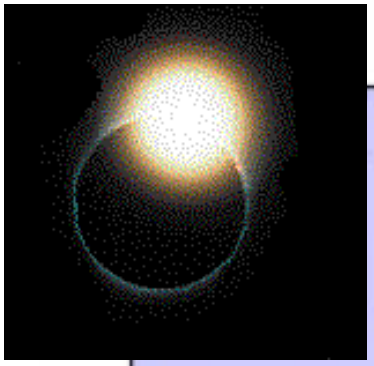
Workshop on Modeling Structures with Joints

Charles R. Pickrel
The Boeing Co.

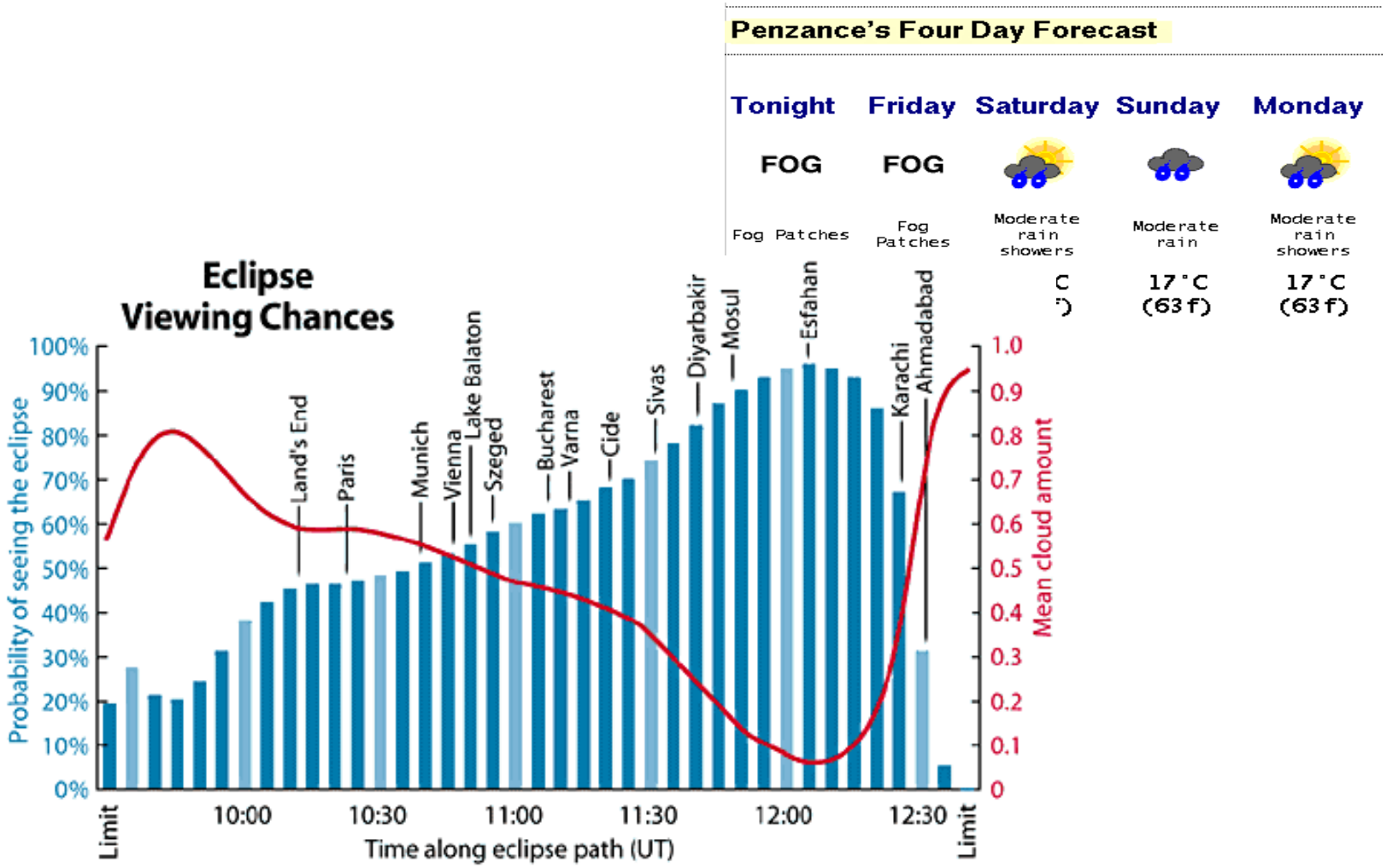
BOEING®

Eclipse: Example of a Predictive Model



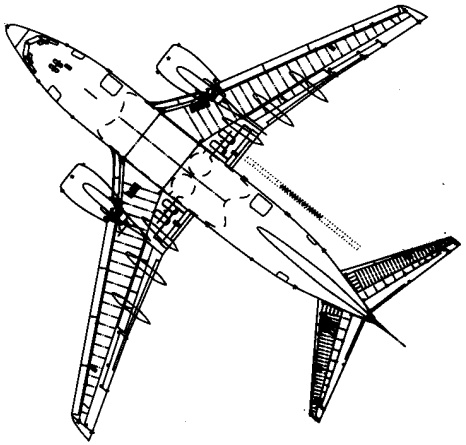
BOEING

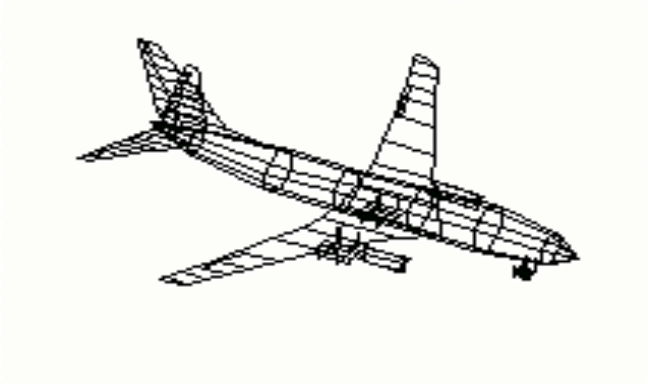
Eclipse Weather: Example of Modeling Limitations

