

N 9 3 - 3 1 4 5 8

VIBRATION ISOLATION

by

Paul Bastin

Flight Crew Systems Department
McDonnell Douglas Space Systems Company
Space Station Division (HB)
5301 Bolsa Avenue, Mail Code 15-1
Huntington Beach, CA 92647

Phone: (714) 896-1399 Fax: (714) 896-2937

435

■ Outline

- Introduction
- Space Station Vibration Requirements
- Proposed Application
- Typical Solutions
- Summary
- Panel Discussion

SP-54
163092
P. 9

— Space Station Freedom

McDonnell Douglas • GE • Honeywell • IBM • Lockheed

VIBRATION ISOLATION

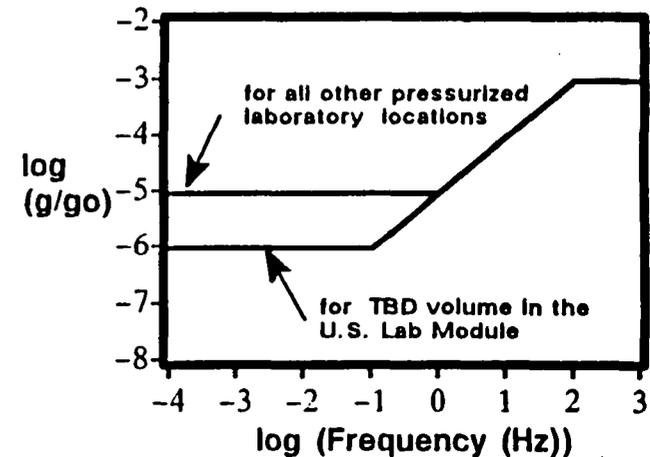
■ INTRODUCTION

- **Many subsystems, payloads, and events on Space Station are potential disturbance sources in the microgravity environment. Examples include**
 - Exercise equipment - treadmill
 - Rotating equipment - centrifuge
 - Planned events - berthing and docking
 - Unplanned events - crew motion
- **Isolation may be required both to attenuate vibration from "noisy" subsystems as well as to protect sensitive payloads**
- **Low frequency disturbance sources are an important concern due to sensitivity of Space Station flexible structure modes**

436

MICROGRAVITY ASSESSMENT CRITERIA

- For continuous periods of at least 30 days and 50% of the operational year, the following criteria applies:
 - No greater than 1 micro-g steady-state acceleration levels in the rack volume of the U.S. Laboratory
 - Torque Equilibrium Attitude +/- 5 degrees of Local Vertical Local Horizontal (LVLH)
 - Induced Vibration acceleration levels:
 - $\leq 1 \times 10^{-6}$ g for $f < 0.1$ Hz
 - $\leq (1 \times 10^{-5} \times f)$ g for $0.1 \leq f \leq 100$ Hz
 - $\leq 1 \times 10^{-3}$ g for $f > 100$ Hz
 - Integrated acceleration response for a 10 second moving window less than 1×10^{-6} g-seconds



VIBRATION ISOLATION

■ PROPOSED APPLICATION

● Life Sciences Centrifuge

- Provide variable gravity centrifugation from 0.01 to 2 g for specimens (maximum 40 RPM [0.7 Hz] rotation rate)
- Rotating mass approximately 2200 lb
- 2.5 meter diameter
- Mounted in Space Station Node endcone
- Independent extraction rotor spins up and down to remove a pair of specimen habitats from rotating main rotor
- Disturbance to Space Station limited to 25% of microgravity requirement
- Disturbance to specimens limited to 1×10^{-3} g in frequency range 0.1 to 100 Hz

