Rotational Vibration Test Data – SCSI Harbor

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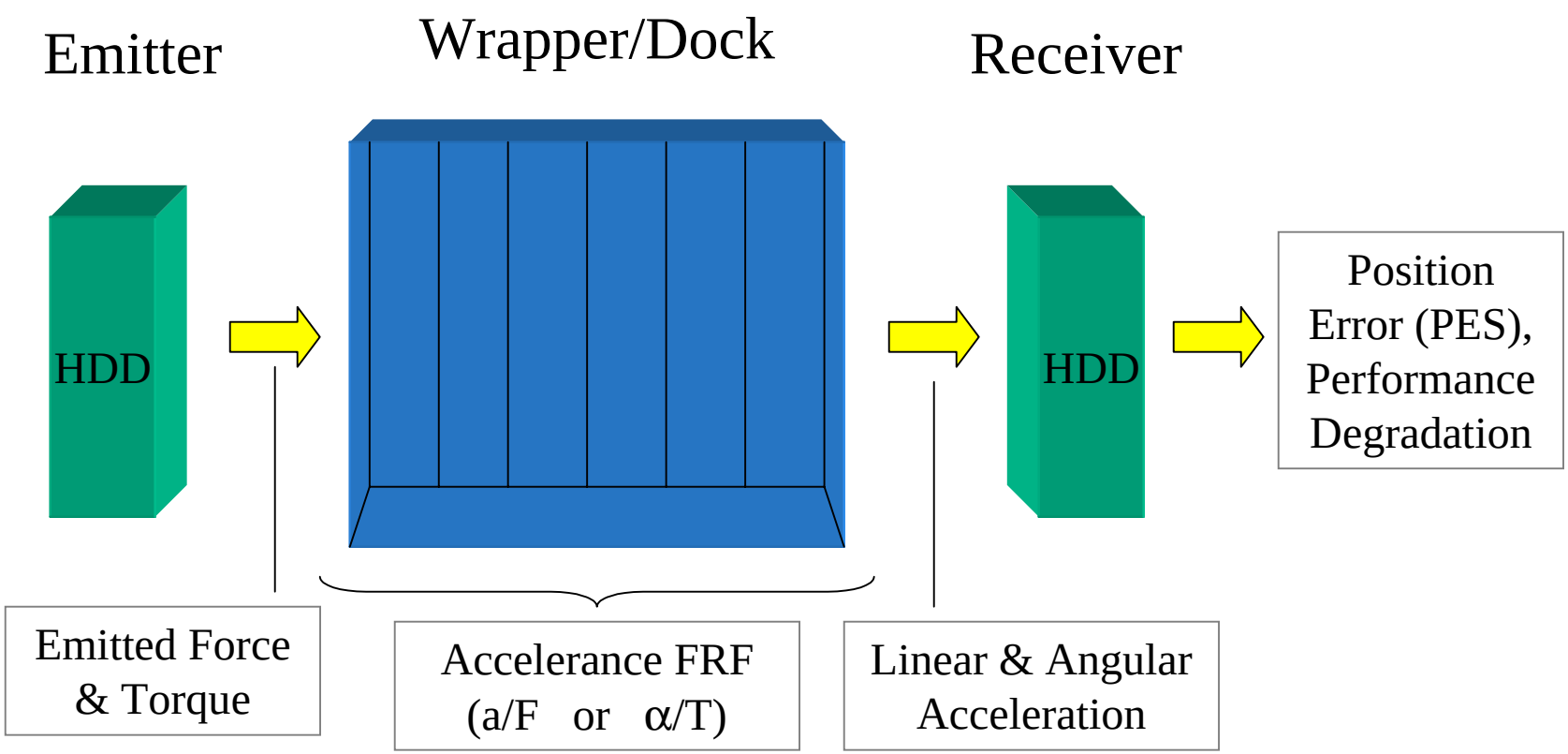
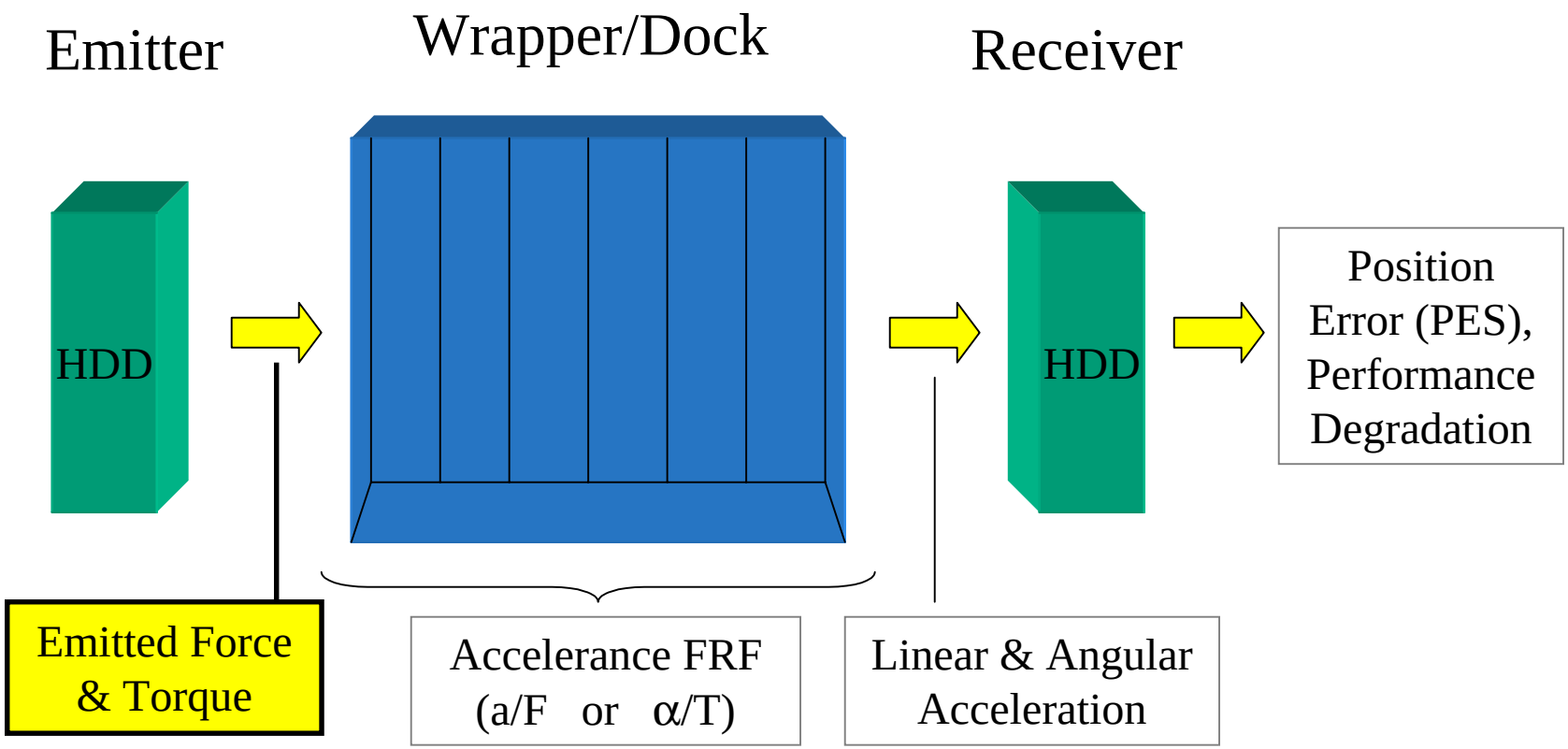
9 February 2000