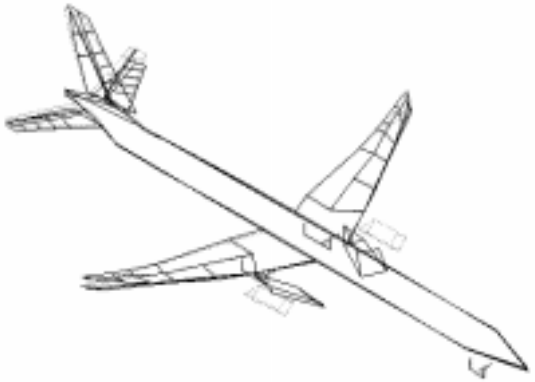


BOEING

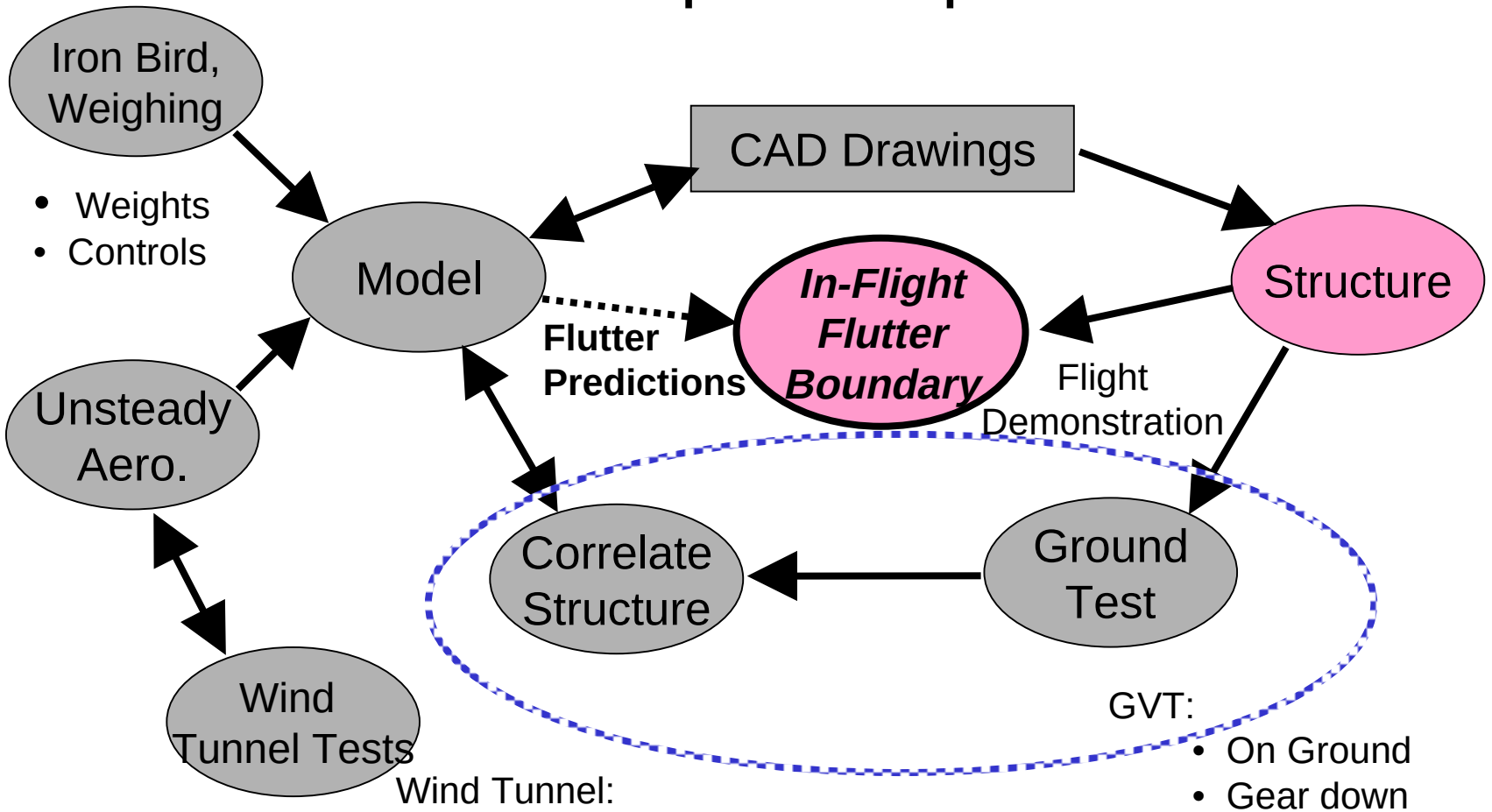
Idealization *vs* Reality





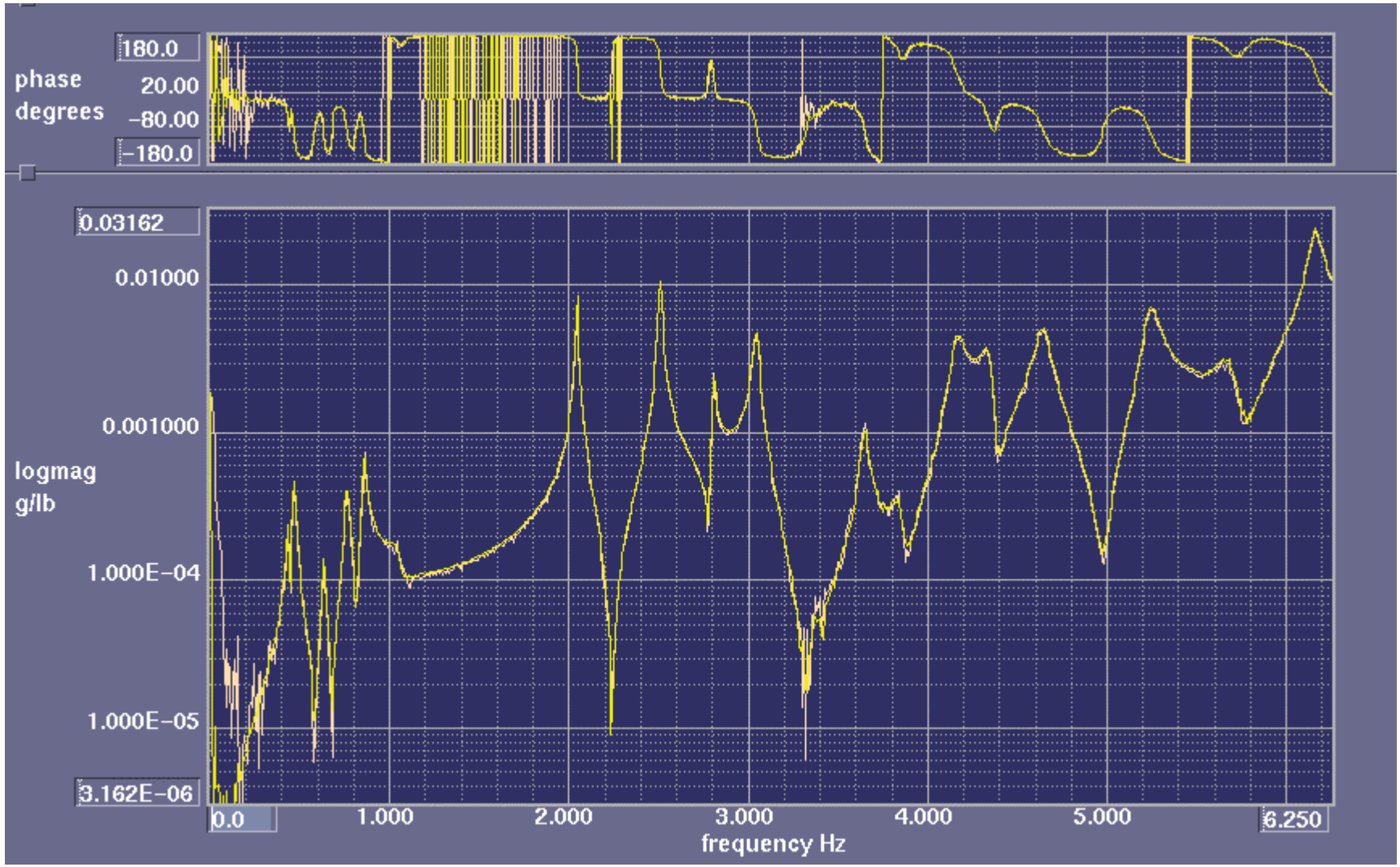


Validation Map for Airplane Flutter



