

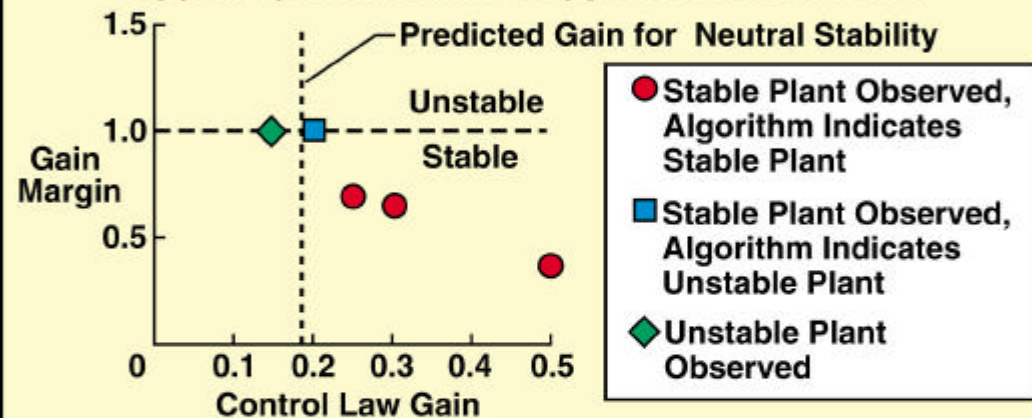
# AEROSERVOELASTIC (ASE) RESEARCH USING THE BENCHMARK ACTIVE CONTROLS TESTING (BACT) WIND-TUNNEL MODEL

## BACT WIND-TUNNEL MODEL

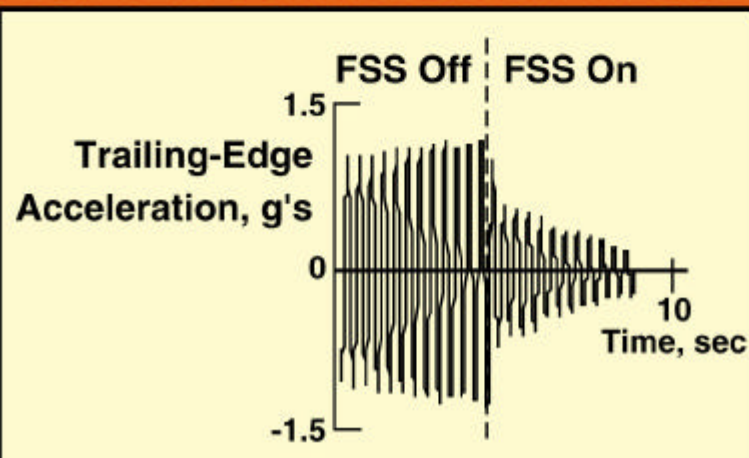


## VALIDATION OF ASE ALGORITHM

Mach Number=0.77, Dynamic Pressure =196 psf,  
Upper-Spoiler Flutter-Suppression Controller