The Path: From Emitted Vibration to Performance Degradation



Emitted Force & Torque

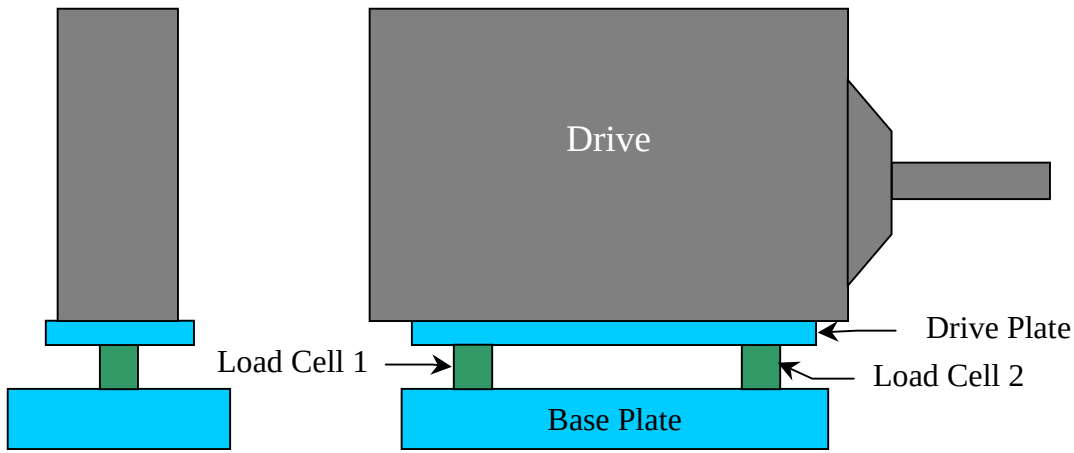


Emitted Force & Torque

- Seeking
  - ¤ Nominally, pure torque is generated
  - ¤ Actuator resonances cause linear force instead of torque
- Disk pack rotation (not studied)

