Whole Body Vibration Exposure of MH-60S Pilots

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Why Study Whole-Body Vibration?

- OPNAVINST 5100.23F
- Prevent long-term back injuries
- Save $$$

What is Whole Body Vibration (WBV)?

- Energy transmitted to the body as a whole, through a supporting surface

- Important Factors:
  - magnitude
  - direction
  - frequency

Health Effects for Whole Body Vibration

- Bone and cartilage degeneration
- Digestive and reproductive system disorders
- Nervous System Disturbances

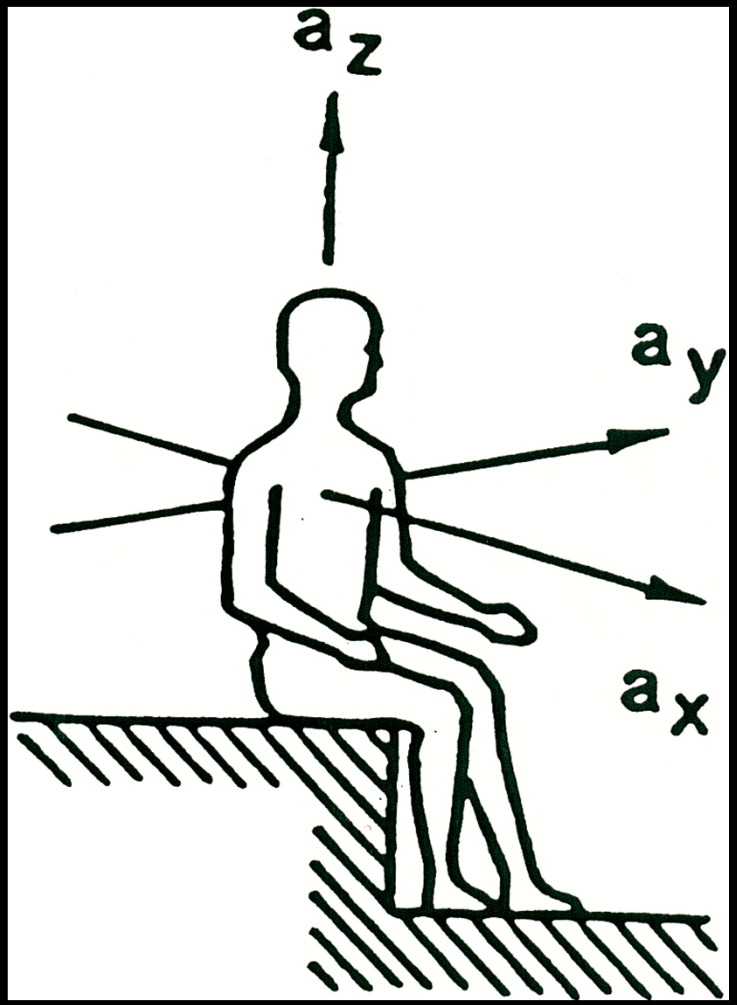
