



Experimental Investigation of a Methodology for Flutter Speed Estimation from Acceleration Measurements

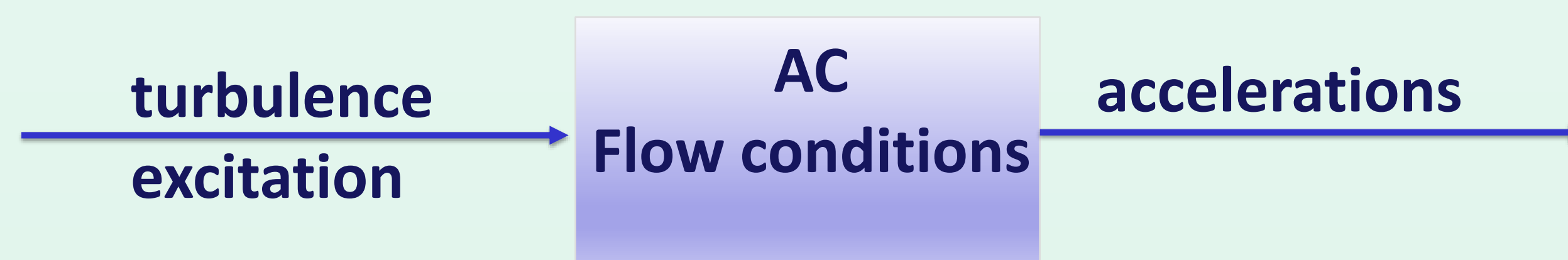
MSc Research Study by Tzliil Nahom Under the Guidance of Prof. Daniella Raveh
Technion - Israel Institute of Technology Department of Aerospace Engineering

Background

- Aeroelastic flutter is a destructive instability phenomenon
- Typical flutter clearance process for flutter flight test :
Analysis → Flight tests → Final clearance
- Most flutter testing methods rely on external mechanical excitation accessories
- The Autoregressive Moving Average (ARMA) flutter prediction method identifies the aeroelastic system based on the aircraft structural response to random air turbulence excitation.
- The proposed study is focused on the validation of the ARMA method based on acceleration measurements obtained by aeroelastic wind tunnel tests

The ARMA model

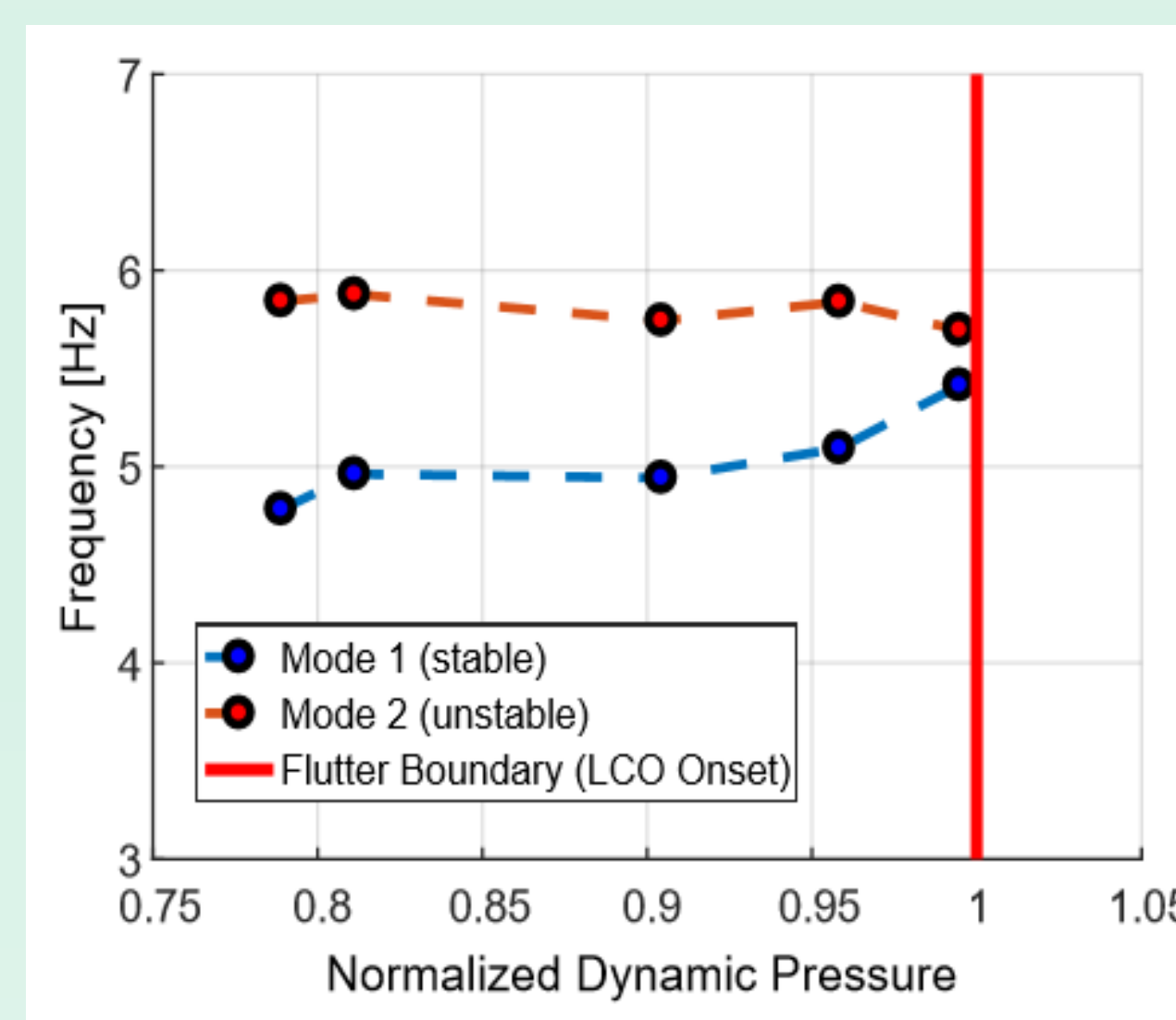
- Discrete-Time method for linear system modelling
- Originally suggested by Matsuzaki and Ando*
- Offers a favorable stability parameter that varies as a linear function of the dynamic pressure