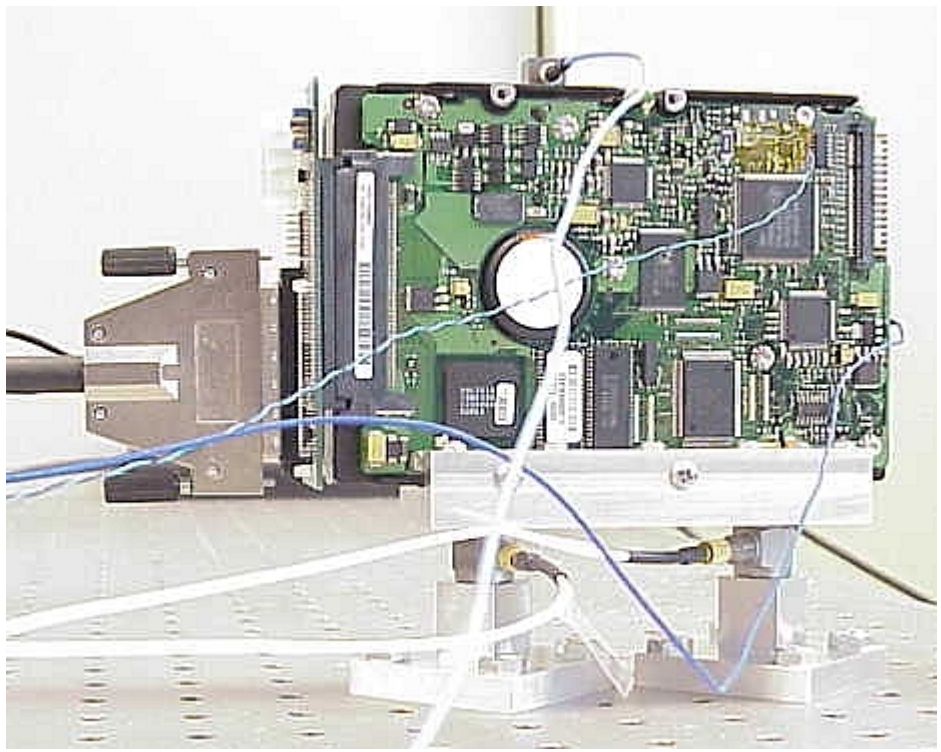
Emitted Force & Torque Measurements

- Dual Force Method



Emitted Force & Torque Measurements

- Setup

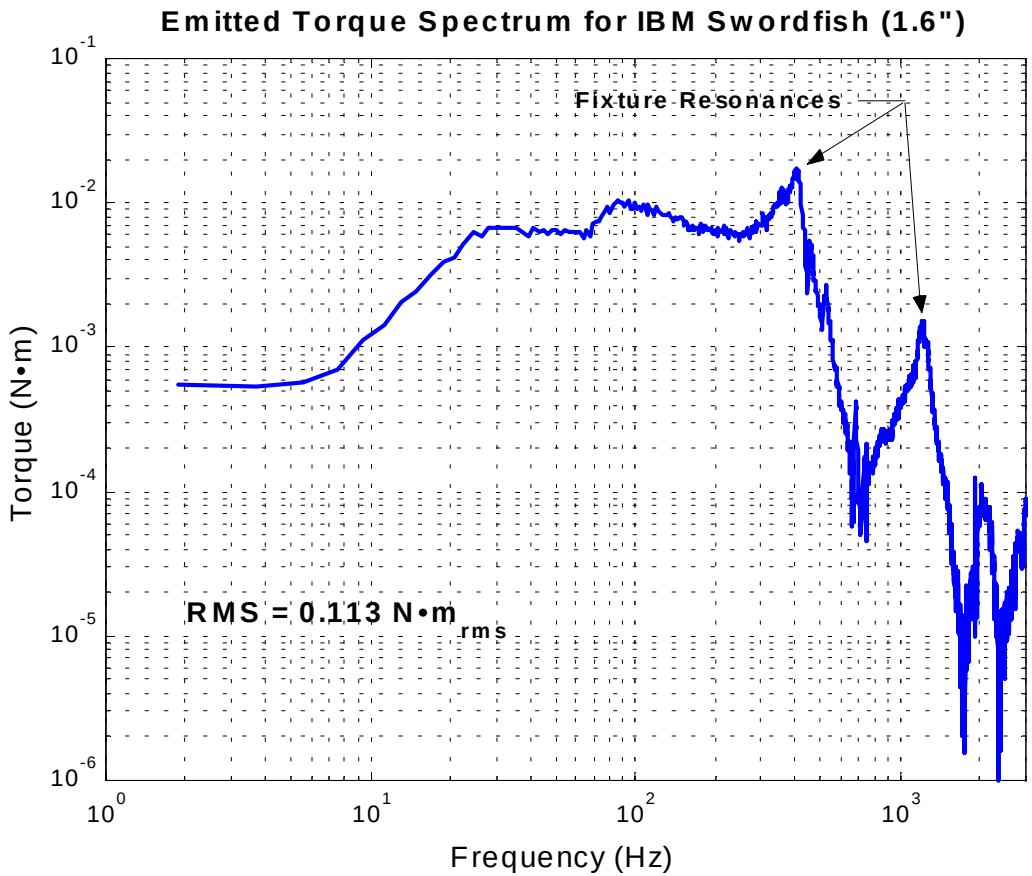


Analysis of Emitted Force & Torque Measurements

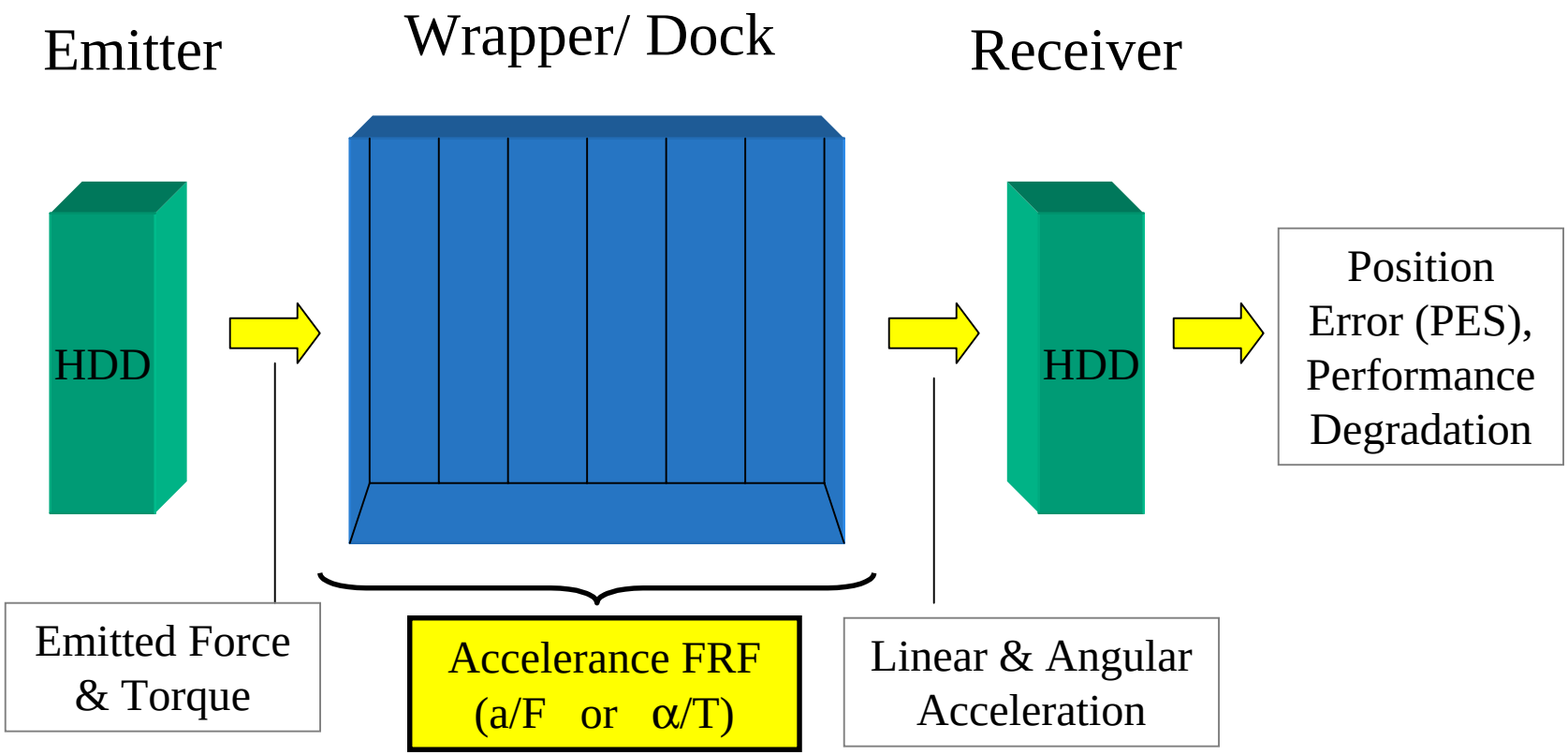
- Time domain
  - ¤ $T_{emit}(t) = [F_2(t) - F_1(t)]/r$
  - ¤ $F_{emit}(t) = ½[F_1(t) + F_2(t)]$
- Frequency domain (from FRFs)

$$T_{emit\_rms}(f) = \left[\frac{F_2(f)}{I_{vcm}(f)} - \frac{F_1(f)}{I_{vcm}(f)}\right] \cdot \frac{r}{2} \cdot \sqrt{I_{vcm\_rms}{}^2(f)}$$

Emitted Torque Spectrum



Structural Transmission

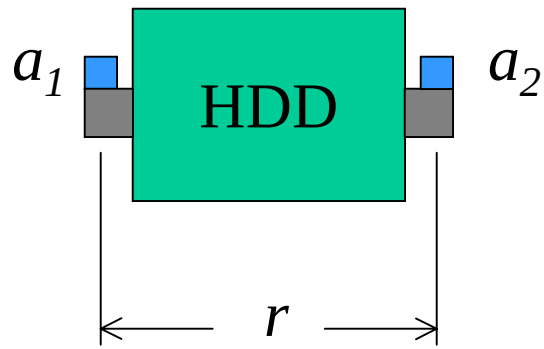


Structural Transmission – Accelerance

- Accelerance is (acceleration/force)
  - Linear: $\frac{a(f)}{F(f)}$
  - Rotational: $\frac{\alpha(f)}{T(f)}$
- Measurement
  - Frequency Response Functions (FRFs) are measured with respect to I_{vcm}

Accelerance Measurements

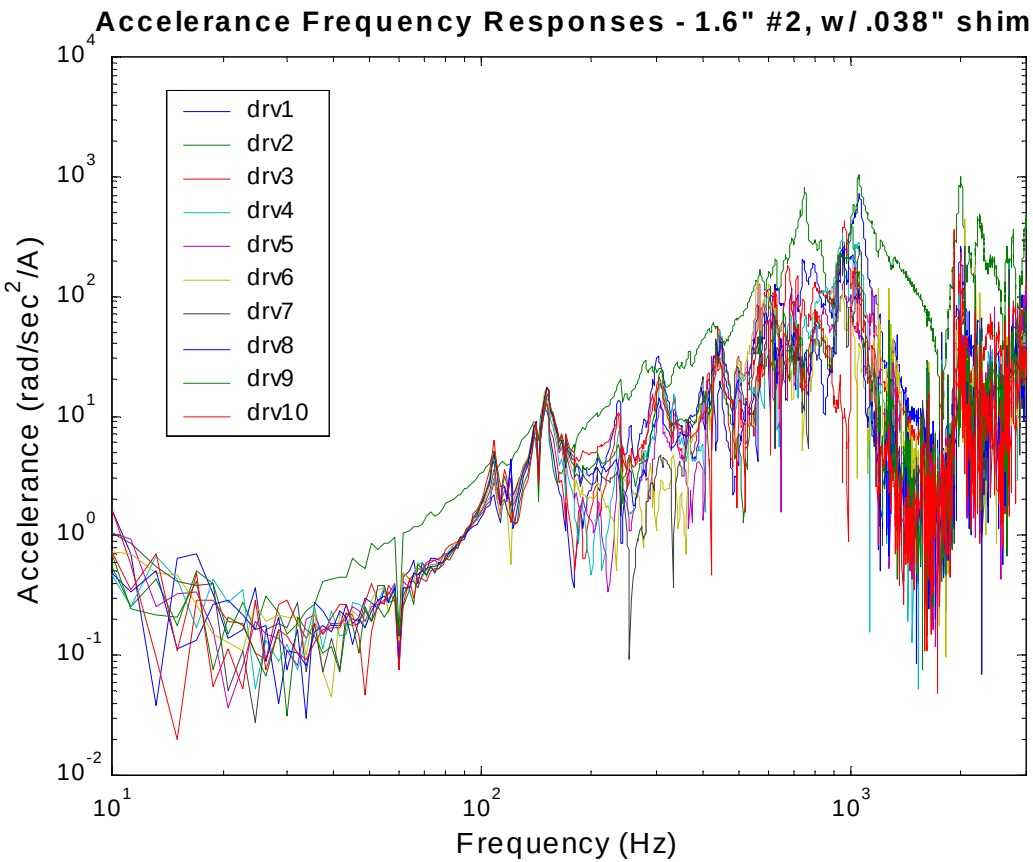
- Setup
  - Measure a_1, a_2 at each receiver
  - Measure I_{vcm} at driver