MH-60S

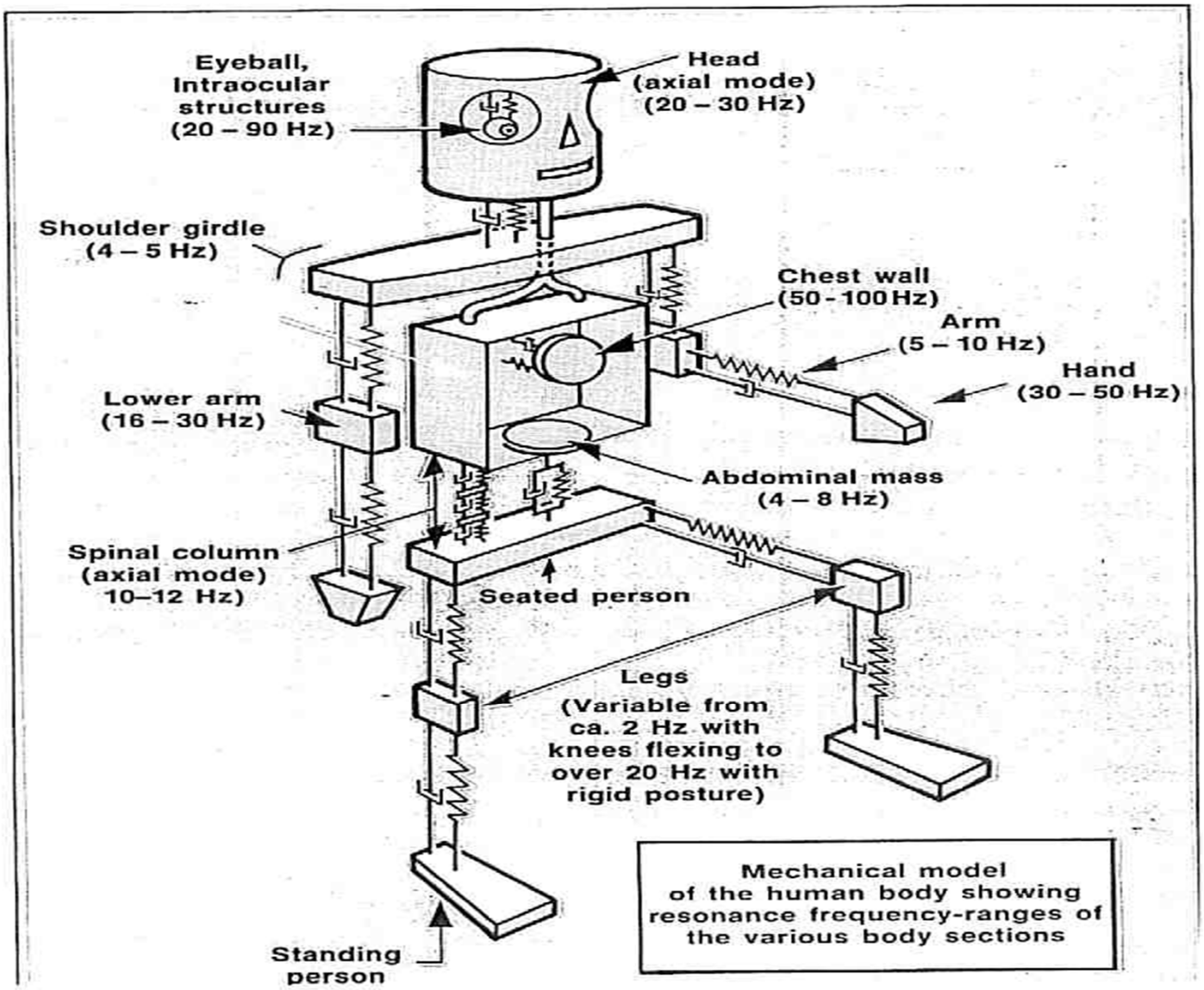
- 2 Navy Pilots
- Up to 13 crewmembers
- SAR, VERTREP, Spec Warfare Support, & Mine Countermeasures
- Seat issue – unauthorized cushion

Measuring Vibration

- Acceleration: measure of vibration
- Vibration: magnitude and direction
- Measurements: three directions: x, y, z
- Units: meters per second squared (m/s^2)

Biodynamic Coordinate System





Mechanical model of the human body showing resonance frequency-ranges of the various body sections

How Do We Control Exposure to Whole Body Vibration ?