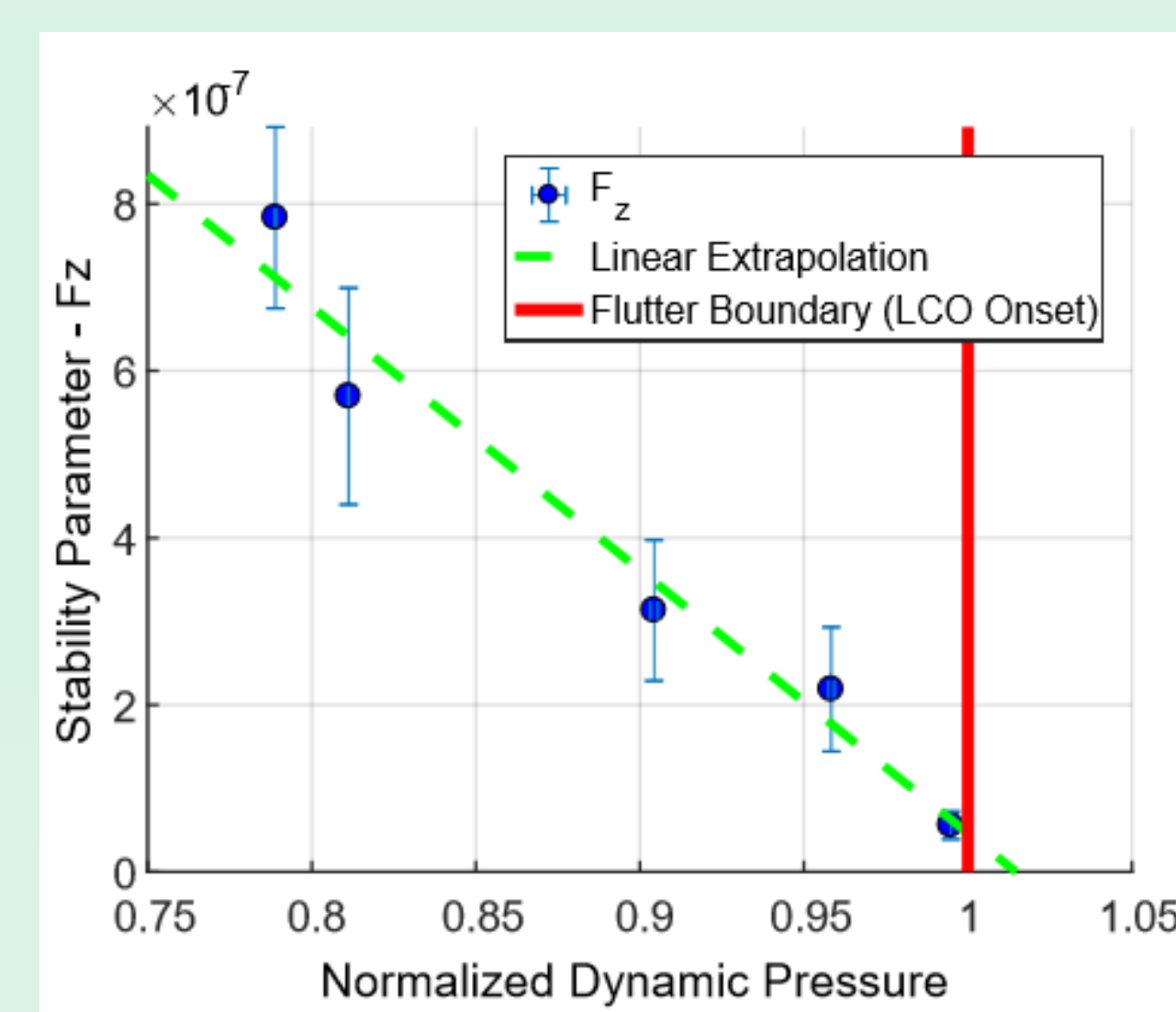
$$y_i + \underbrace{\phi_1 y_{i-1} + \phi_2 y_{i-2} + \dots + \phi_p y_{i-p}}_{AR(p)} = \underbrace{\epsilon_i + \theta_1 \epsilon_{i-1} + \theta_2 \epsilon_{i-2} + \dots + \theta_q \epsilon_{i-q}}_{MA(q)}$$