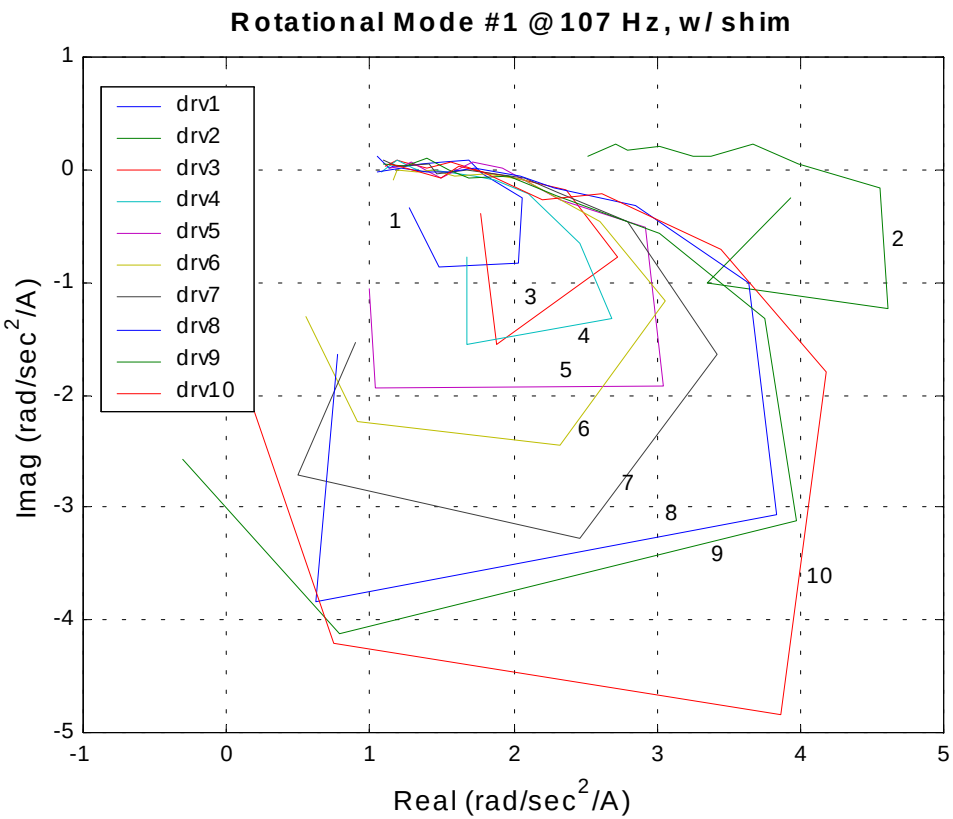
$$\frac{\alpha_{ij}(f)}{I_{vcm\_i}(f)} = \frac{1}{r} \cdot \left[\frac{a_{2j}(f)}{I_{vcm\_i}(f)} - \frac{a_{1j}(f)}{I_{vcm\_i}(f)} \right]$$

