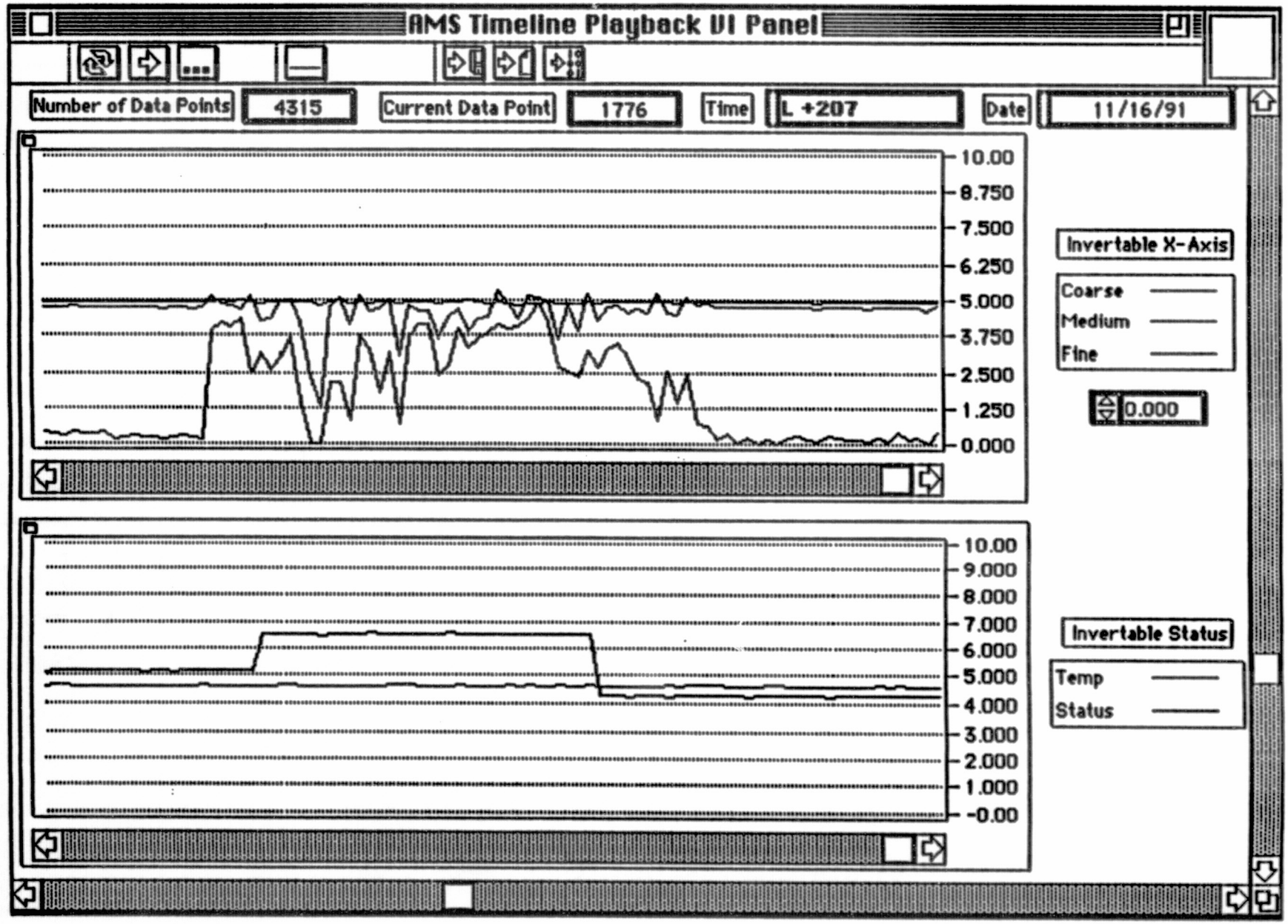
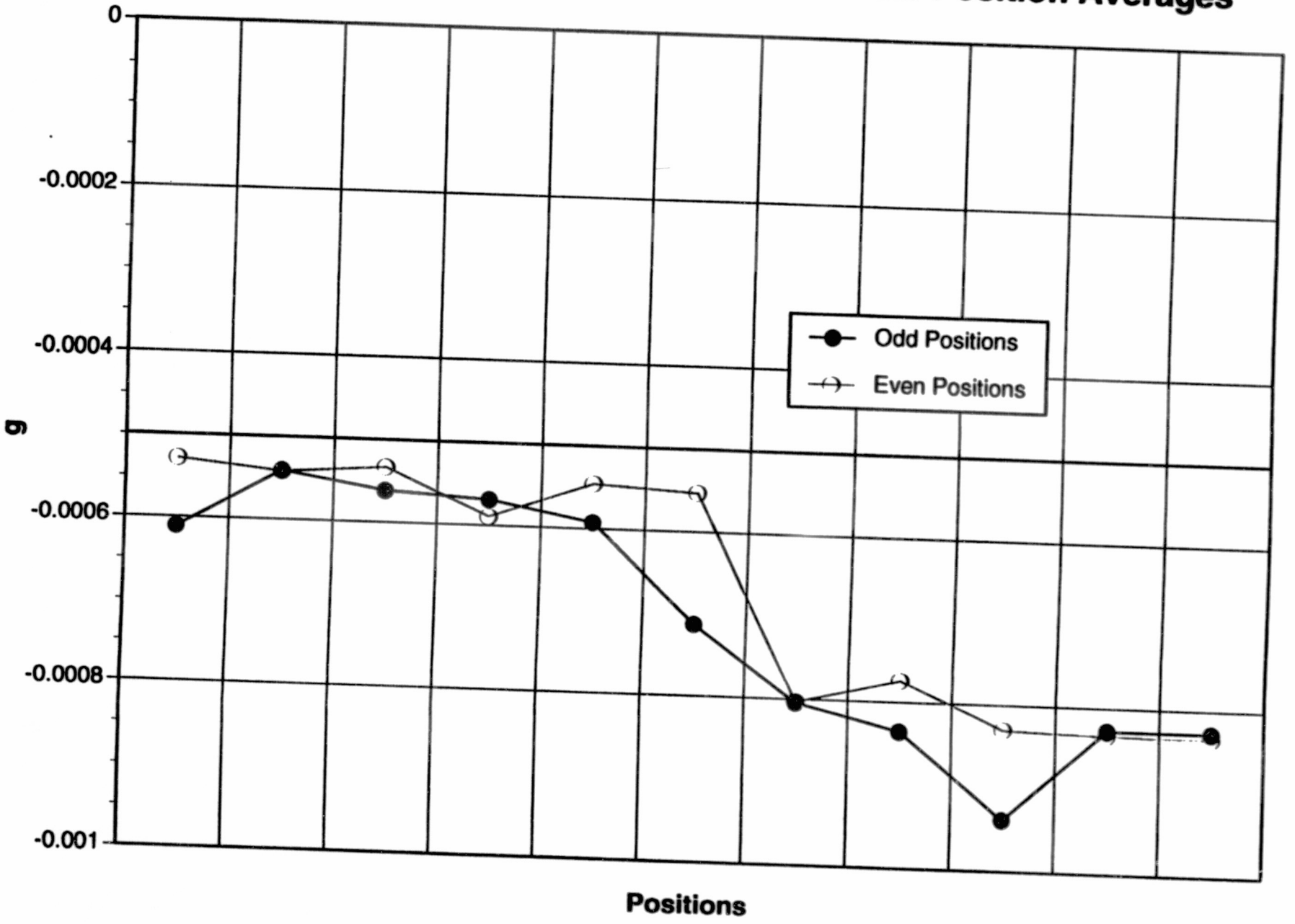