ARMA model validation- Israel Air Force

- Evaluation of the ARMA method based on F16 platform flight tests results



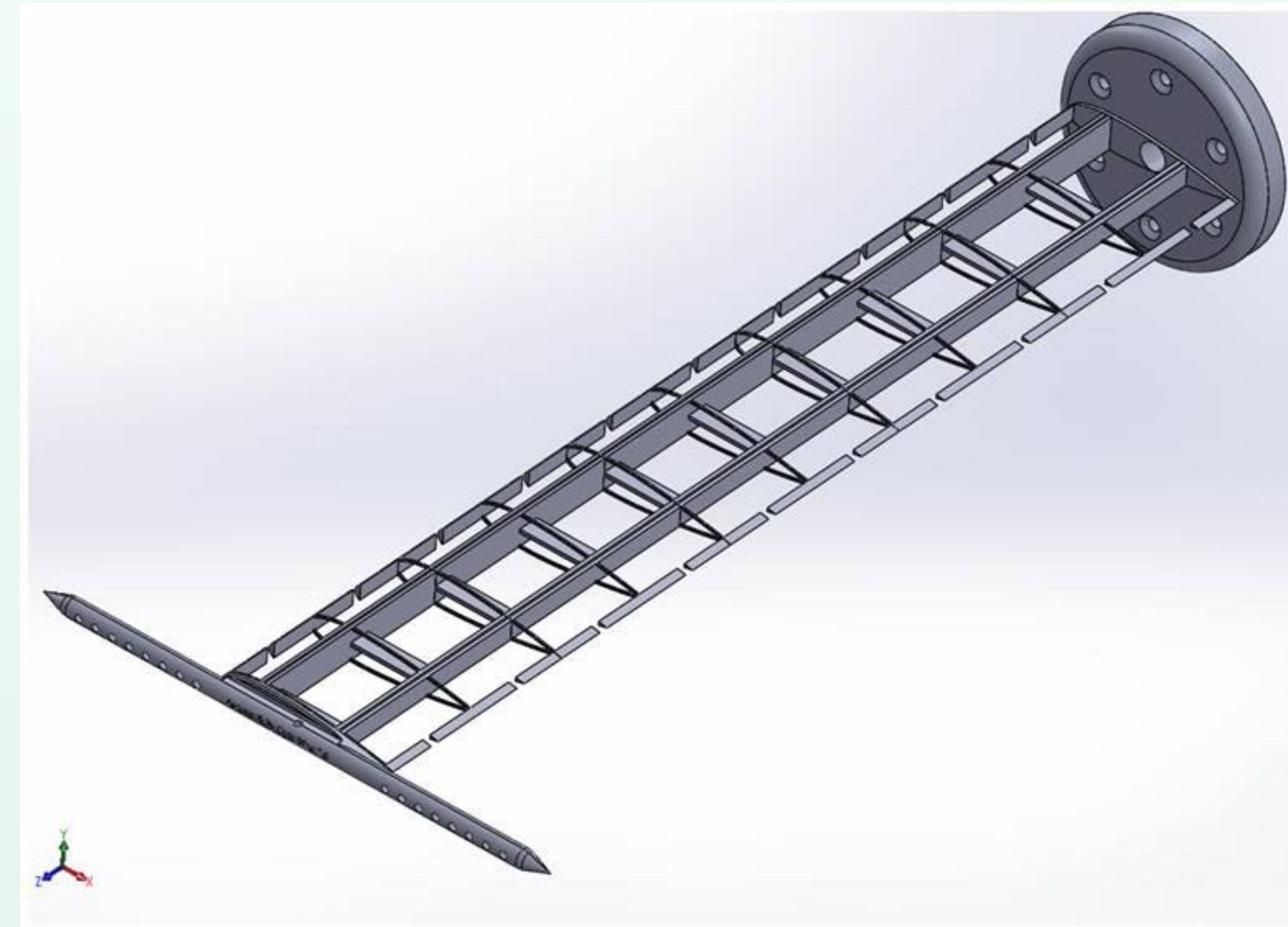
Modal Frequency



Stability Parameter