— Space Station Freedom

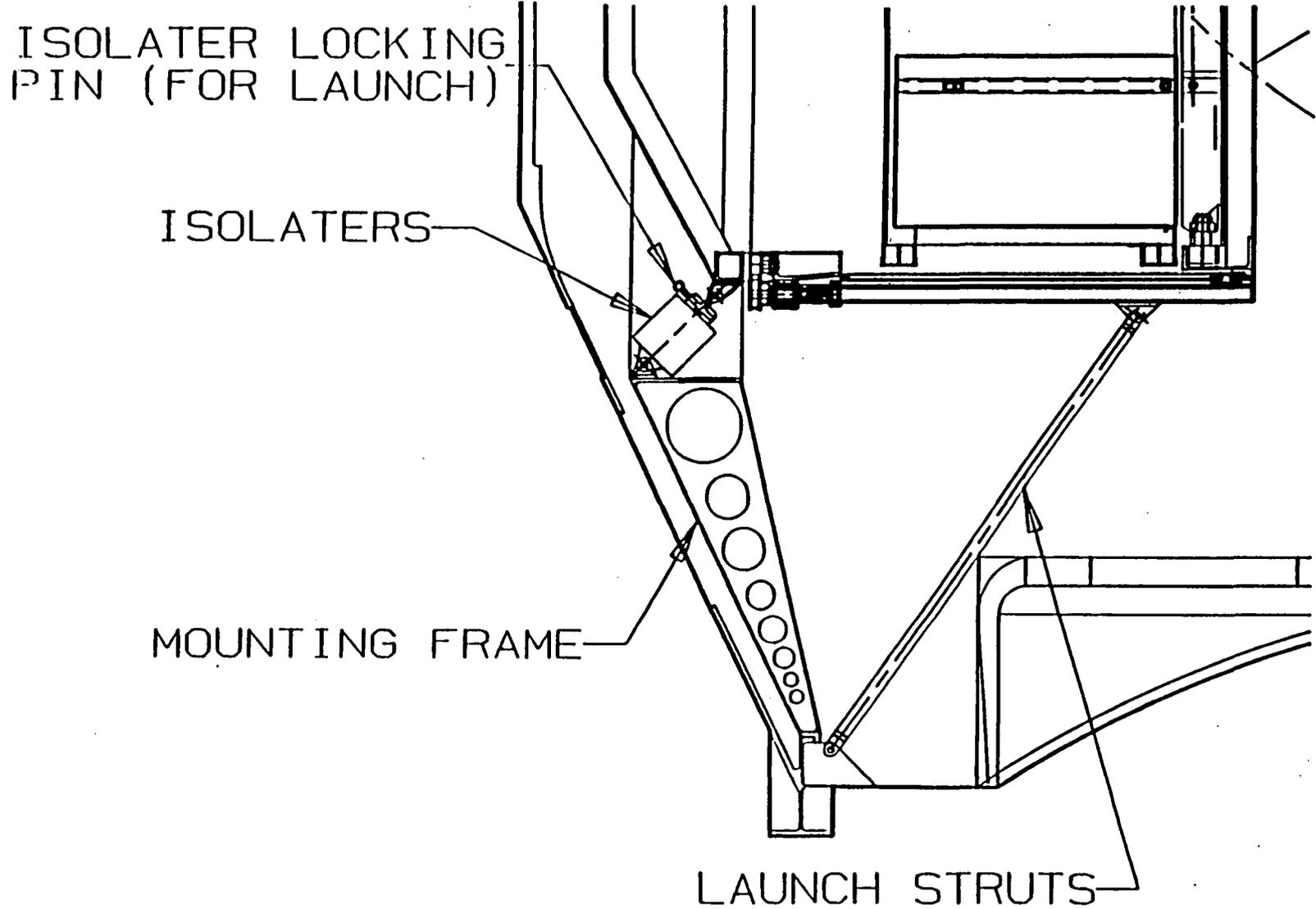
McDonnell Douglas • GE • Honeywell • IBM • Lockheed