## FLUTTER SUPPRESSION RESULT

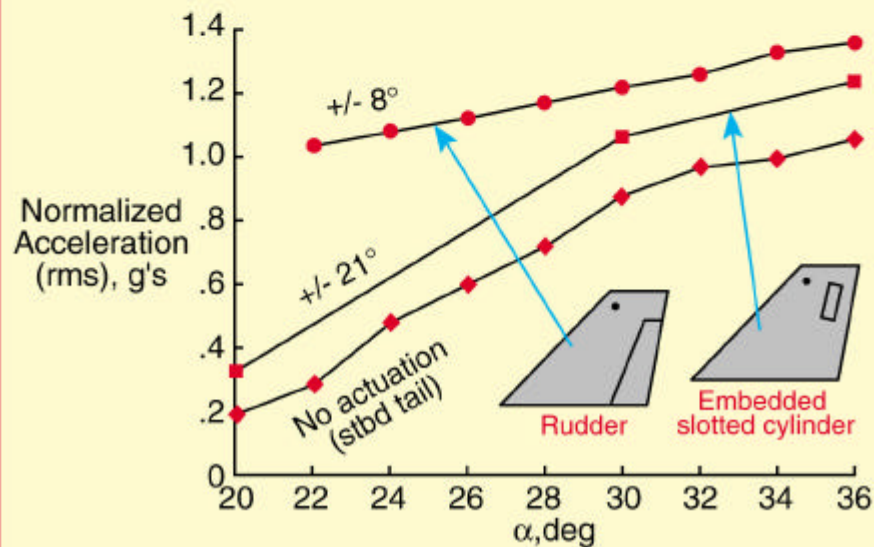
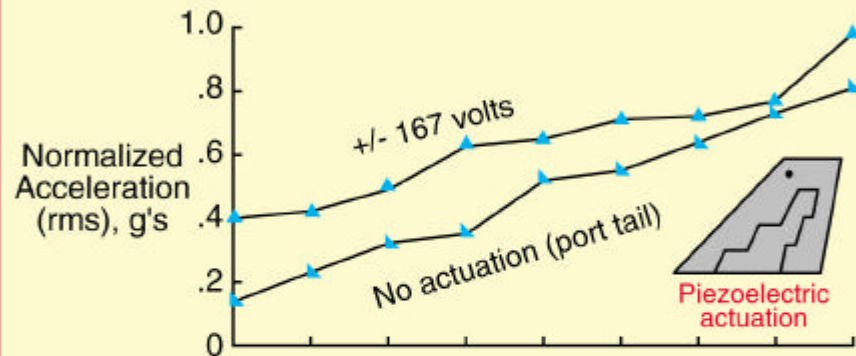


## USE OF THE BACT WIND-TUNNEL MODEL AS AN ASE TESTBED

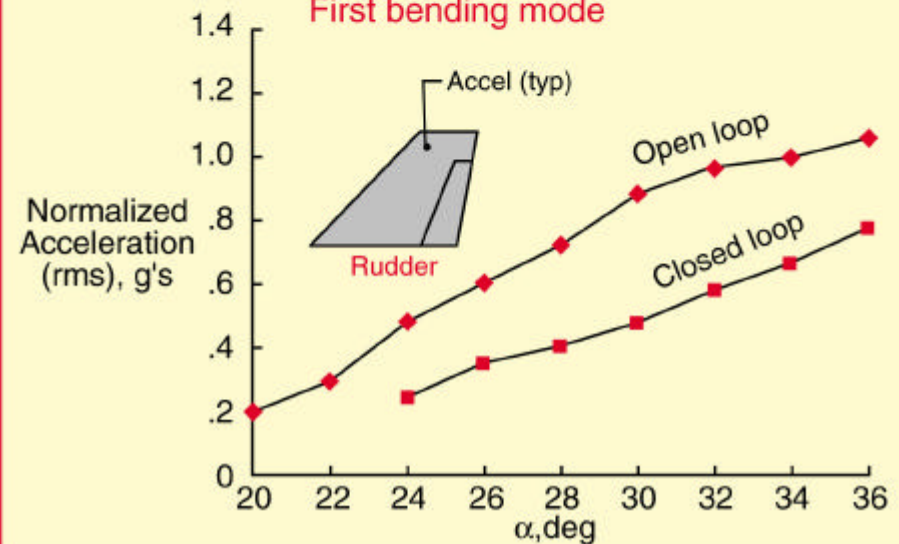
- Multi-Input/Multi-Output Flutter Suppression Using Trailing-Edge Control Surface & Spoilers
- Flutter Suppression Using Neural Networks
- Flutter Suppression Using an Adaptive-Predictive Technique
- Nonlinear Gust Load Alleviation

# TDT TESTS OF F/A-18 MODEL REVEAL EFFECTIVENESS OF SEVERAL ACTUATION DEVICES IN ALLEVIATING VERTICAL TAIL BUFFETING AT HIGH ANGLES OF ATTACK

