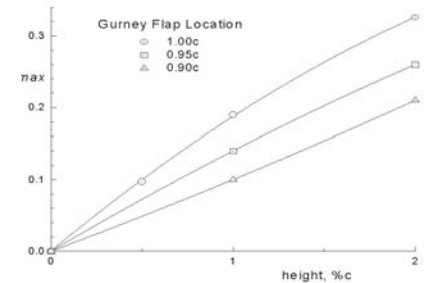
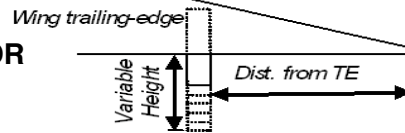
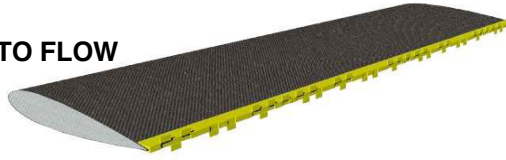


# A PIEZOELECTRIC ACTUATOR FOR MINIATURE TRAILING-EDGE EFFECTORS

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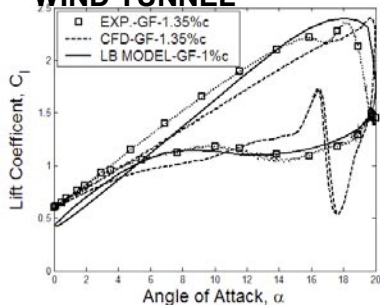
## BACKGROUND – MiTEs

- **GEOMETRY**
  - SMALL TAB PERPENDICULAR TO FLOW
  - PARTIAL SPAN
  - VARY HEIGHT AND LOCATION
- **STEADY AERODYNAMICS**
  - TWO STABLE VORTICES
  - INCREASE EFFECTIVE CAMBER
- **MINIATURE TRAILING-EDGE EFFECTOR DEPLOYABLE GURNEY FLAP**
  - UNSTEADY AERODYNAMICS
  - **ACTIVE FLOW CONTROL**



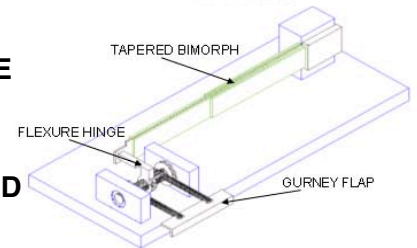
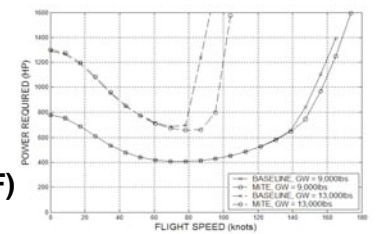
## AERODYNAMIC MODELING

- **UNSTEADY AERODYNAMICS**
  - DYNAMIC STALL
  - COMPRESSIBILITY
- **OSCILLATING VR-12 AIRFOIL**
- **NASA AMES DYNAMIC STALL WIND TUNNEL**

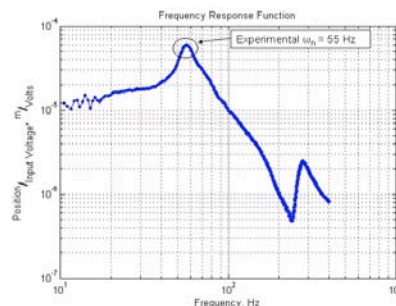
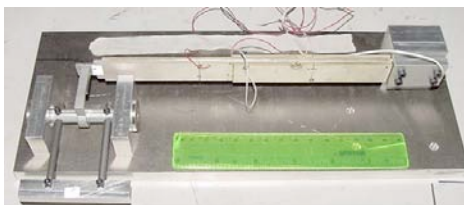


## PIEZOELECTRIC ACTUATOR CONCEPT

- DEVELOPED FOR ROTORCRAFT PERFORMANCE GAINS
- QUASI-STATIC OPERATION
  - **NATURAL FREQUENCY > 40 Hz**
- AUGMENT WITH CENTRIFUGAL (CF) LOADS PRESENT IN BLADE
- **DEFLECTION > 3 mm**
- NO SLIDING PARTS/SOLID STATE
- DEVELOPED FINITE ELEMENT MODEL OF BIMORPH
- EVOLUTIONARY STRATEGY USED TO OPTIMIZE DESIGN



## FABRICATION AND TESTING



SHIM THICKNESS	1.63 [mm]
PZT THICKNESS (BOTH LAYERS)	1.90 [mm]
BIMORPH WIDTH	20.50 [mm]
BIMORPH LENGTH	211.74 [mm]
1 <sup>ST</sup> PZT LAYER LENGTH	194.00 [mm]
2 <sup>ND</sup> PZT LAYER LENGTH	108.00 [mm]
FLAP SPAN	69.60 [mm]
FLEXURE THICKNESS	0.635 [mm]

MEETS DEFLECTION REQUIREMENT  
200 VOLTS → 3.4 mm DEFLECTION

## FUTURE WORK

- **ADVANCED TESTING**
  - WHIRL TOWER (CF LOADING)
  - DYNAMIC WIND-TUNNEL (AERODYNAMIC LOADING)
- **APPS TO WIND TURBINES**
  - LOAD ALLEVIATION
  - SIMILAR ACTUATOR REQUIREMENTS