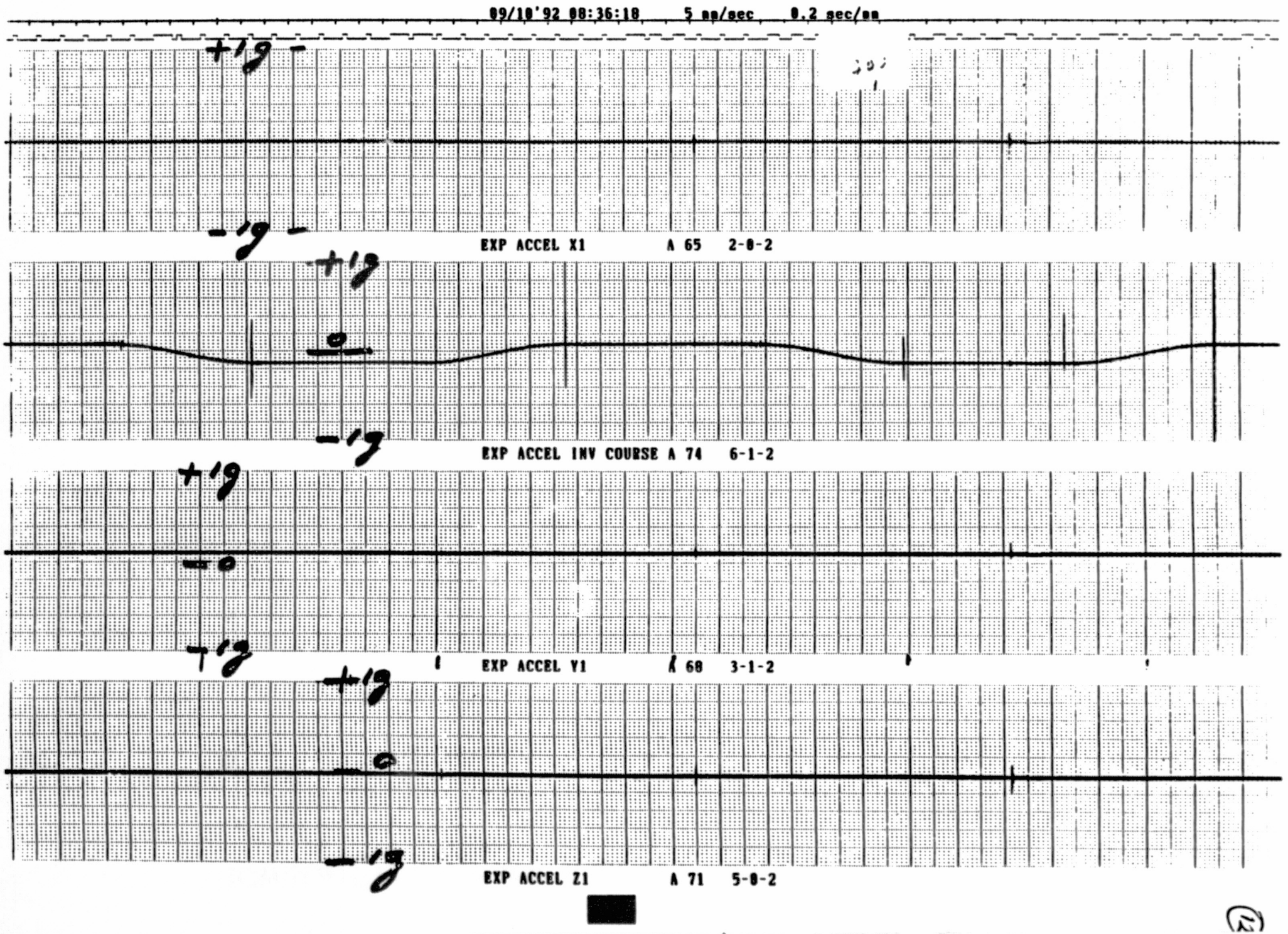
DIAGRAM 5: INVERTIBLE ACCELEROMETER DATA INTERVAL