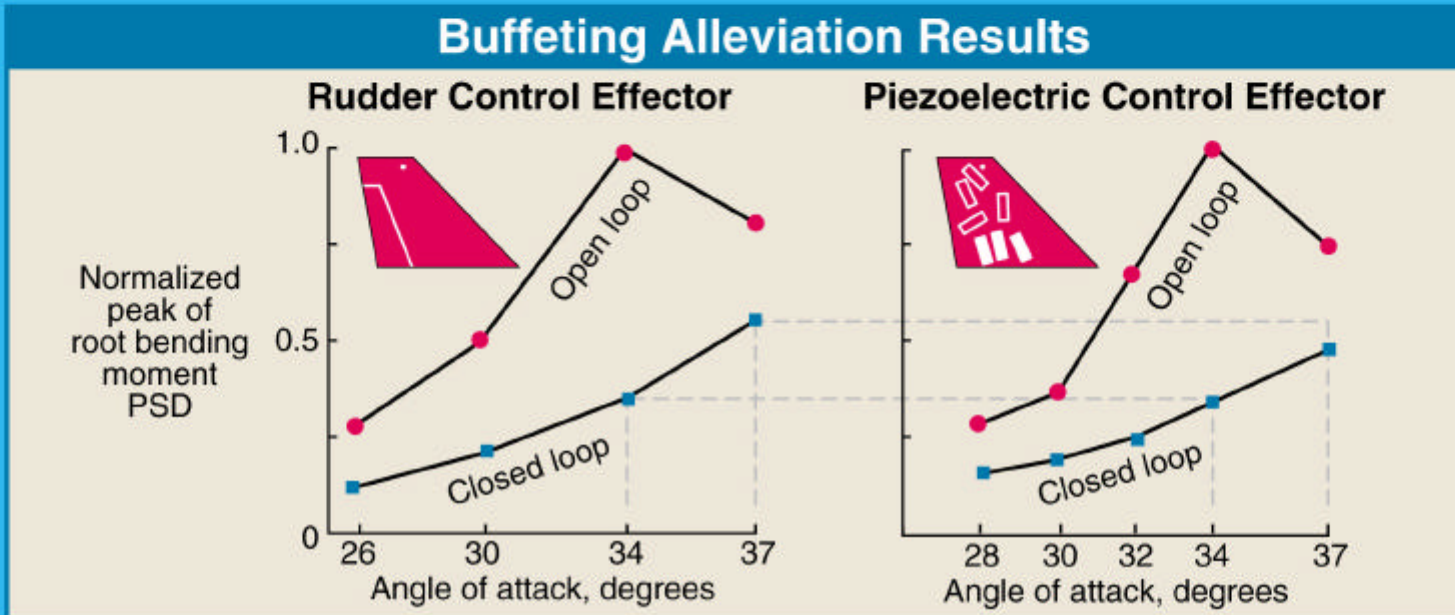
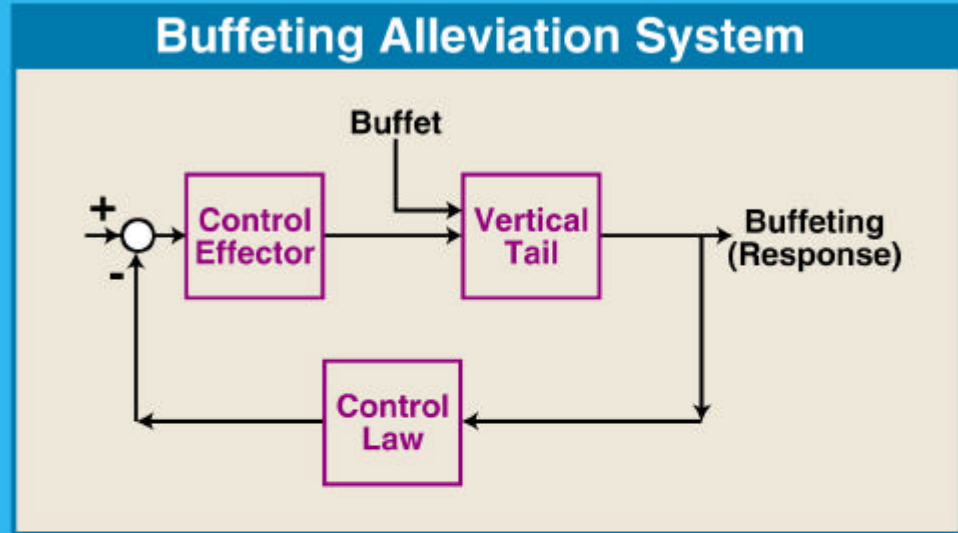
**Actuator effectiveness**  
First bending mode