- Redesign or engineering controls
- Maintain seating systems
- Administrative controls
- Anti-vibration seat cushions

Previous Study

- Pilot and crew seats evaluated in 2004
- Results showed crew seat won!
- X-axis at 16Hz was the worst for WBV
- 4-8 hour TLV curves were reached for the Z-axis

Current Study

- Compare current MH-60S pilot/co-pilot seat cushion to an “anti-vibration” seat cushion

Current Seat Cushion

“Anti-vibration” Seat Cushion

Current MH-60S Pilot Seats

- 1” Foam Cushion
- Minimal lumbar support
- Adjustable Fore/aft & vertically
- Crashworthiness
  - Sustain a 19G crash
  - Spinal Force

Needs for New Seat Design

- Comfort (Limited Focus)
  - "Excessive use of soft cushion is a common fault in helicopter seats. This type of seat may appear to be comfortable to the casual occupant, but after an hour or so the material begins to ‘bottom’ under the load and the pelvis gradually sinks towards the floor of the seat pan."

An Approach to the Problem of Backache in Aircrew Dr. J.G. Fitzgerald, RAF Institute of Aviation Medicine

Seat Cushion Specifications

- Crash worthiness:
  - 19G/1500 pound lumbar load survivability specification of 14 CFR (FAR) 23.562
- Fire Resistance
- Flotation capability