for receiving drive ***j*** driven by drive ***i***

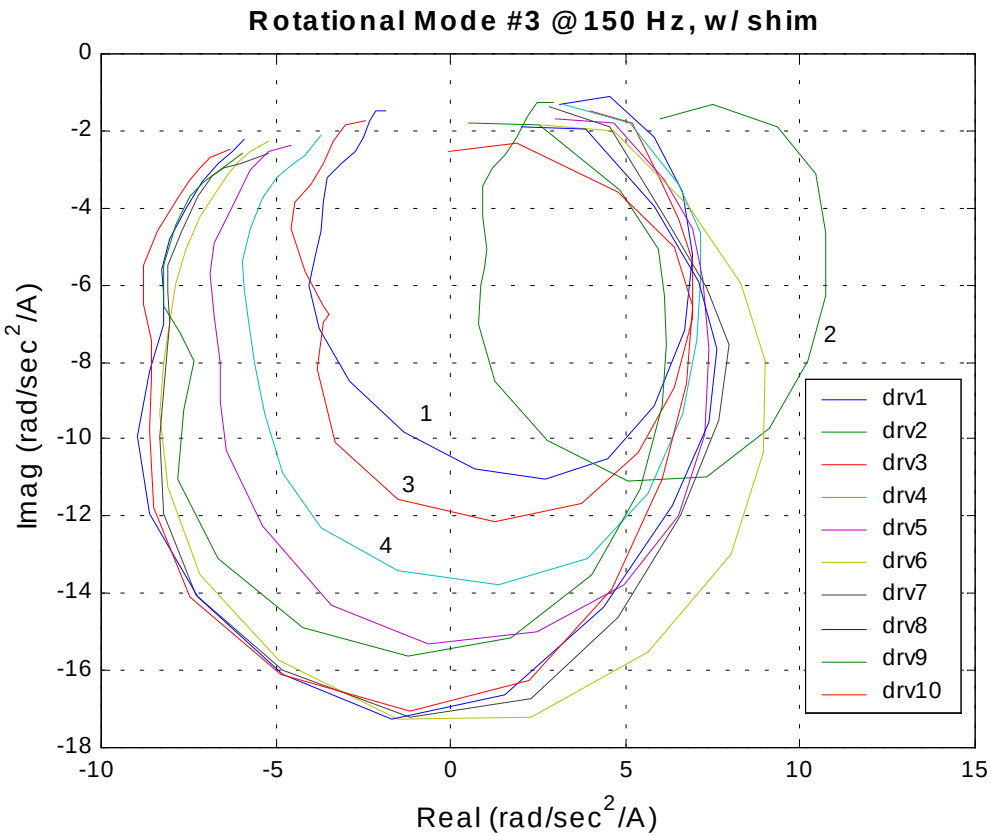
Accelerance Results



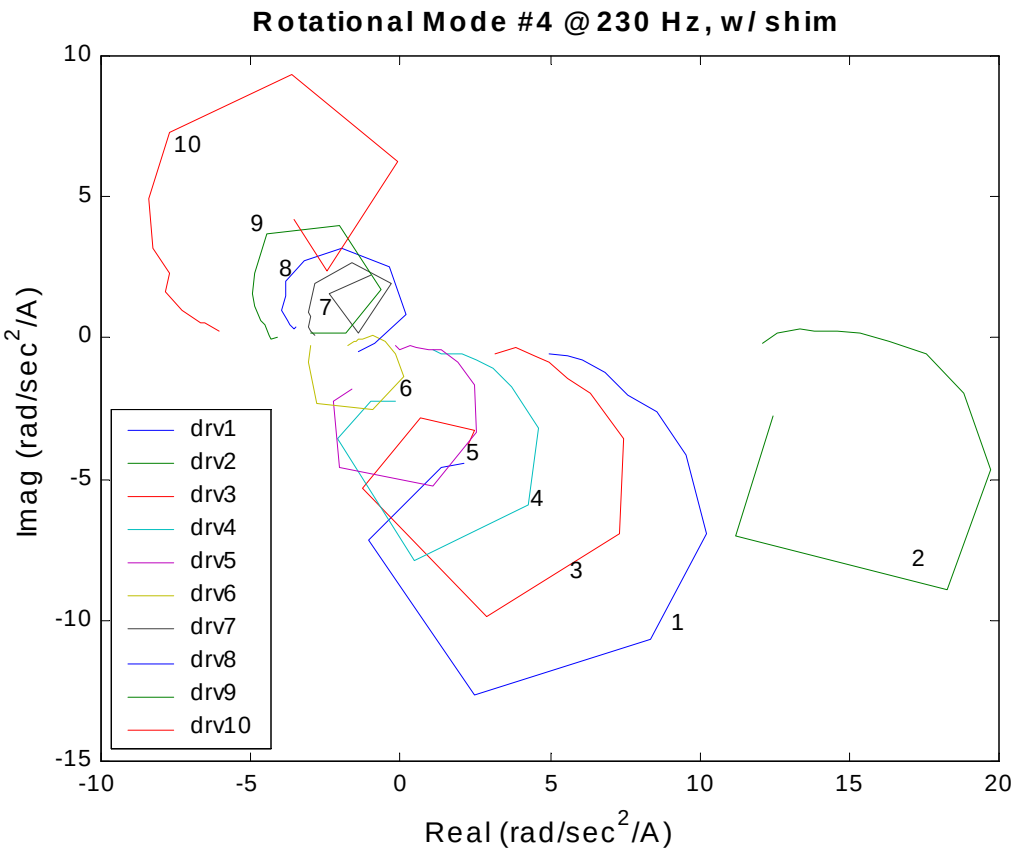
Mode Shapes from Accelerance



Rotational Mode #3 – 150 Hz



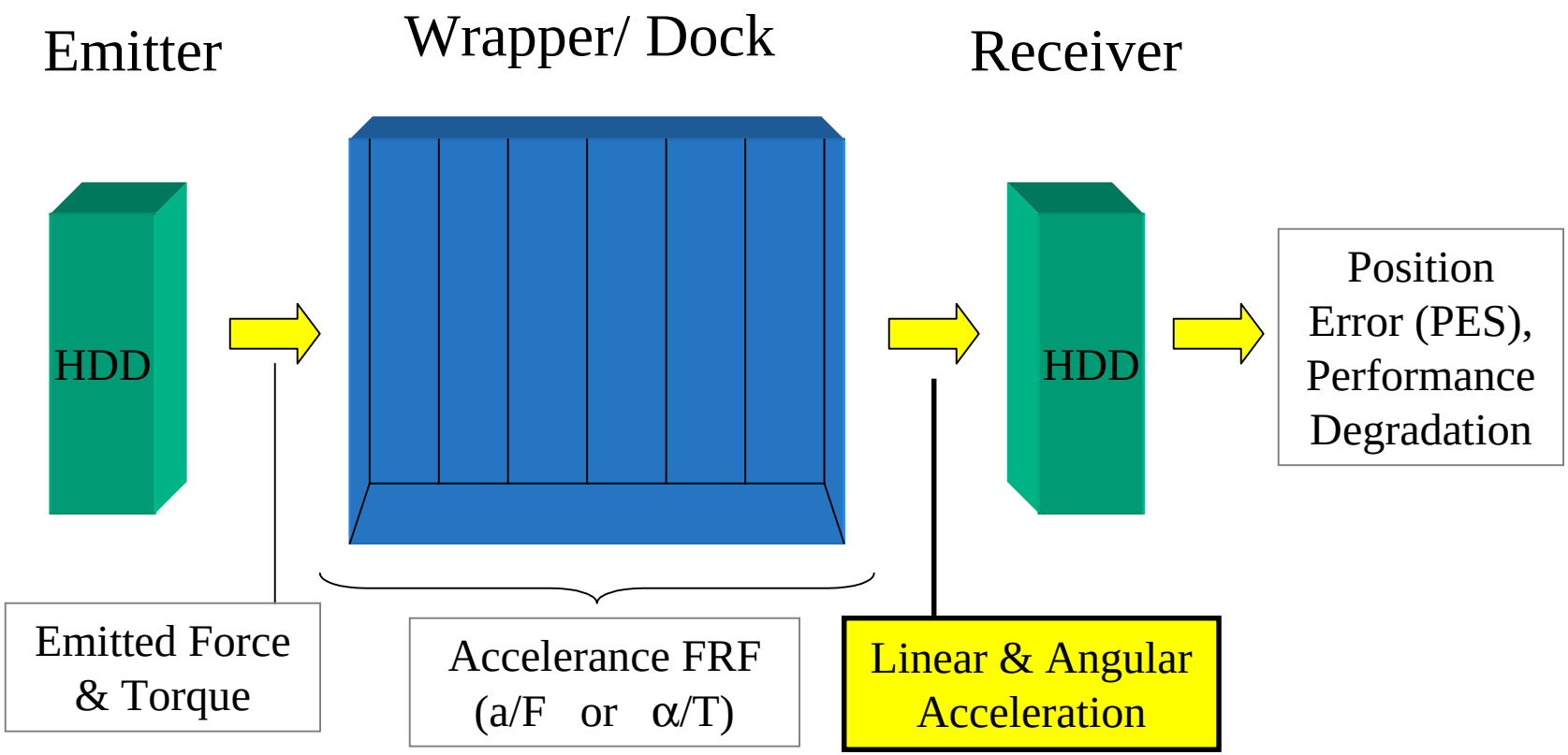
Rotational Mode #4 – 230 Hz



Modal Analysis

- Results are with hammer excitation
- Don’t have results with drive excitation (the superior method)
- **Rotational modes that affect performance may not be excited by linear** (hammer or shaker) **excitation!**