CONSORT IV Invertable Accelerometer: Alternate Position Averages




09/10'92 08:36:18 5 mm/sec 0.2 sec/mm
+1g
-1g
EXP ACCEL X1 A 65 2-0-2
+1g
0
-1g
EXP ACCEL INV COURSE A 74 6-1-2
+1g
0
-1g
EXP ACCEL Y1 A 68 3-1-2
+1g
0
-1g
EXP ACCEL Z1 A 71 5-0-2

CMDS/UAH ACCELERATION MEASUREMENT DEVELOPMENT PROGRAM

MISSIONS	DATES	INSTRUMENTATION	REMARKS
CONSORT 1,2,3	1989/90	UAH 3DMA + MSFC LGAS	SLOW RESPONSE LGAS CONSORT 2 MISHAP BIAS SHIFTS
JOUST 1	1991	NEW UAH - 3DMA + INVERTIBLE ACCELEROMETER (IA)	LAUNCH MISHAP-ALL H/W LOST ALL EVENTS RECORDED
CONSORT 4	NOV. '91	NEW 3DMA + I.A. (QA -700'S)	BIAS SHIFTS
STS 46, CONCAP-III	AUG. '92	3DMA + I.A. + DATA PROCESSING + RECORDING	TETHER MISSION FAILED SYSTEM NOT TURNED ON
CONSORT 5	SEP. '92	3DMA + I.A. (QA-3000'S)	FLIGHT MISHAP-NO μG ABSOLUTE G MEASURED ALL EVENTS RECORDED
COMET GU		3DMA-(QA 700) FOR EXPERIMENT TESTS ON THE GROUND	START TESTS SEP. 92
COMET FU	SPRING 93	3DMA (QA 3000) + TELEMETRY TO GROUND	DELIVERY SEP. '92
SPACEHAB-01, 02	SPRING 93 FALL 93	3DMA (3RU'S) + 3 I.A.'S + DATA PROCESSING + RECORDING	
USML-1	1995	3DMA (3RU'S) + I.A.'S + DATA PROCESSING + RECORDING	