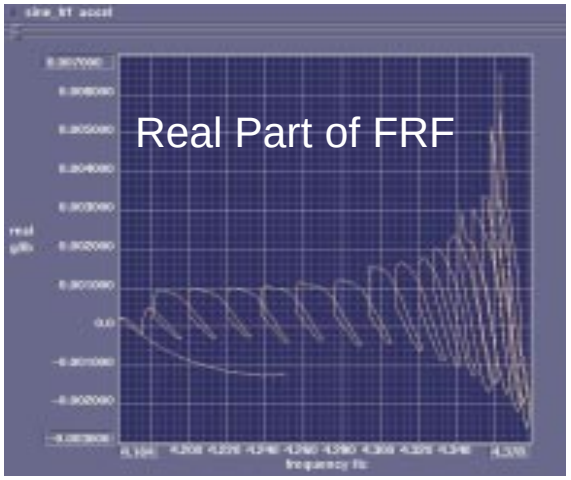
Wind Tunnel:
- Dynamically-scaled model
- Low-speed flying model
- Transonic cantilevered model
- Lab GVT of models, components

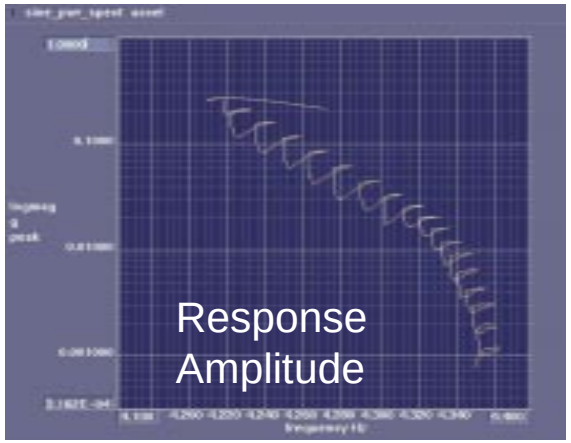