**Preliminary buffet alleviation results**  
First bending mode

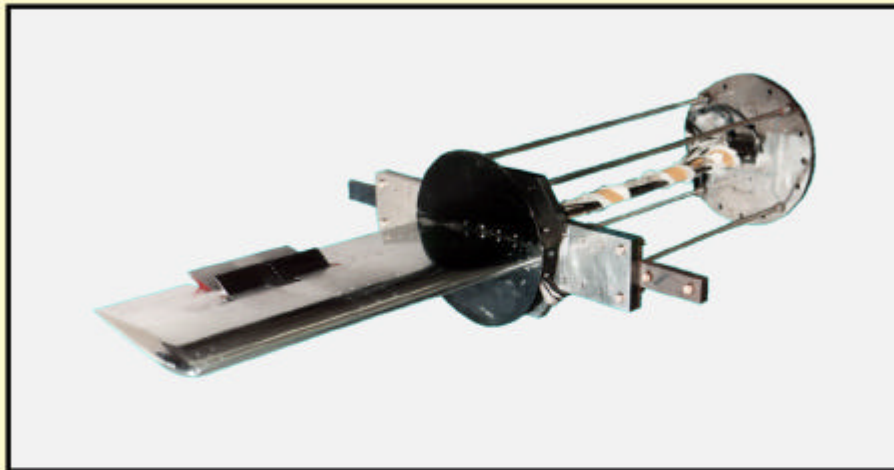


# TDT TESTS OF F/A-18 MODEL REVEAL EFFECTIVENESS OF TWO CONTROL EFFECTORS IN ALLEVIATING VERTICAL TAIL BUFFETING AT HIGH ANGLES OF ATTACK