ADDITIONAL DESIGN DETAILS

NASA / AMES RESEARCH CENTER

FLIGHT SUPPORT EQUIPMENT FOR LAUNCH

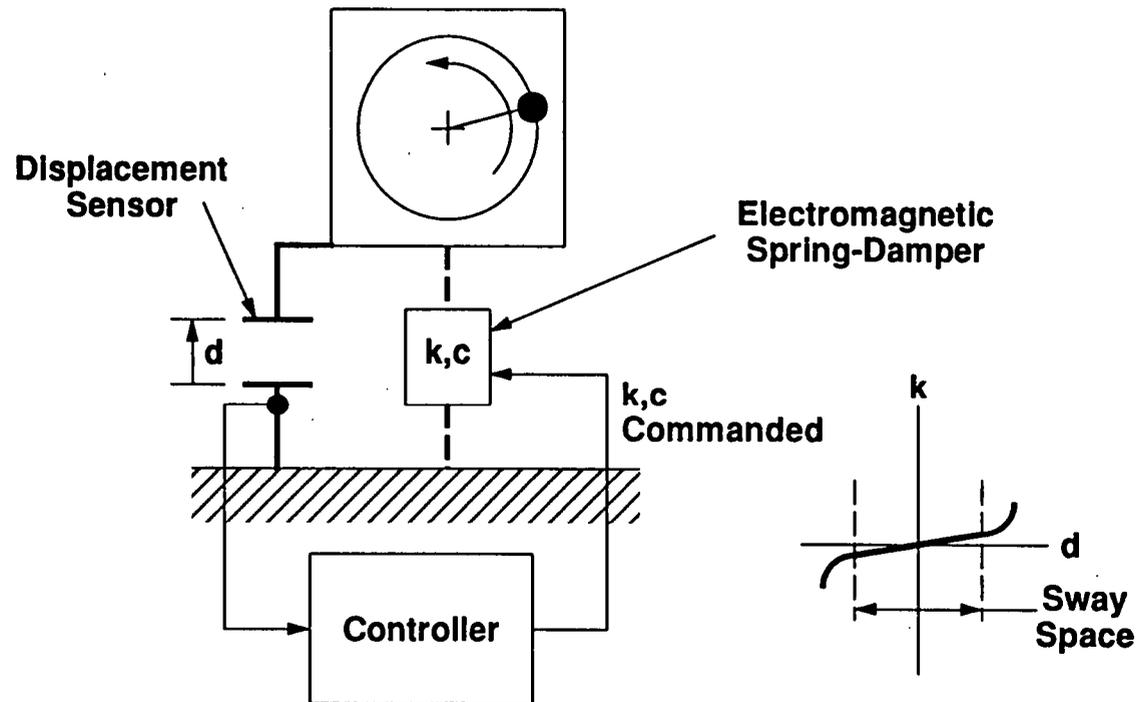


439

VIBRATION ISOLATION

■ TYPICAL SOLUTIONS

- Active vibration isolation system



440

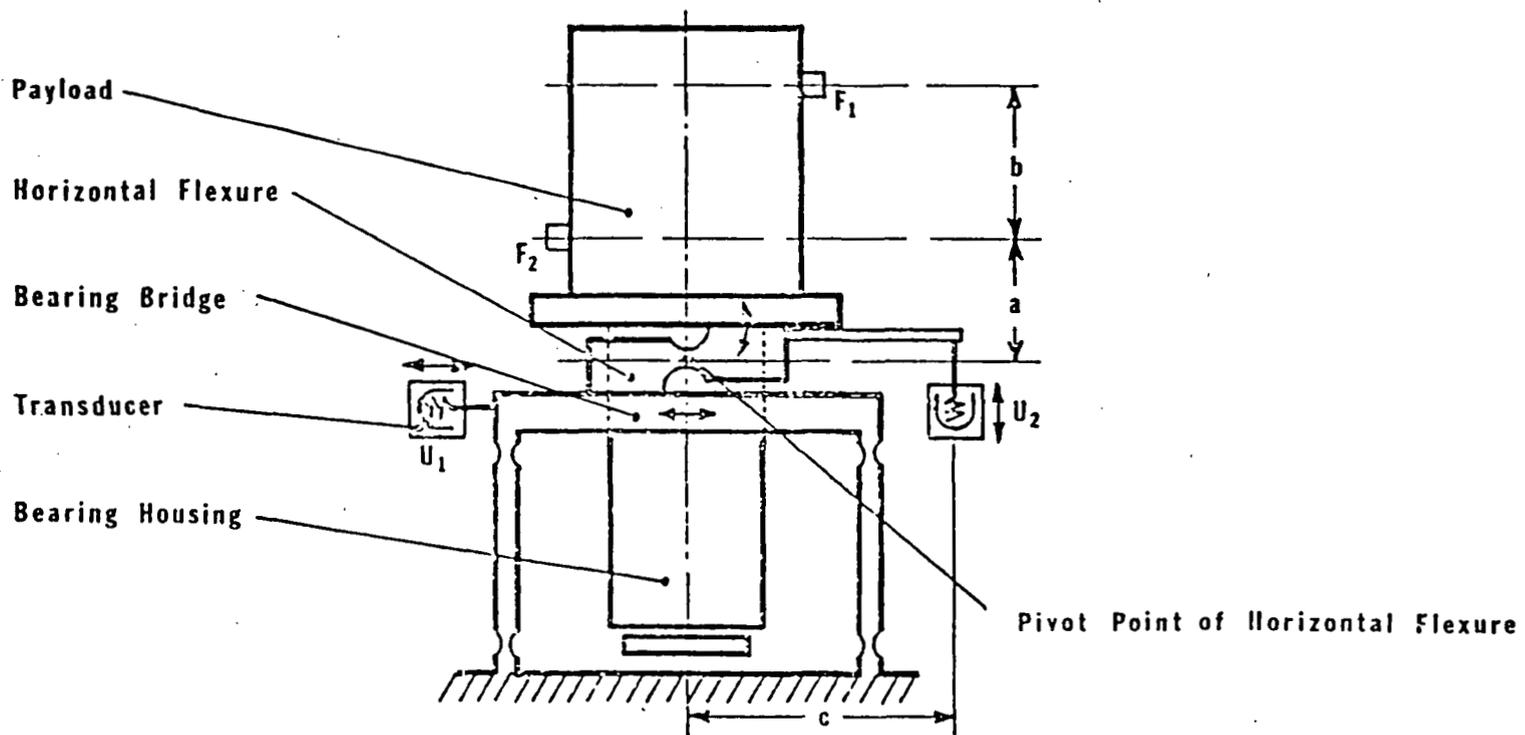
— Space Station Freedom

McDonnell Douglas • GE • Honeywell • IBM • Lockheed

VIBRATION ISOLATION

■ TYPICAL SOLUTIONS (continued)

● Active balancing system



$$U_1 = F_1 + F_2$$

$$U_2 = F_1 \cdot \frac{a+b}{c} + F_2 \cdot \frac{a}{c}$$

Data courtesy of Schenk Trebel

Space Station Freedom

McDonnell Douglas • GE • Honeywell • IBM • Lockheed

VIBRATION ISOLATION

■ SUMMARY

- Techniques to control and isolate centrifuge disturbances have been identified
- (Opening questions for Panel discussion)

How can fuzzy logic be applied to Space Station vibration isolation systems to improve performance over passive approaches or reduce the cost and complexity of active approaches?

Could fuzzy logic control be used to facilitate an inexpensive active low frequency isolator? Could a simple active controller be implemented to augment a conventional passive isolator?

Can fuzzy logic control be used to improve signal to noise ratio or response time?

Topic: Vibration Isolation
Presenter: Paul Bastin

Comment: (Knackstedt) The problem of vibration isolation may have more stringent requirements than those of Rotational Speed Control.

Comment: (Brown) The conflicting requirements mentioned have no effect on the fact that there is a serious problem of isolation of vibrations. The question of whether Fuzzy logic can be used to build an active isolator or to design a passive isolator to improve performance over cost should be considered.

Comment: (Berenji) The experiments on board need a steady, vibration-free platform. These systems must be stable, fuzzy logic is applicable. Is this problem different from those of which fuzzy logic can be used?

Comment: (Jani) Fuzzy logic should not be too difficult in implementing a solution to this problem.

Comment: (?) The "fuzzy" control surfaces shown in Dr. Kosko's examples were "pipe organ-ish" showing discontinuity. With Vibration Isolation problem, there is a great concern for smoothing the operation.

Comment: (Berenji) Agreed with comment that a non-smooth transition can create problems. However, the examples shown were not necessarily optimal (which is problem dependent); multiple fuzzy rules can create a smoothing operation