Predicting the Rotational Vibration Environment



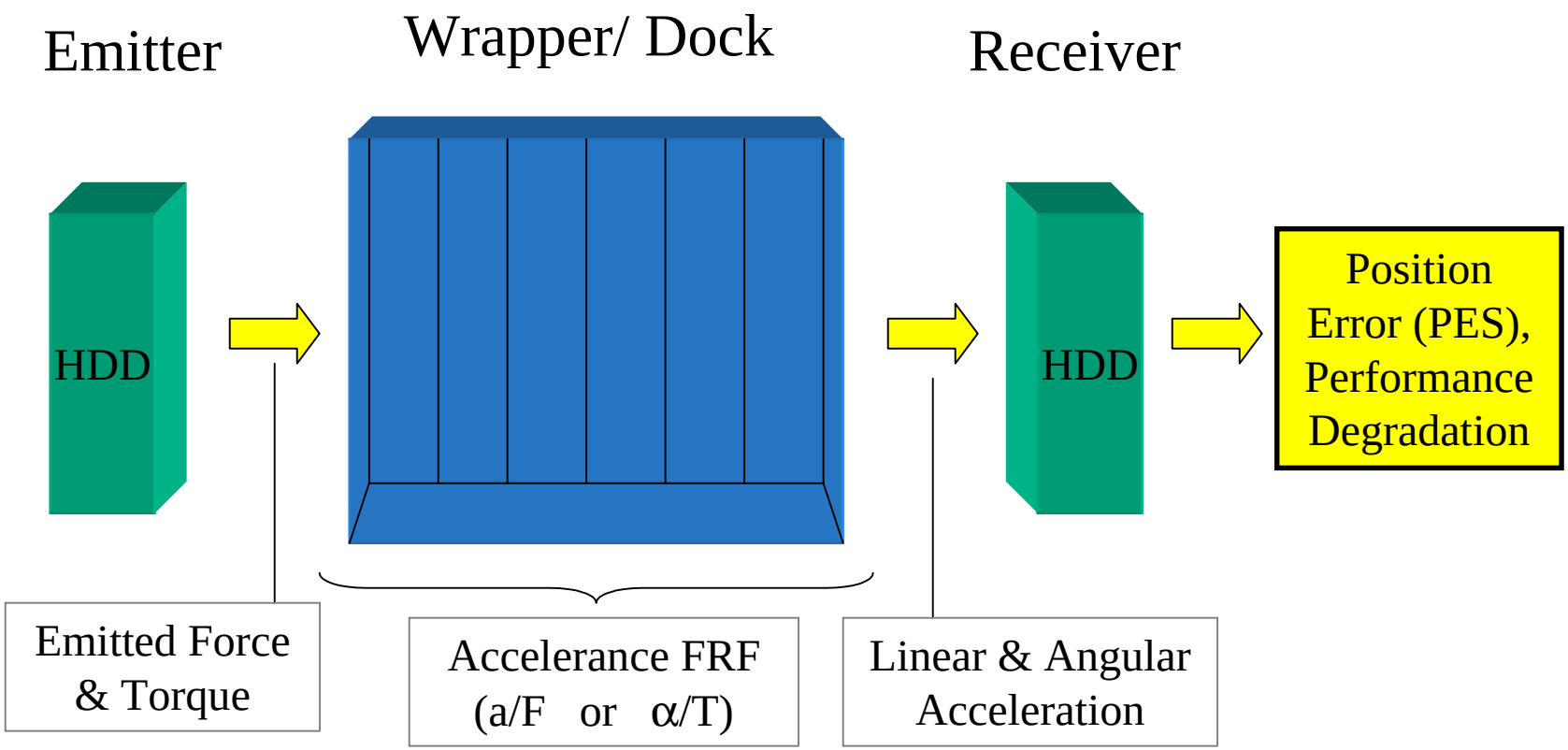
Predicting the Rotational Vibration Environment

- For Rotational Vibration, PES depends on angular displacement (θ) and frequency (*f*)

$$x_{RV\_j}(f) = \sqrt{\sum_{i=1}^{N} \left[\underbrace{T_{emit\_i}(f) \frac{\alpha_{ij}(f)}{T_{emit\_i}(f)}}_{\text{Ang accel}} \frac{r_{hd}}{s^2} \right]^2}$$

Off-track displacement @head [= $x_{RV\_ij}(f)$]

Rotational Vibration and Position Error



Rotational Vibration and Position Error

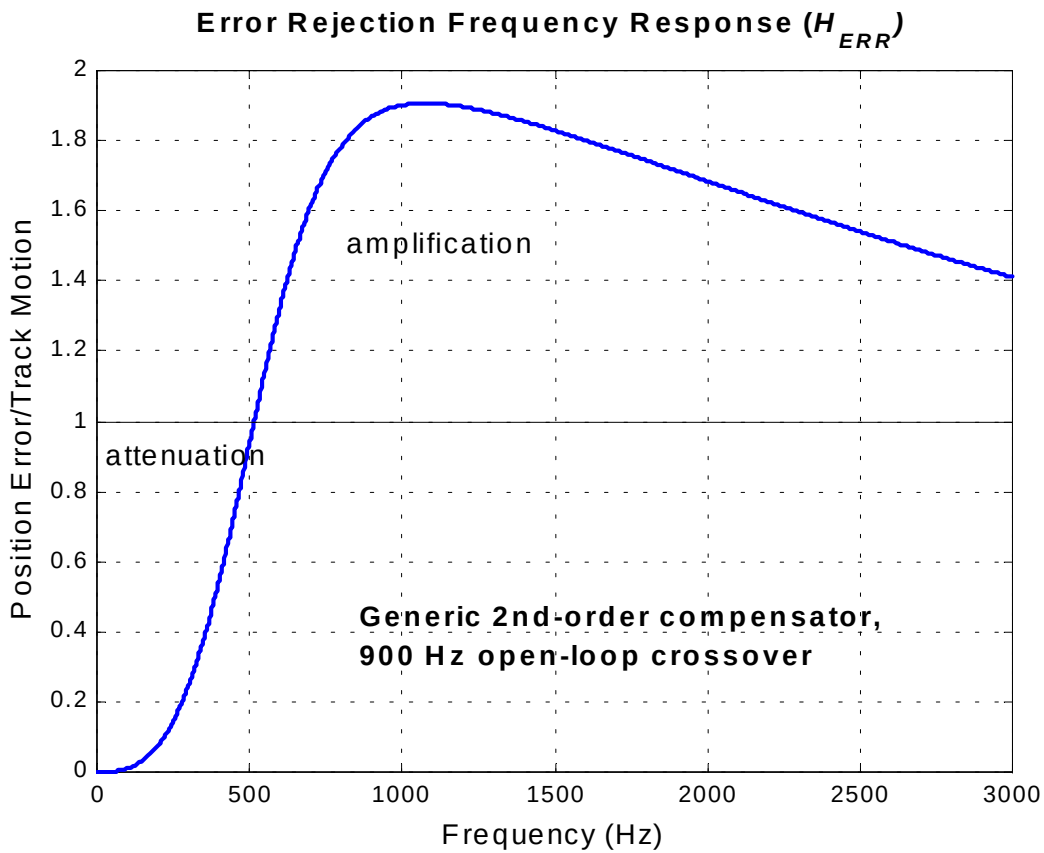
- Linear acceleration
- Angular acceleration (rotational vibration)