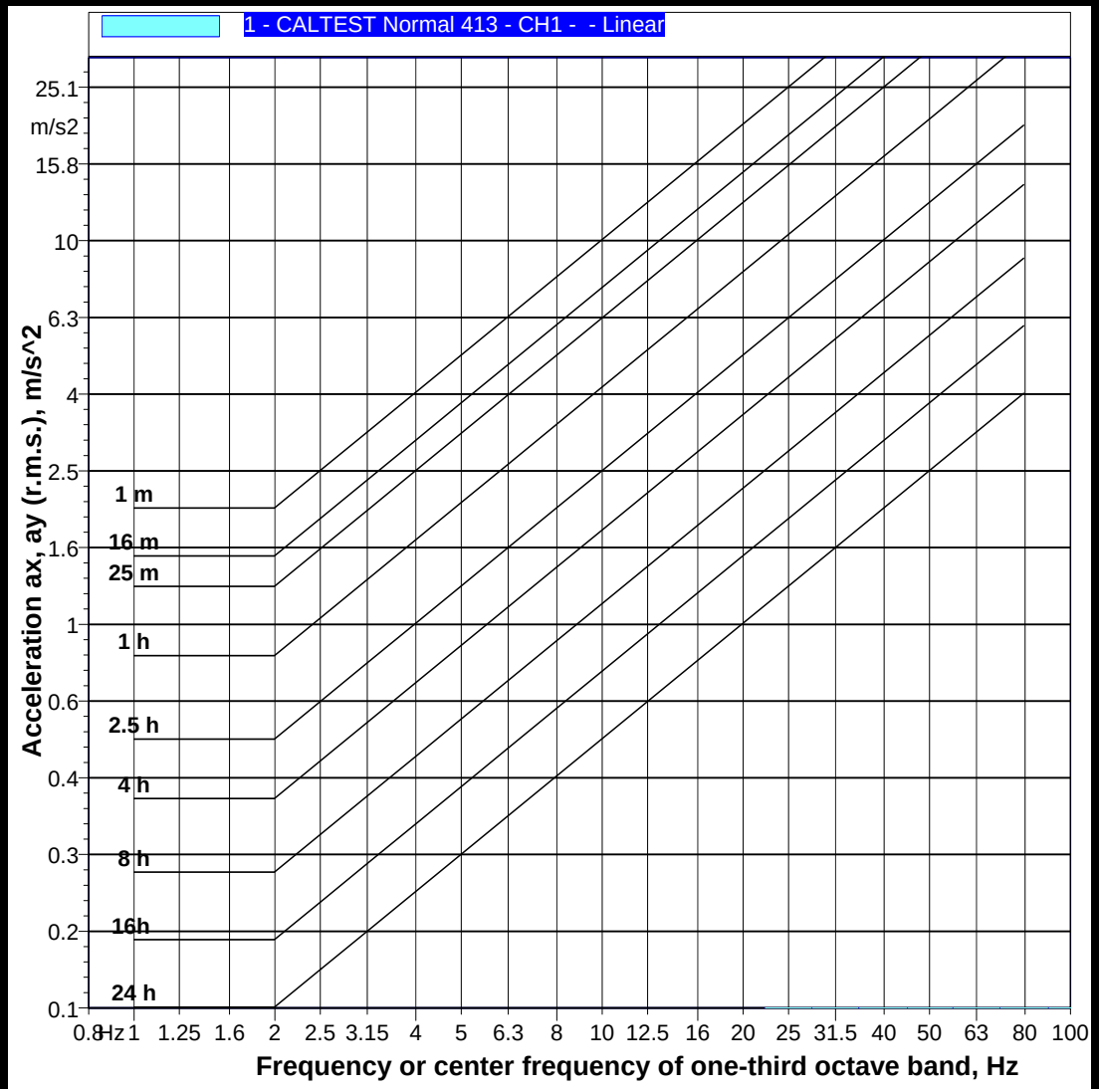
Solutions to Design Problem

- Material construction: Visco-elastic rate damping foams
  - Acts like shock absorber – not a spring
  - Slowly returns to original shape after impact
  - Crashworthiness:
    - 50 to 200 milliseconds of a crash or ejection
    - Poly foams return instantly, creating the "jack-hammer" effect
    - Converts kinetic energy to thermal energy as indicated by 2°F temperature increase resulting from a 50 millisecond pulse