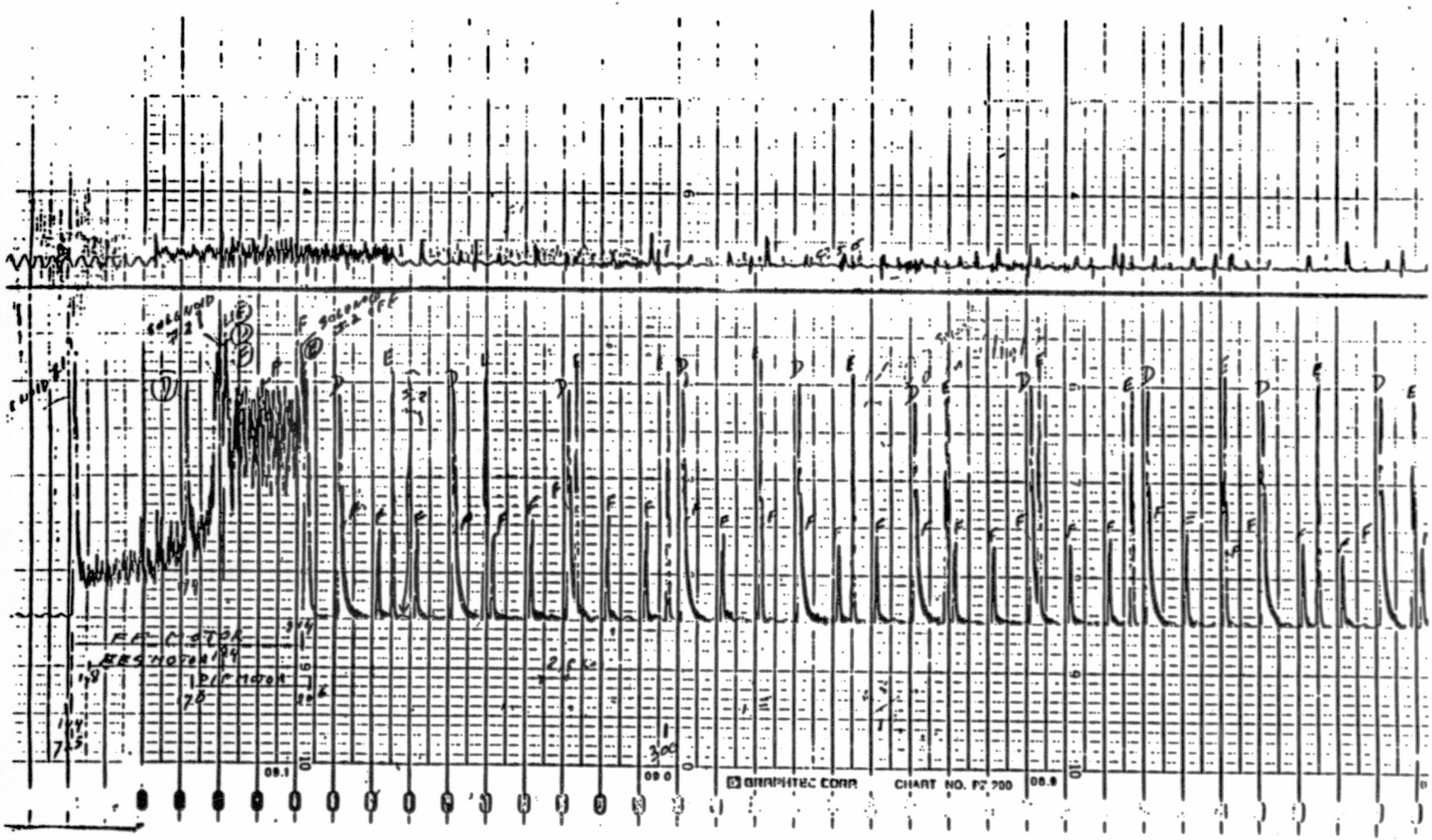