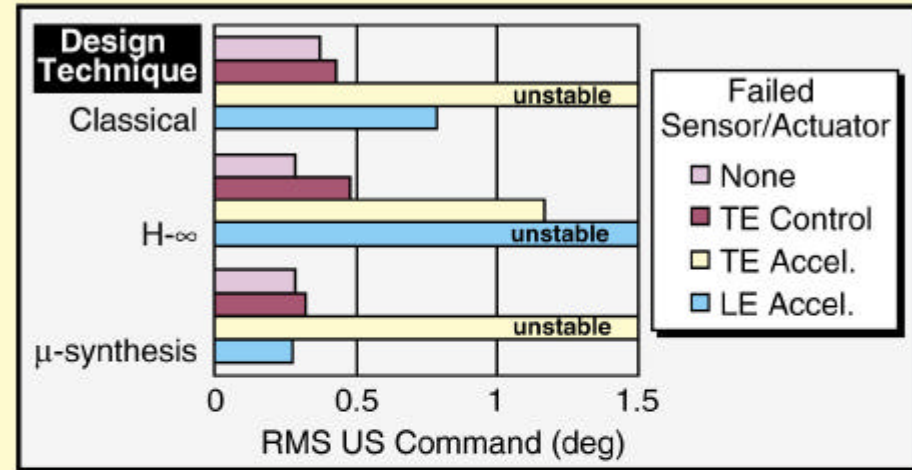


# ACTIVE CONTROLS RESEARCH USING THE BACT WIND-TUNNEL MODEL

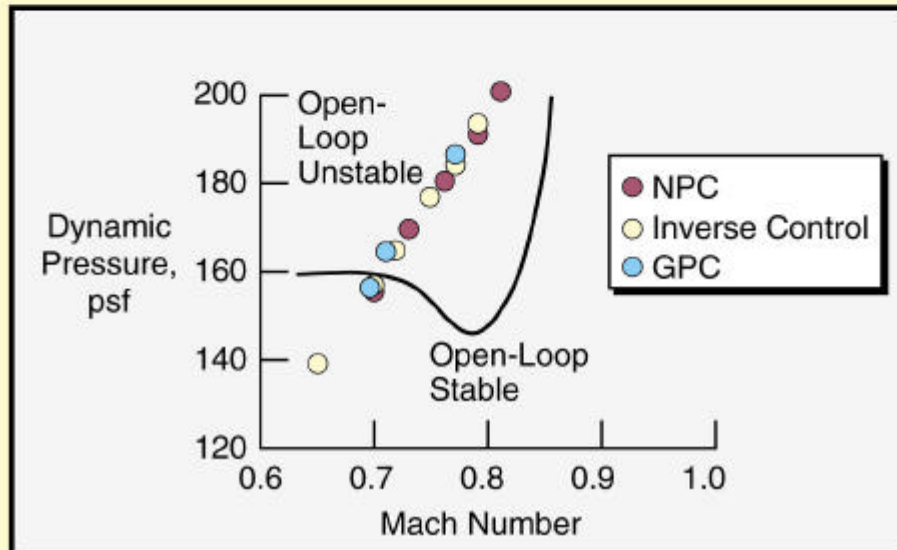
BACT Wind-Tunnel Model