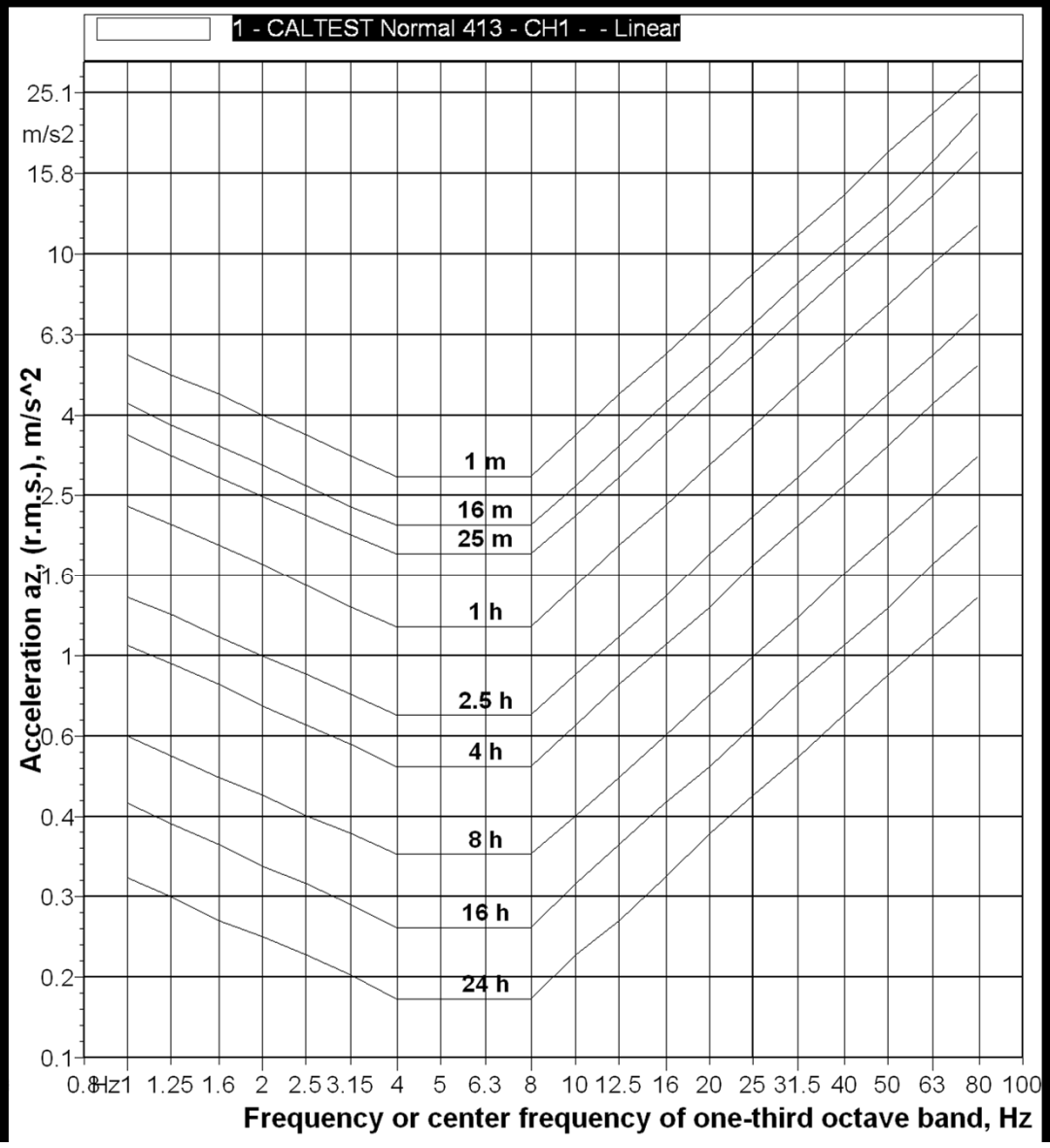
Whole Body Vibration Standards

- ISO 2631-1
  Guidelines for evaluation of whole body vibration
- ANSI S3.18-1979
  Whole body vibration standard
- MIL-STD 1472-F
  DOD Guidelines for design criteria
- ACGIH-TLV
  Guidelines for evaluation and control

Whole Body Vibration
ACGIH-TLV for X &Y-axis



Whole Body Vibration ACGIH-TLV for Z-axis



Recommended Action Level

- 0.5 m/s^2 for an 8 hour day
- Recommended by the Commission of the European Communities