$$PES_{RV\_j}(f) = x_{RV\_j} \cdot H_{ERR}(f)$$

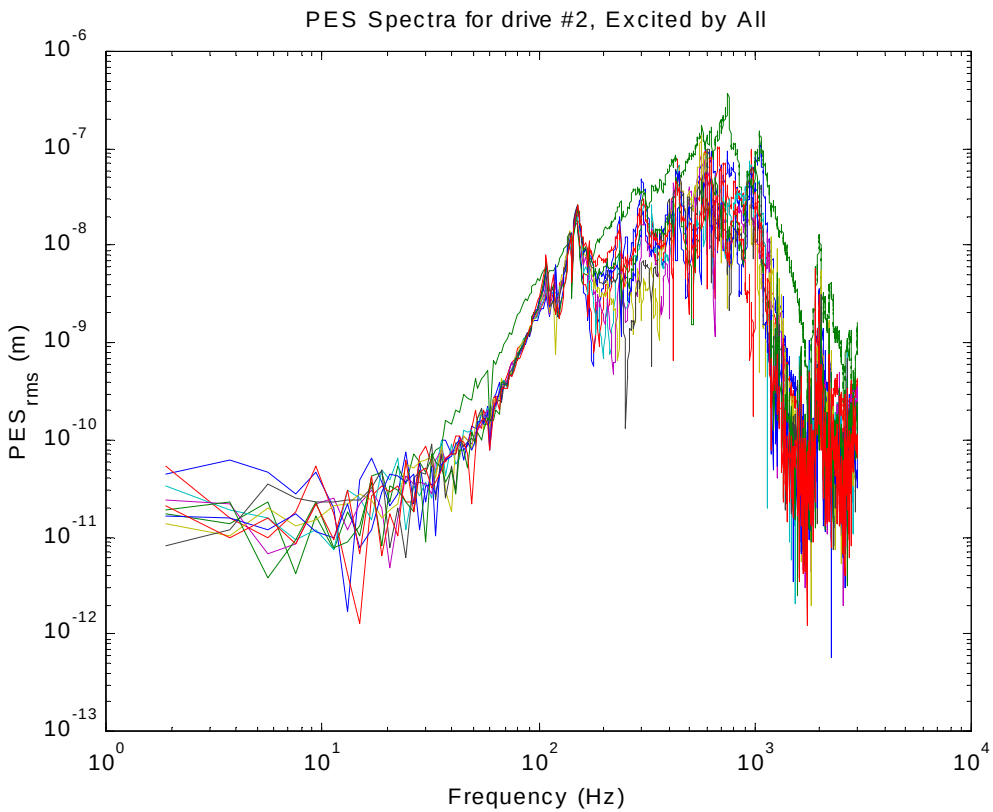
- $H_{ERR}(f)$ is the Error Rejection Response

$$H_{ERR}(f) = \frac{\text{position error}}{\text{track motion}}$$

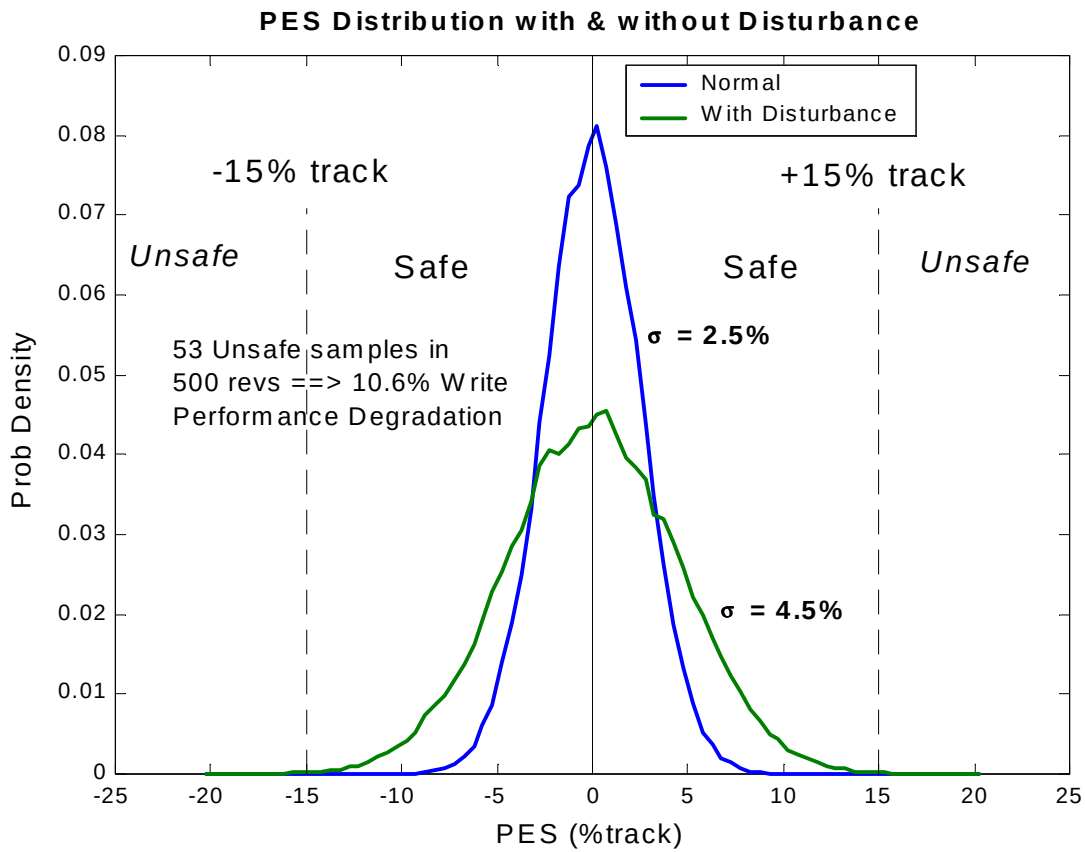
The Servo: Error Rejection FRF



Contribution of each drive to PES



PES and Performance: Write Performance Degradation



Prediction of Throughput

- Based on emitted torque, accelerance

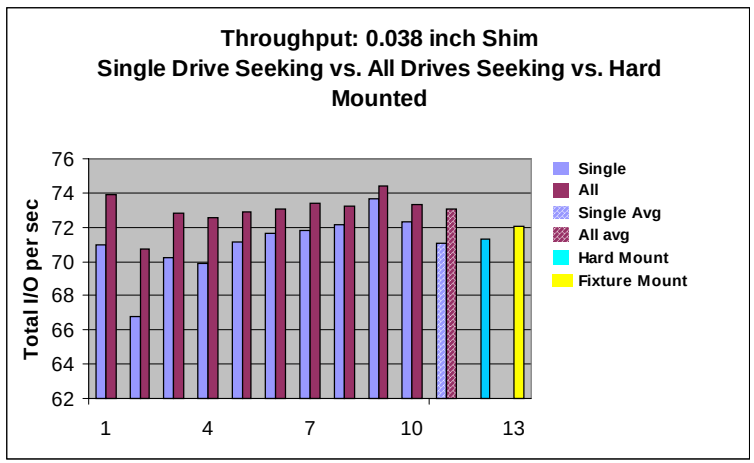
Measurement of Throughput

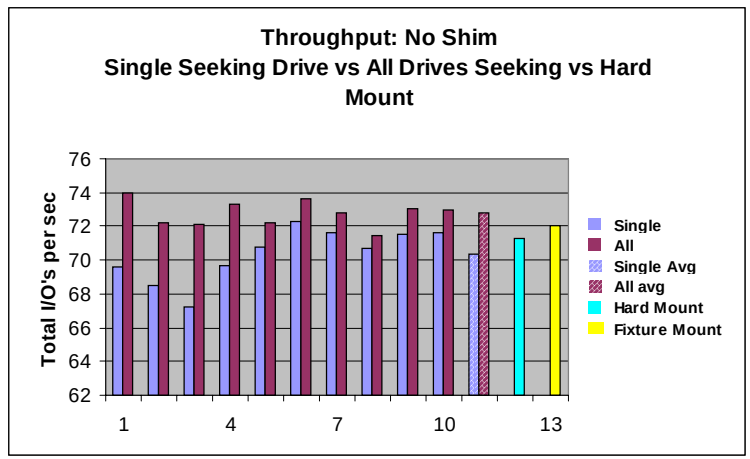
- Measure of overall dock performance
- Measure of individual slot performance
- 3 tests
  - single drive rigidly mounted to table (best case)
  - single drive seeking in dock (self-induced excitation) other drives idling
  - all drives seeking in dock (self+neighbor induced)