Reciprocal FRF's from MIMO Burst Random



Characterizing Non-Linearity

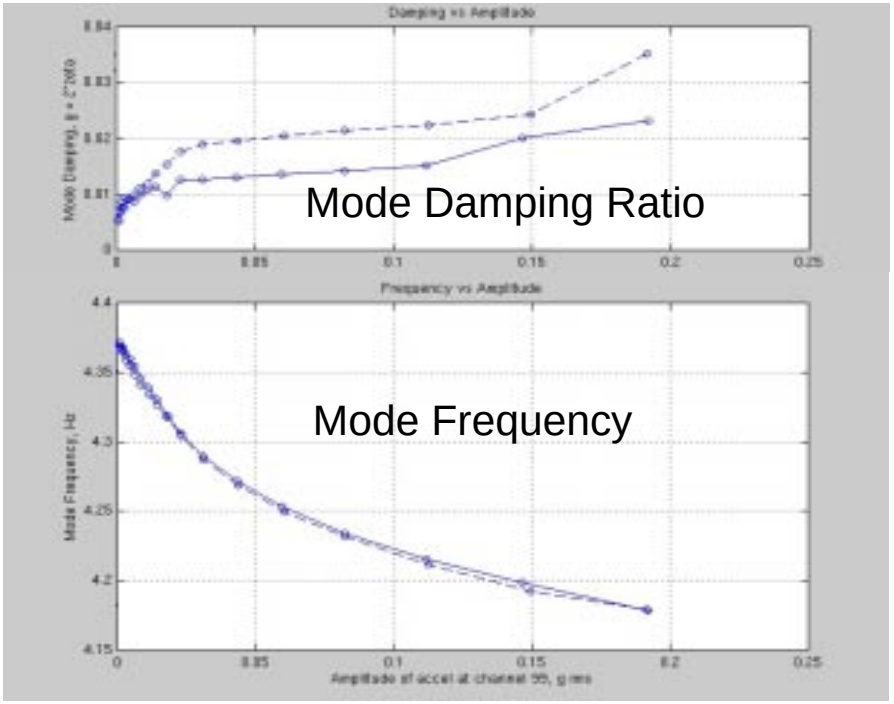
("Fitting a Curve with a Ruler" - Linear Model Approximations)