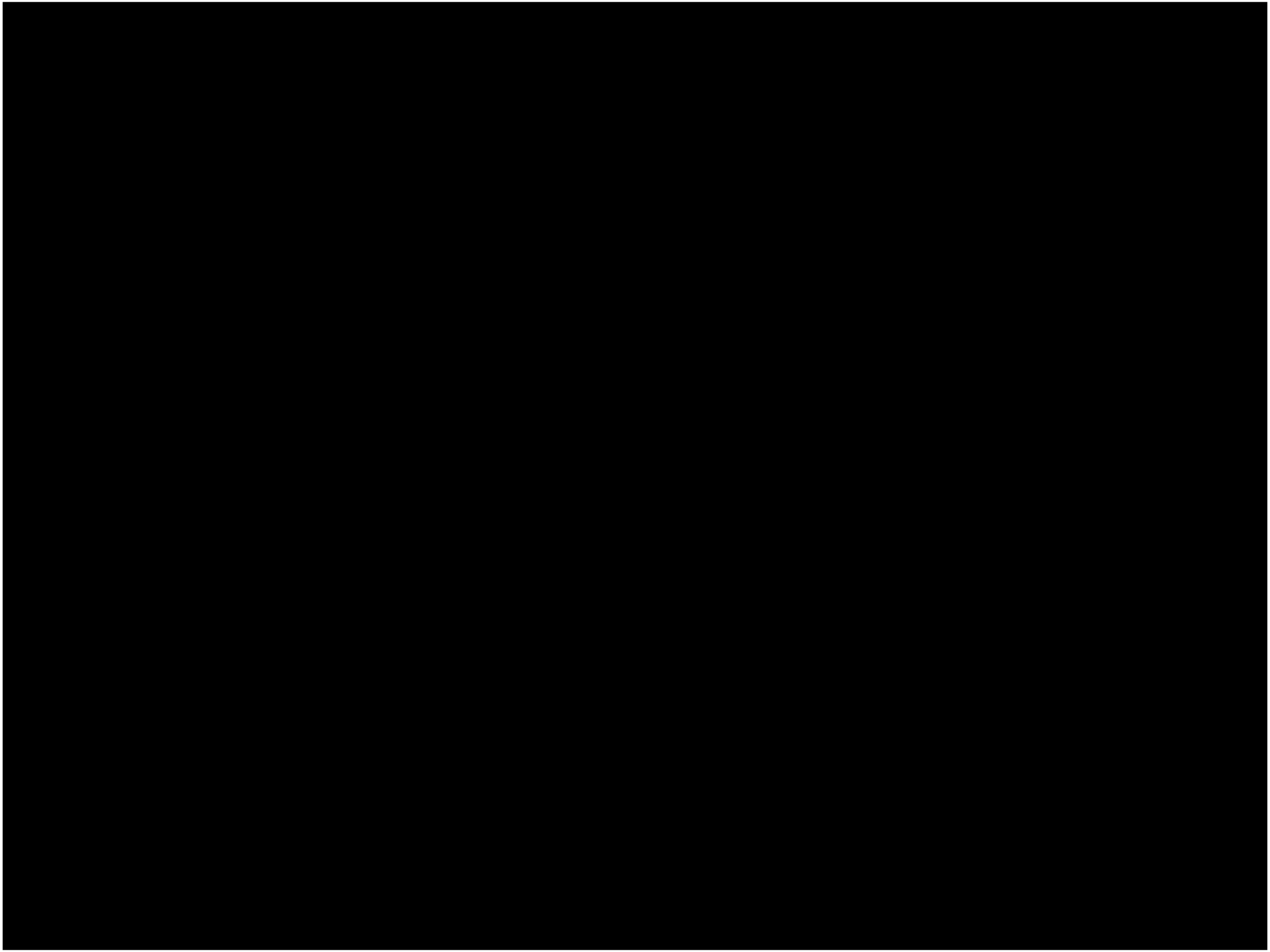
Methods

- 4 straight and level flights
- Acceleration for each axis averaged over 5 min intervals
- Compared original seat cushion to anti-vibration seat cushion
- Statistical Analysis (t-test) performed for each axis at the dominant frequency