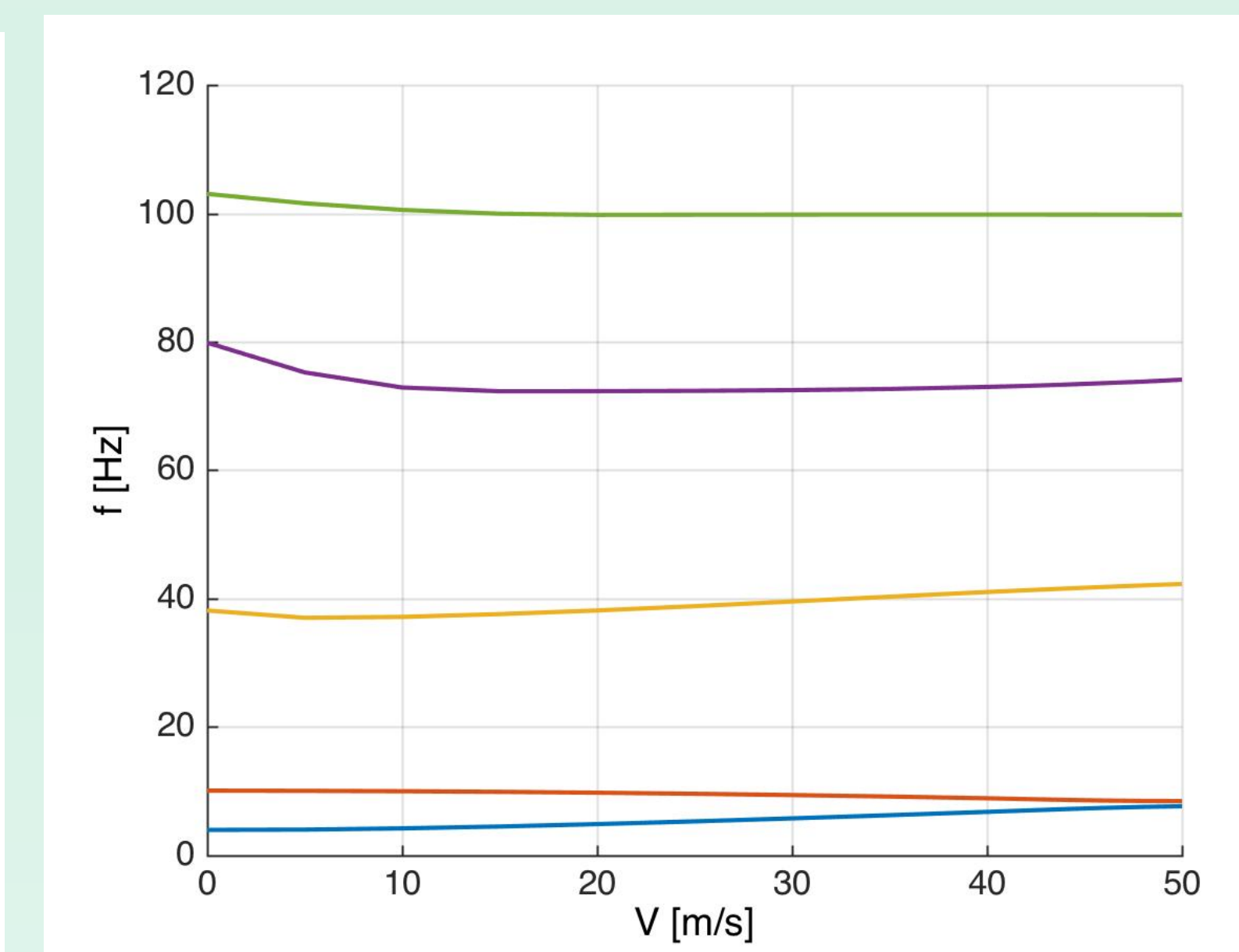
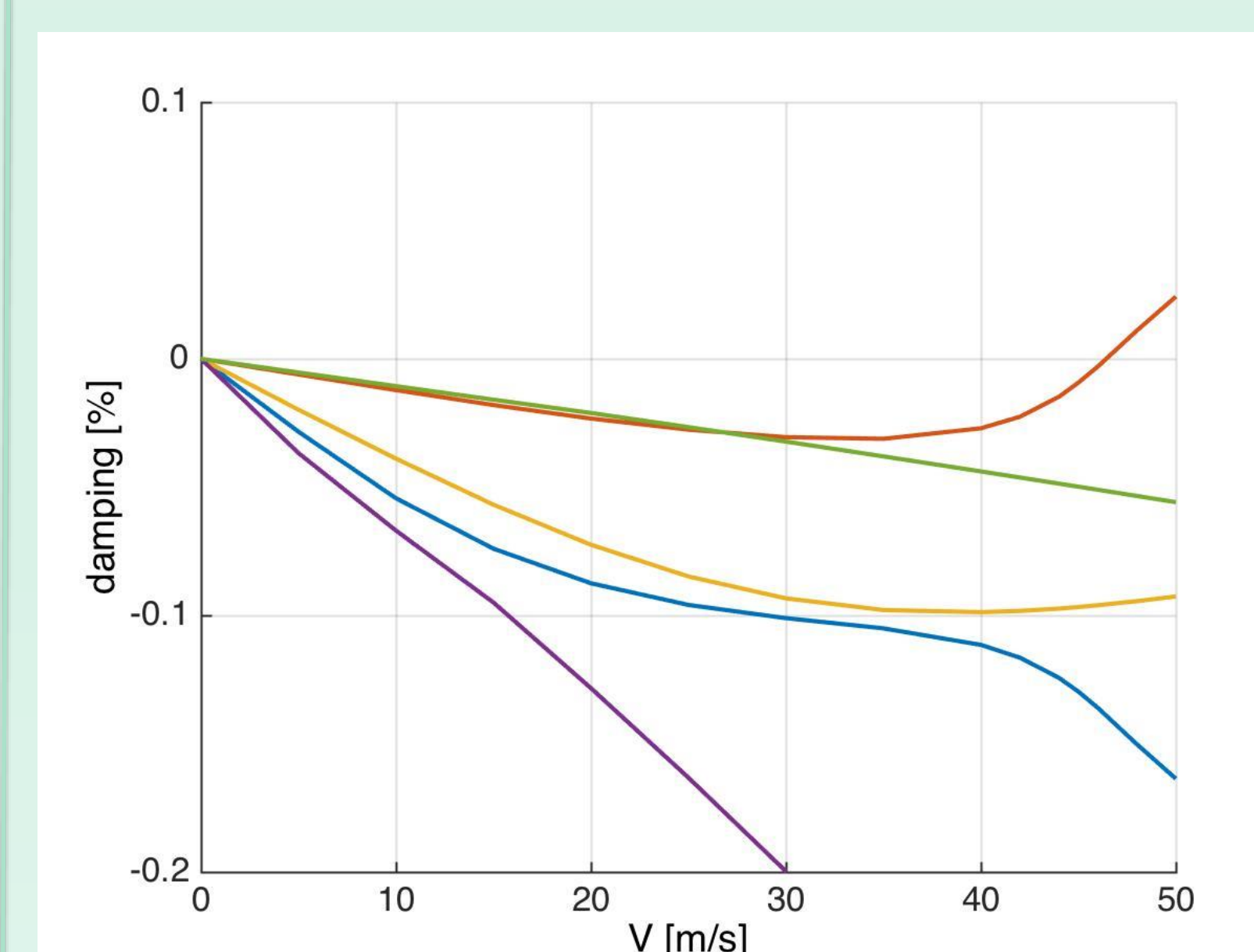
Test case