Excitation Frequency

Mini-Sweeps Track
Mode with Amplitude

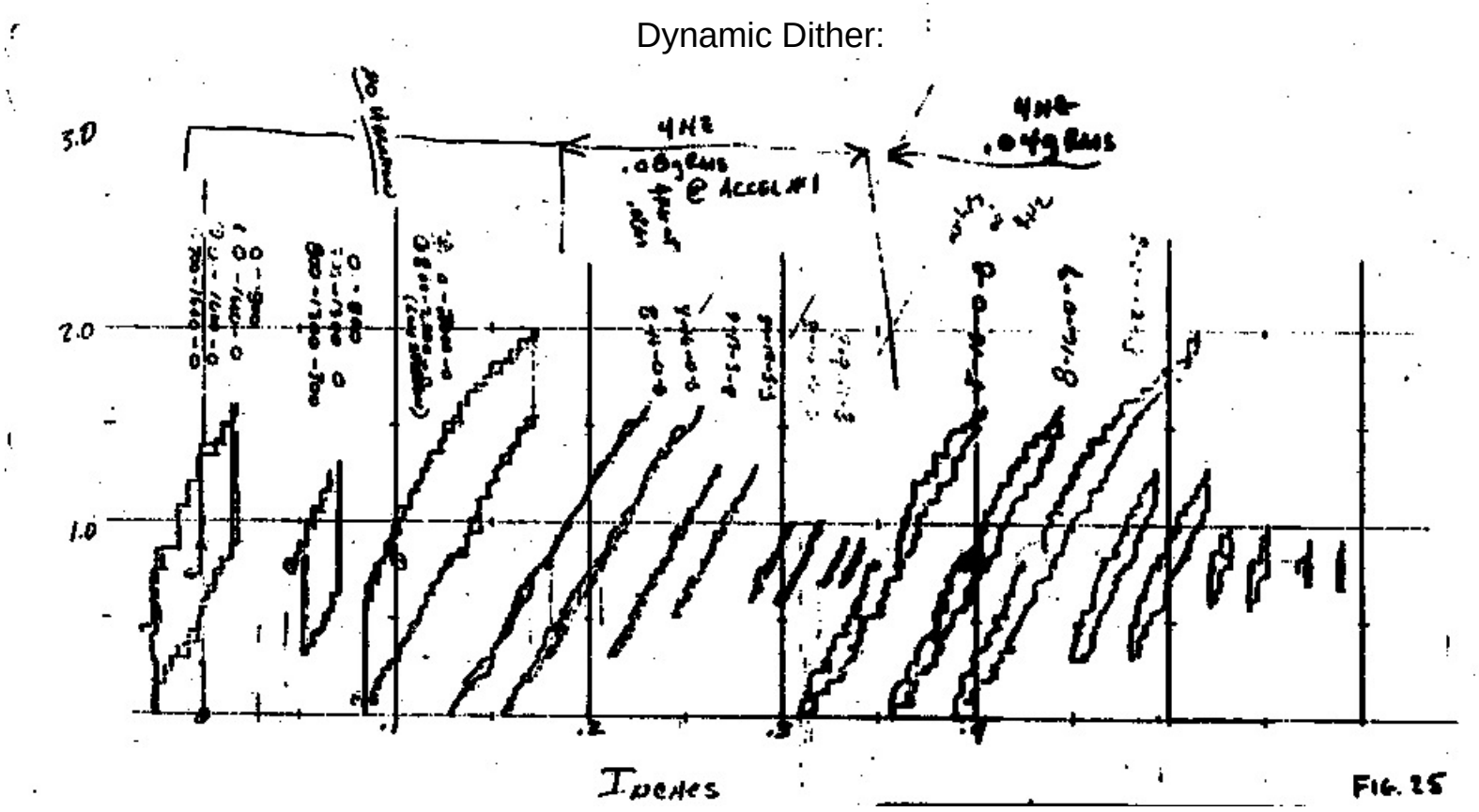


Response Amplitude

BOEING

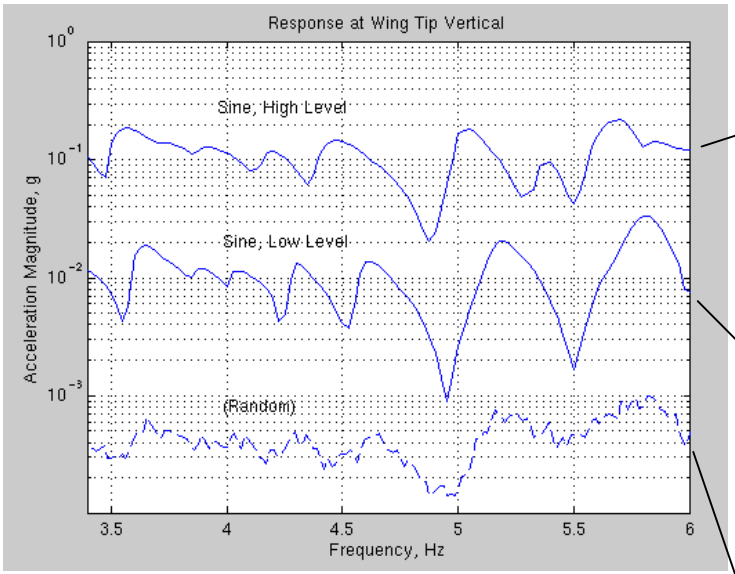
Load-Deflection Curves Reveal Nonlinear “Sticktion”

Dynamic Dither:



Mode Shapes (Almost) Unaffected by Nonlinearity

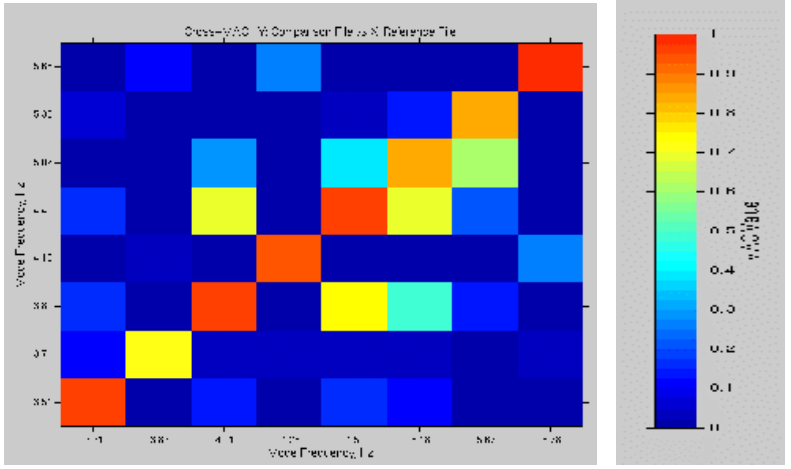
Response Amplitude



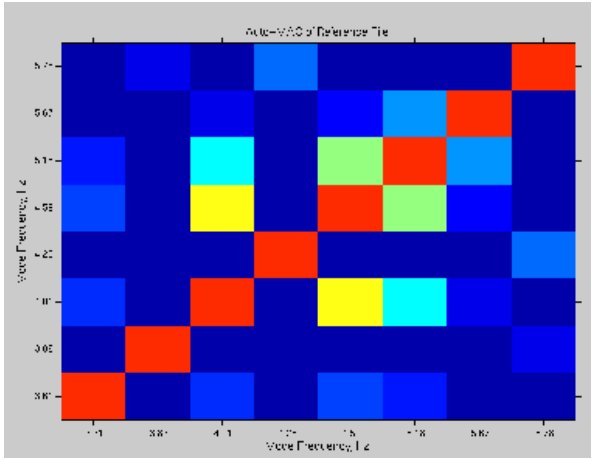
- 3.4 - 6 Hz
- Modes 12 - 19

Cross - MAC

"High Level" Sine



"Low Level" Sine



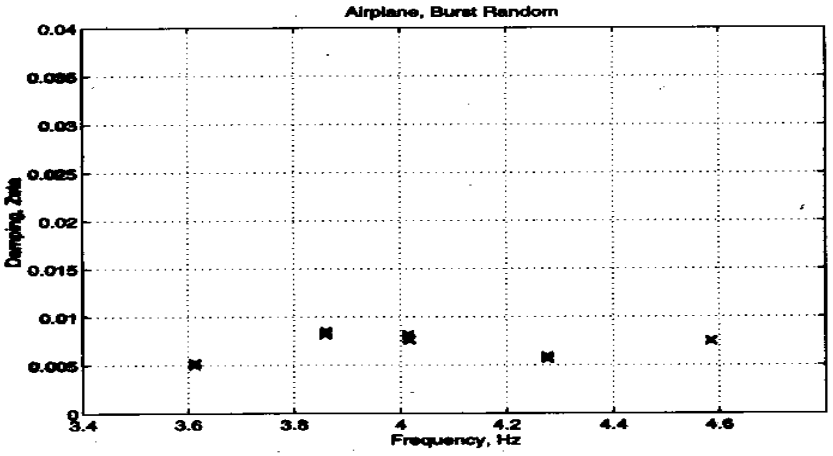
Burst Random

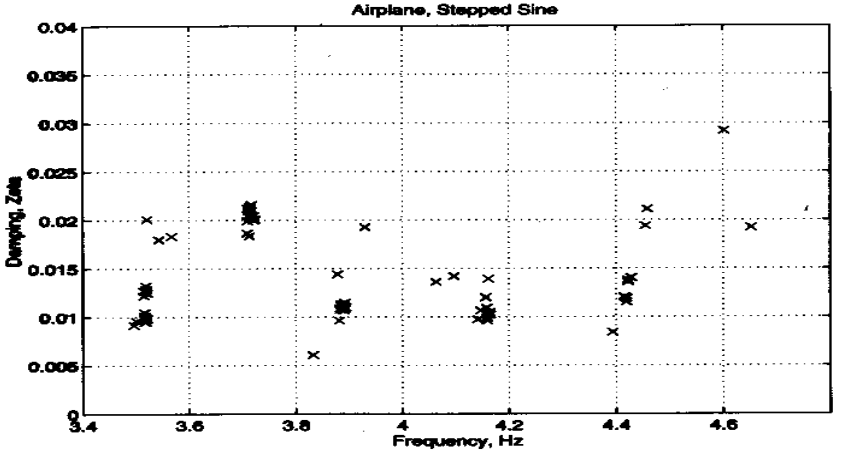
Nonlinearity Dominates Variance in Mode Poles