Measurement of Throughput

- Iometer software used to work drives
- 512 byte/2 kbyte block xfers, 100% random, 100% write
- 5 minute average of Total I/O's per second
- *To properly compare results need same Iometer loads (same number of working drives)

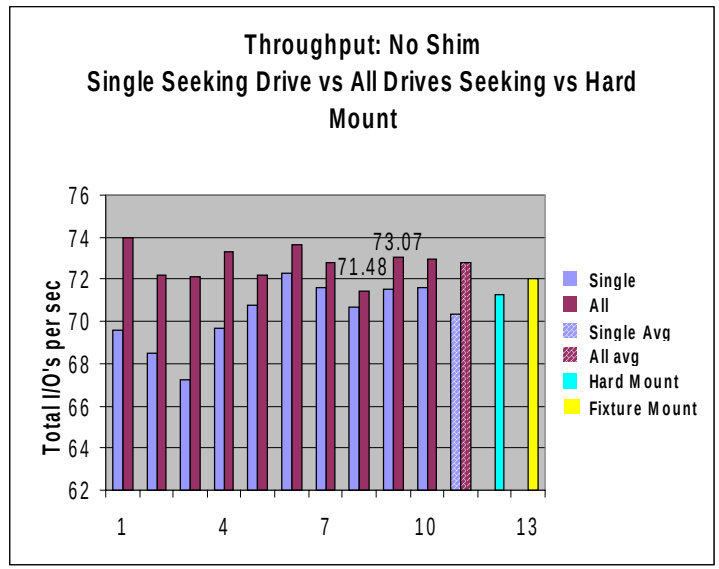
Single/All Seeking vs Hardmount





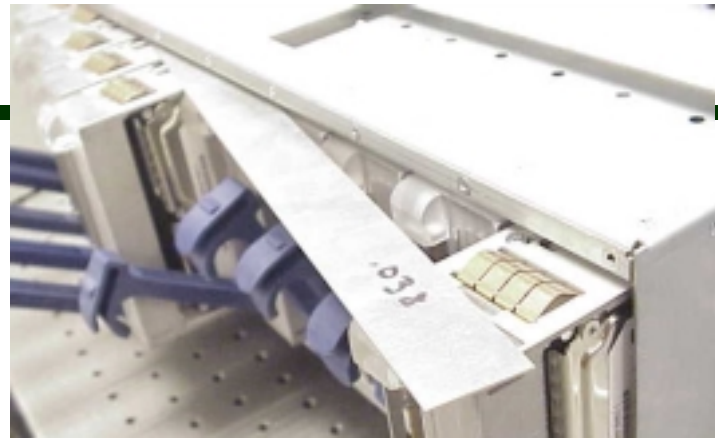
Swapping Wrapped Assemblies

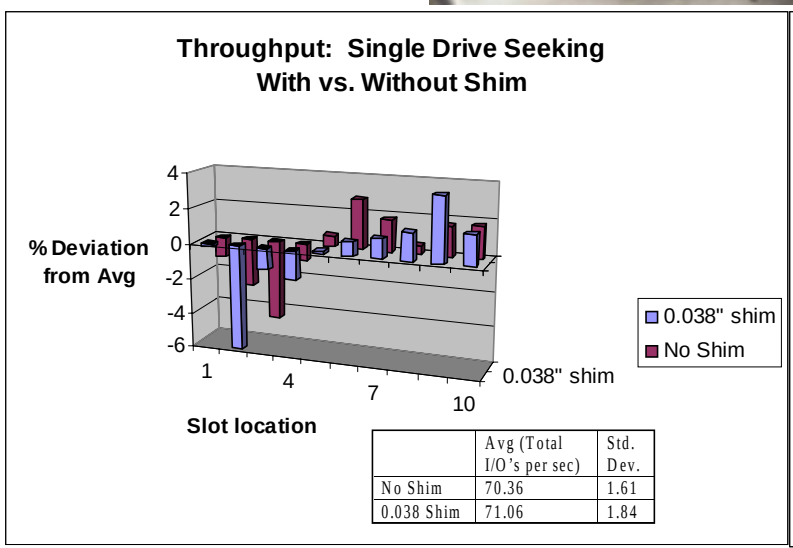
Slot no.	8	9
Initial	71.48	73.07
Swap	73.73	72.96
Swap back	73.27	74.23



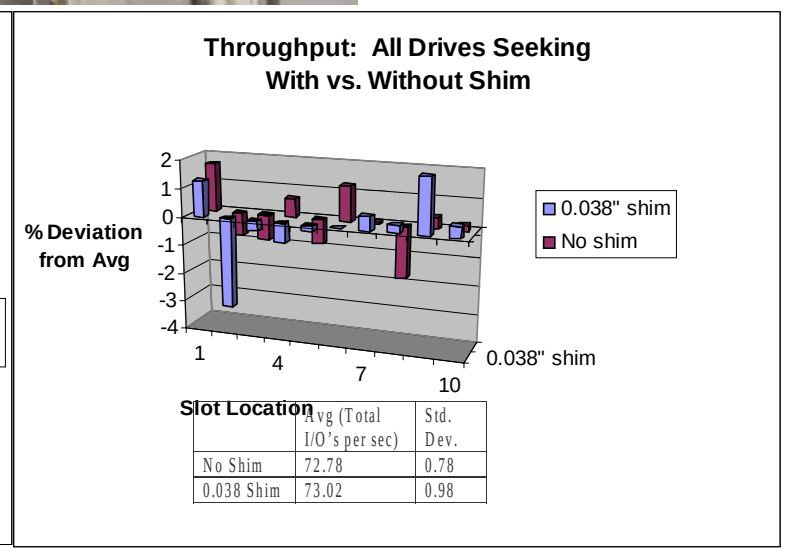
-Drive to drive variability significant
-Minor adjustments to dock significant

Shim vs no Shim





	Avg (Total I/O's per sec)	Std. Dev.
No Shim	70.36	1.61
0.038 Shim	71.06	1.84



	Avg (Total I/O's per sec)	Std. Dev.
No Shim	72.78	0.78
0.038 Shim	73.02	0.98

Measurement of Throughput

- Desired: use common drive from which throughput is always taken (remove drive to drive variability)
- Desired: same load on Iometer for all tests
- Unsure why All Seeking shows highest thruput - may be issue with Iometer
- Shim increases rigidity, also increases variability
- Slot to slot variability (all drives working) as high as 3%, due partially to drive to drive variability
- Minor adjustments to dock can lead to significant changes in throughput