- An elastic wind-tunnel wing model designed, analyze and manufactured using rapid prototyping



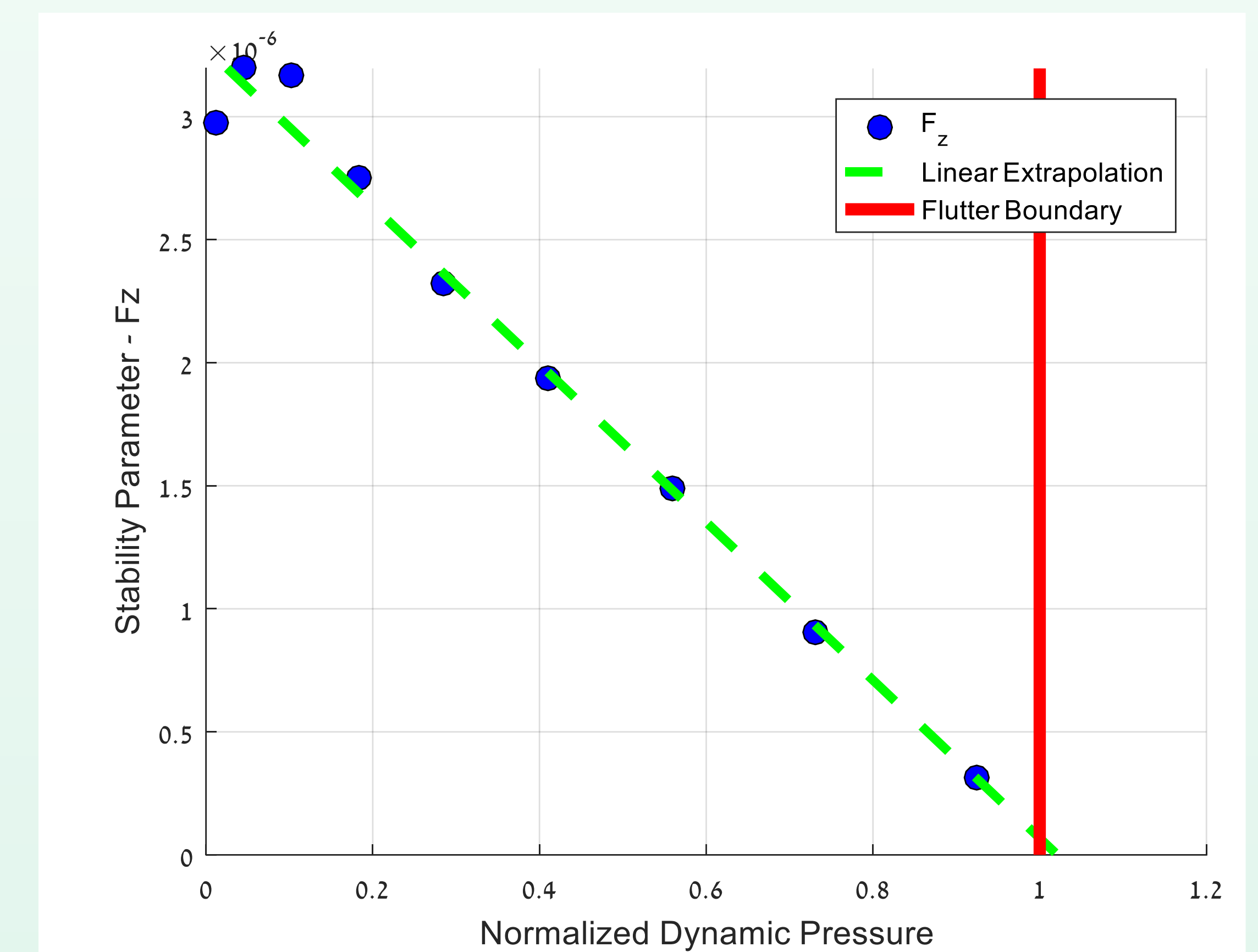
wing characteristics	
Span length	0.6 [m]
Chord length	0.1 [m]
Airfoil	NACA0018