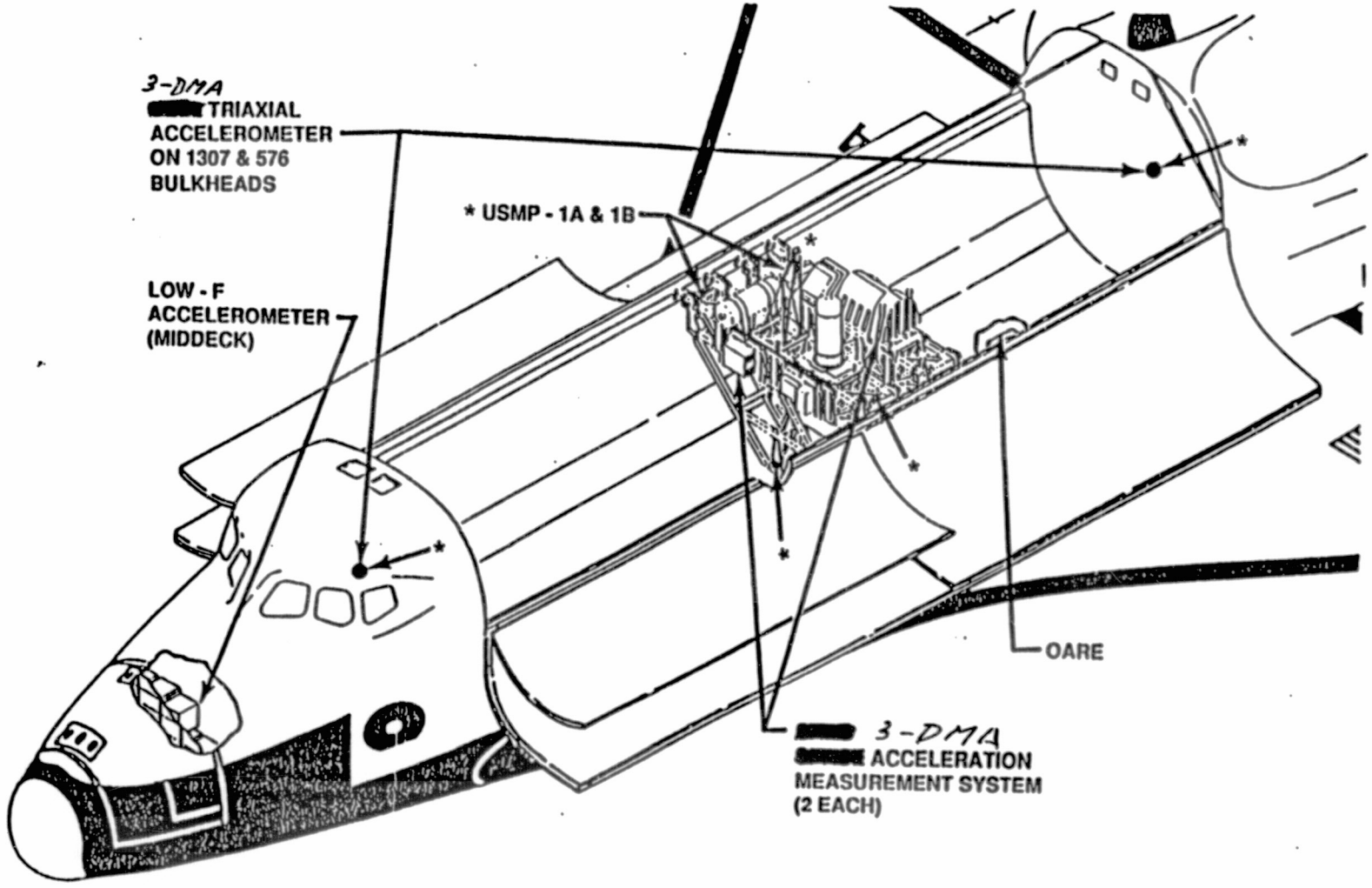