MIMO Burst Random

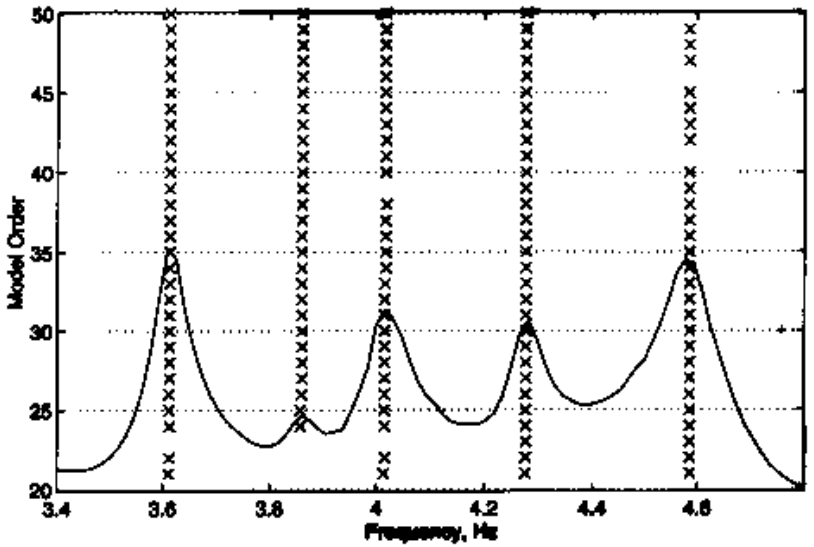
Higher Level Sine

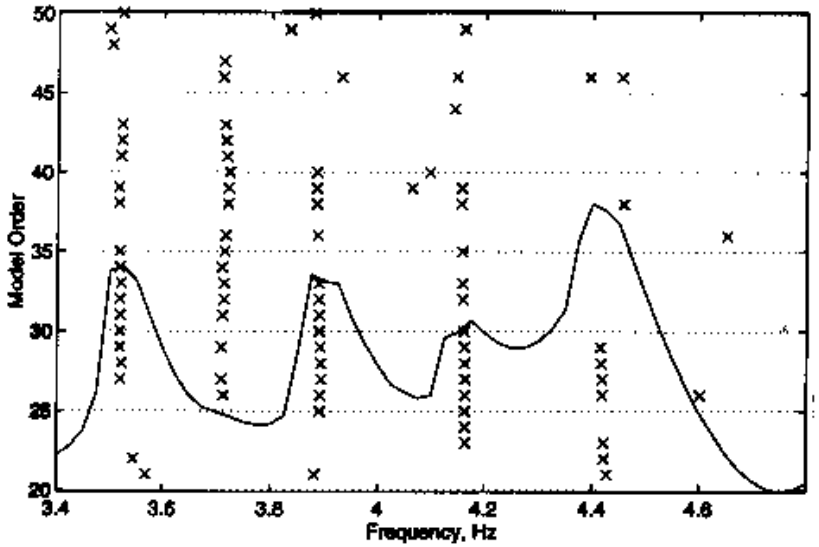
Pole Surface





Stability Diagram



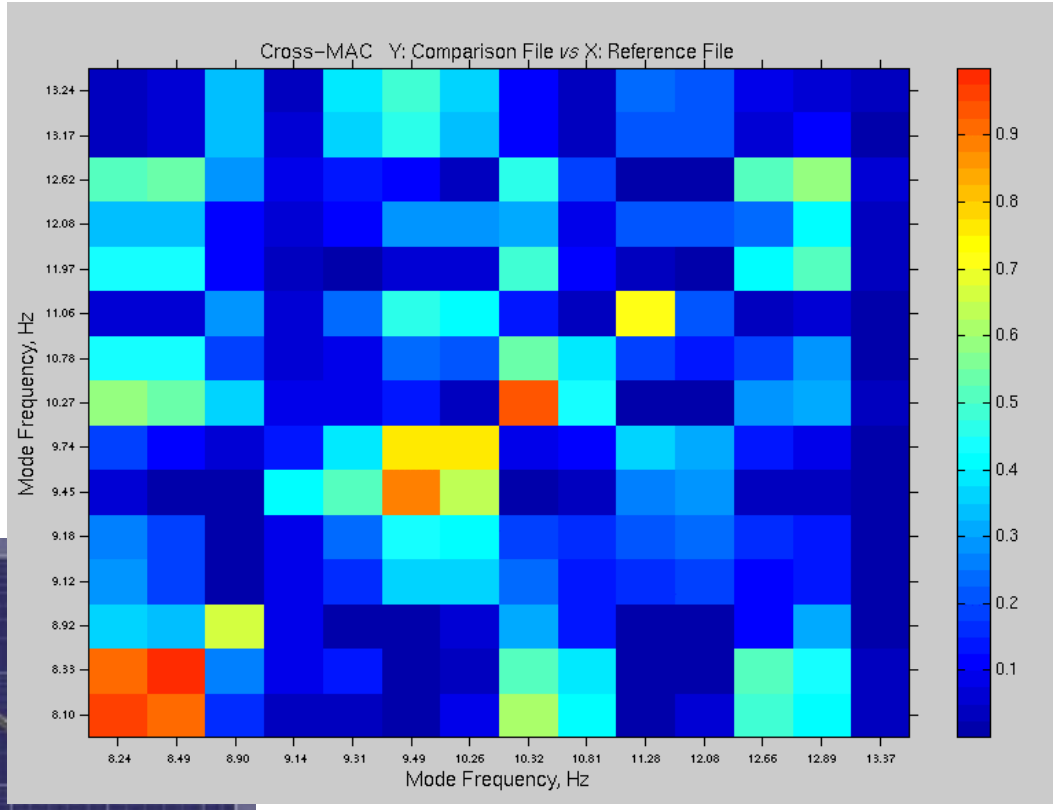


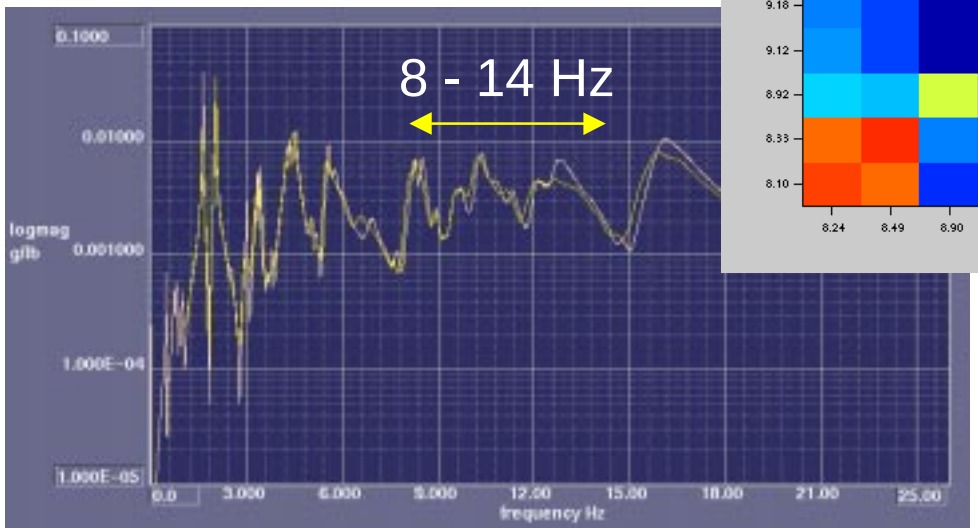
BOEING

Structural Nonlinearity Limits (Linear Model)Mode Correlation at “Higher” Frequencies

- 8 - 14 Hz
- Modes 34 - 47
- Shapes Different
- FRF’s Similar

Higher-Level Sine





Low-Level Random

BOEING