ω -V -g charts from linear flutter analysis - ZAERO

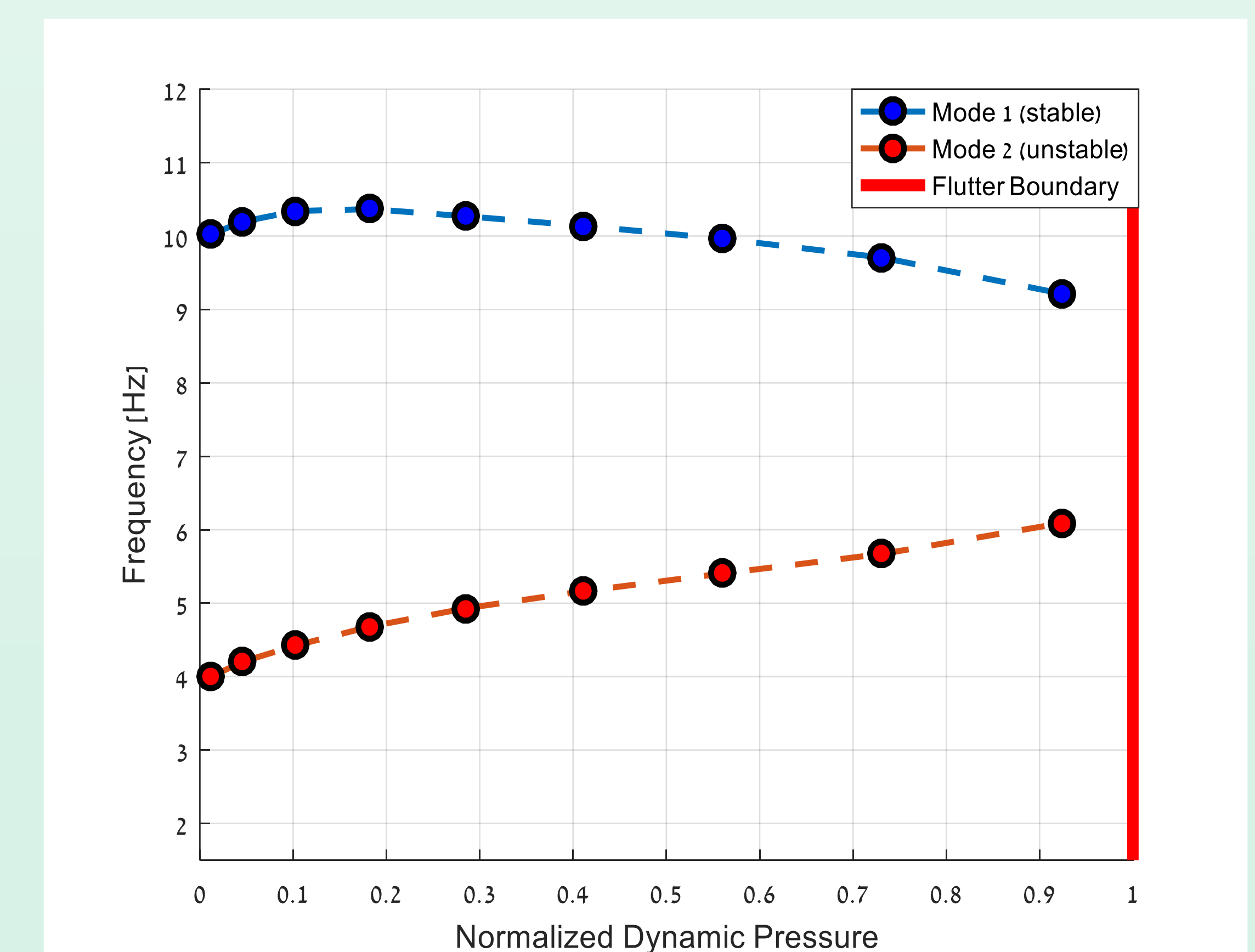


ARMA estimation results

- Based on acceleration responses to random excitation computed by linear aeroelastic simulation (ZAERO)



Stability Parameter



Modal Frequency

Future work

- Wind tunnel testing
- Study of the method's accuracy and limitations

*Matsuzaki, Y. and Ando, Y., "Estimation of Flutter Boundary from Random Responses Due to Turbulence at Subcritical Speeds," Journal of Aircraft, Vol. 18, No. 10, 1981, pp. 862-868.