DIAGRAM 7: Camera Disturbances Measured at CMDS Sounding Rocket on-the-ground suspension test.



STS = 70
EXPERIMENT MANIFEST
- OARE (IF AVAILABLE)
- (2) [redacted] WITH 6 TRIAXIAL SENSOR HEADS *
- (1) LOW - F

FIGURE 8 - POSSIBLE LOCATIONS OF ACCELEROMETERS ON SHUTTLE

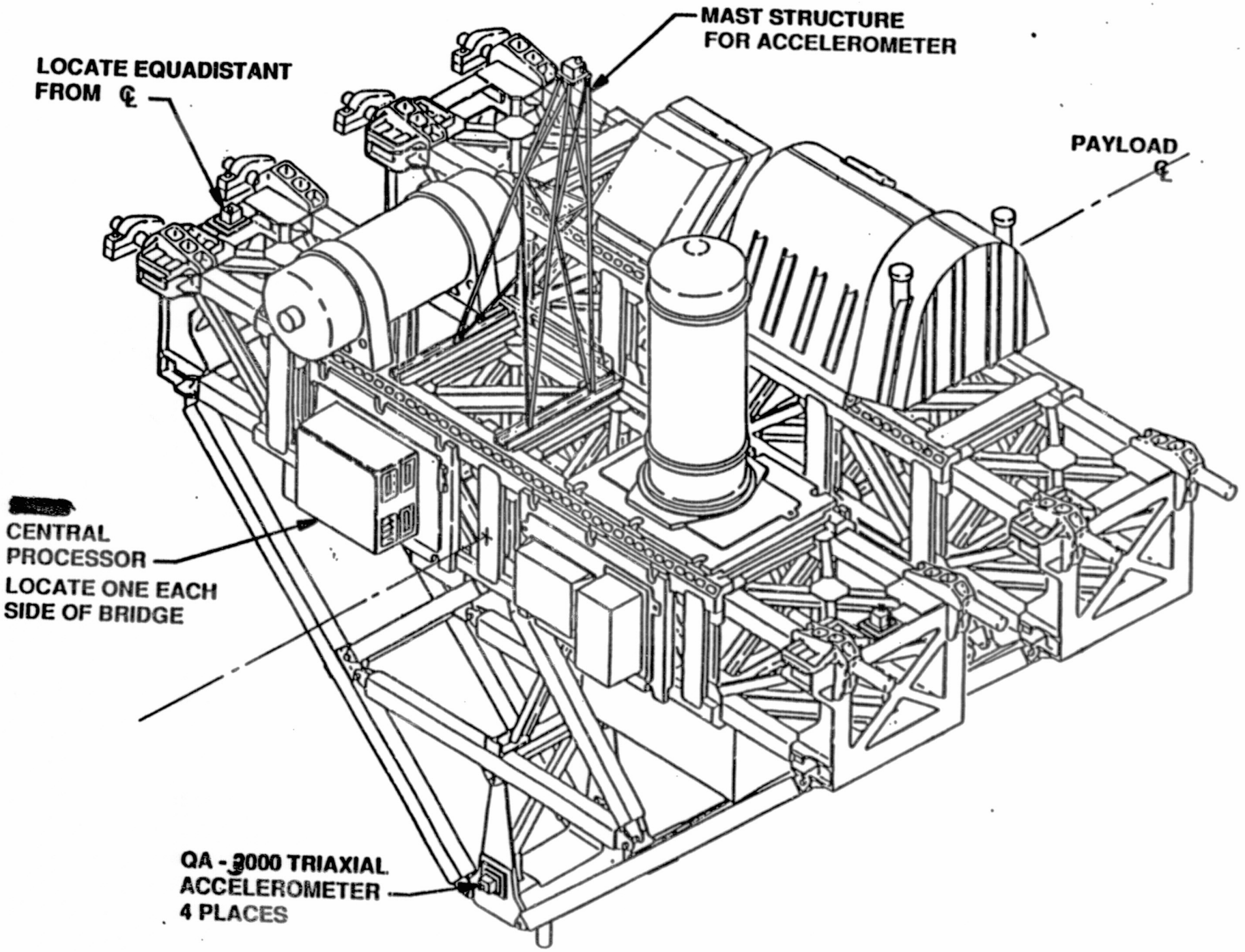


Fig. 9.: Locations of Accelerometers and Processor on Shuttle Bridge Structure

FIG. 5.3

OUTREACH	ACCELERATION MEASUREMENT AND MANAGEMENT	– UAH – TBE

M & M PROCESS FLOW