Instrumentation

2 SVAN 948's

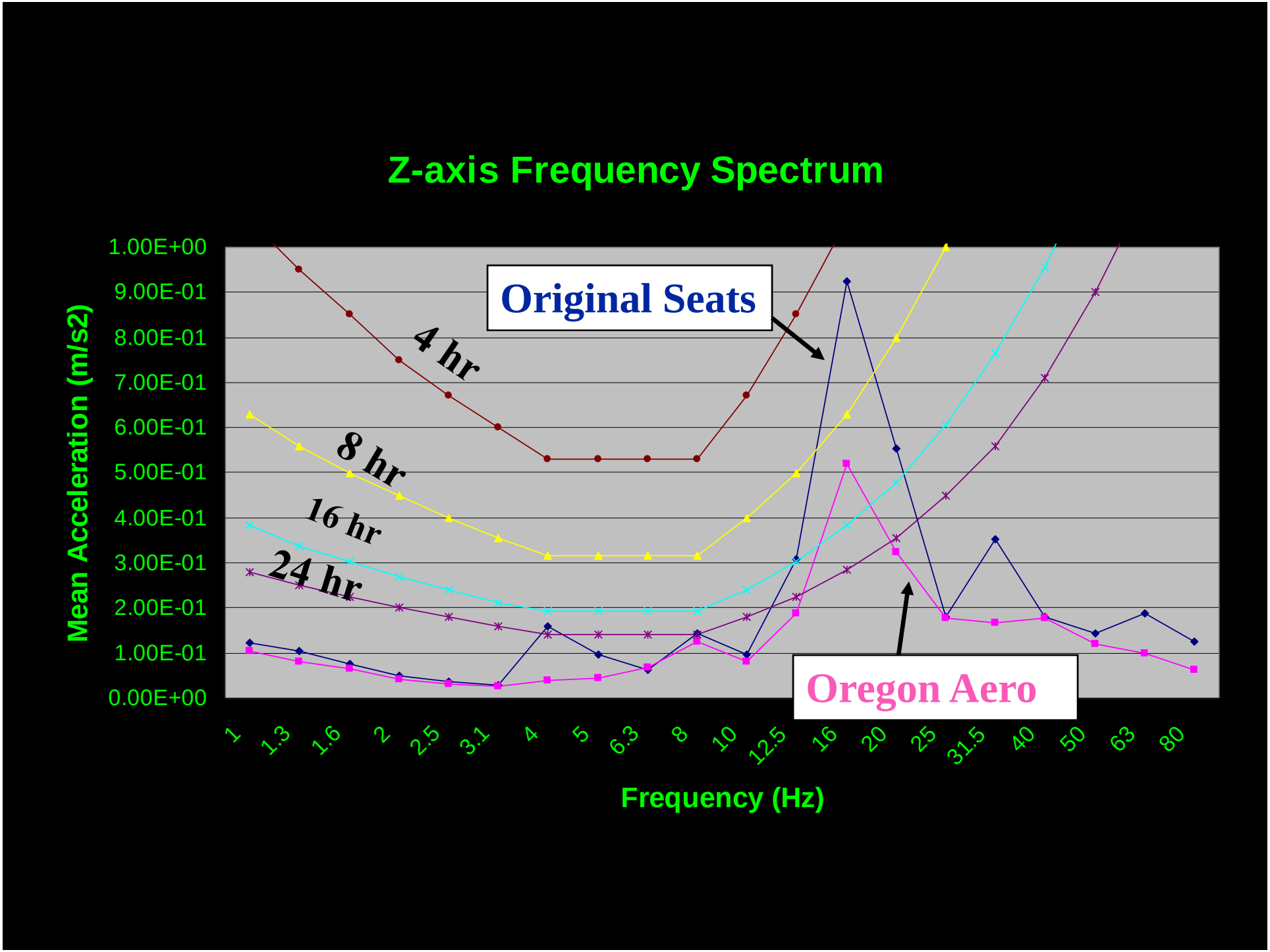
2 tri-axial accelerometer seat pads



Weighted Results

	X-axis	*Y-axis*	*Z-axis*
Original Seat Cushions	0.21 m/s^2	0.20 m/s^2	1.38 m/s^2
Oregon Aero Seat Cushions	0.20 m/s^2	0.19 m/s^2	0.88 m/s^2

******** ***0.5 m/s^2 is the recommended Action Level by the Commission of European Communities***


Z-axis Frequency Spectrum
Mean Acceleration (m/s2)
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
1
1.3
1.6
2
2.5
3.1
4
5
6.3
8
10
12.5
16
20
25
31.5
40
50
63
80
Frequency (Hz)
4 hr
8 hr
16 hr
24 hr
Original Seats
Oregon Aero

Statistical Summary of the Two Sample t-test in the Z-axis at 16Hz

Seat Cushion	Mean Acceleration (m/s^2)	Standard Deviation (m/s^2)
Original	1.247	0.303
Oregon Aero	0.707	0.163

t-value = 2.65 → **$p \leq .005$** → **Highly significant**

Discussion

- More studies needed
- Fixing accelerometer to seat cushion is an issue.
- Whole-body vibration is a problem!
- Anti-vibration seat cushion is an improvement

Future Studies

- Continued seat cushion comparison
- Longer flights
- Transmissibility study
- Crew seat study
- Other Navy operations

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QUESTIONS????

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