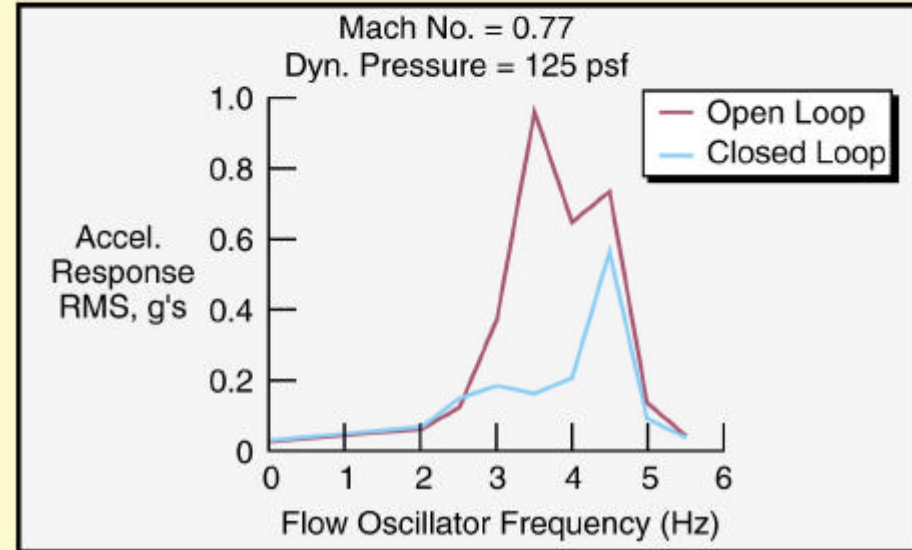
MIMO Control Laws - Effects of Failures



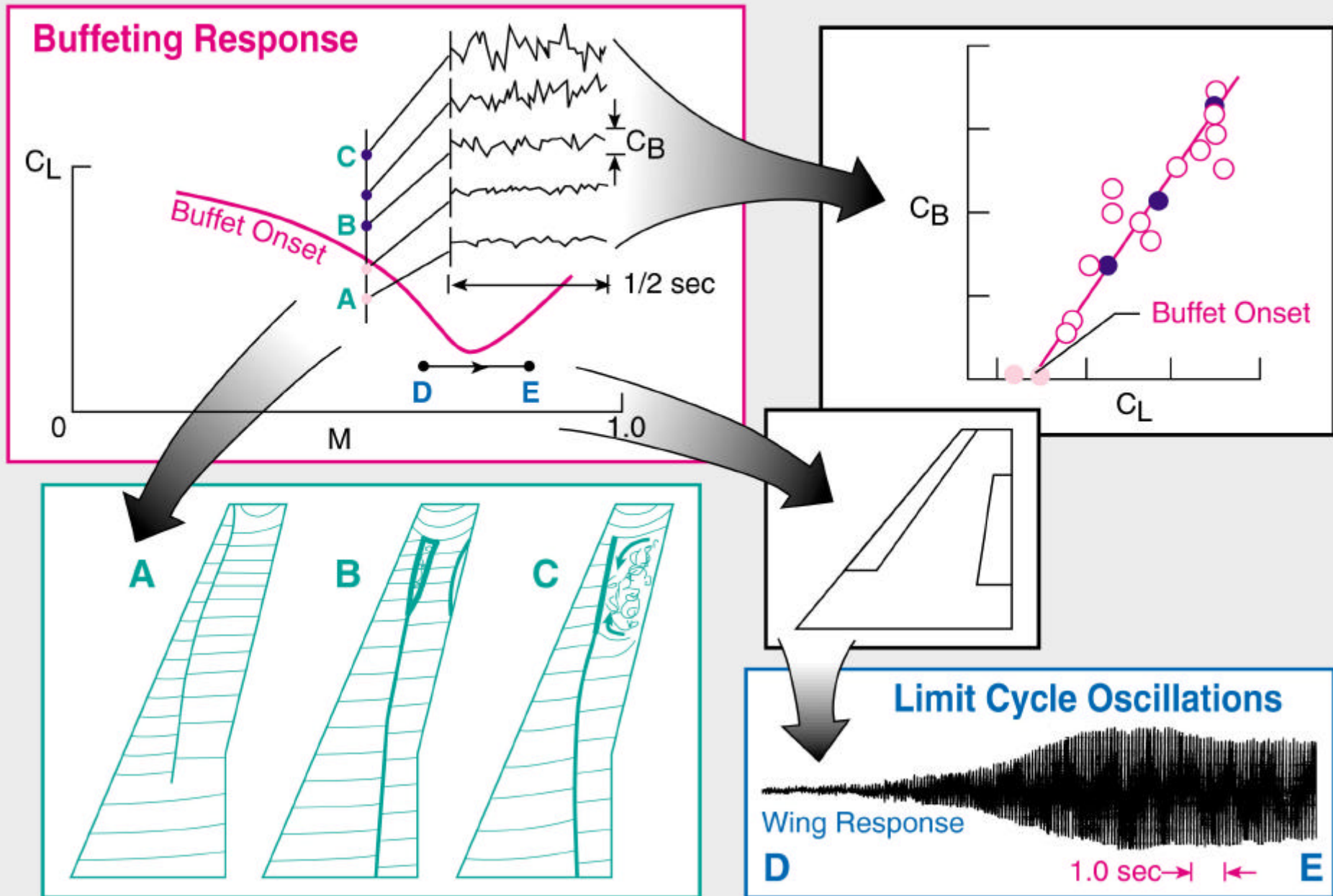
Semi-Adaptive Flutter Suppression Systems



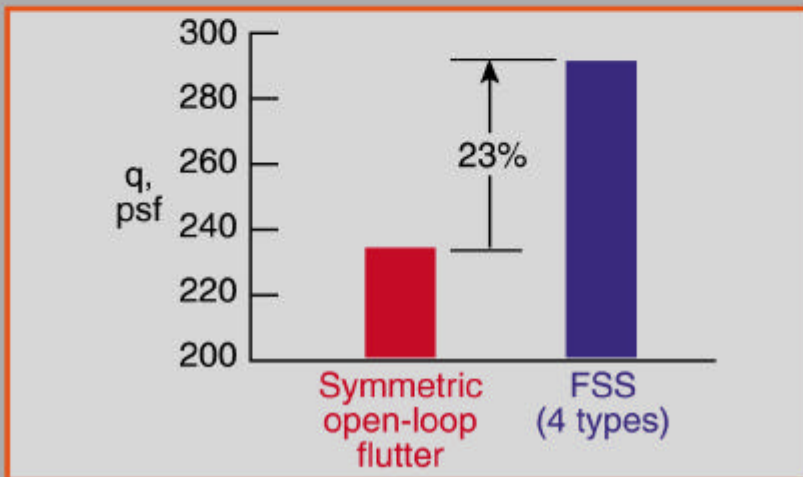
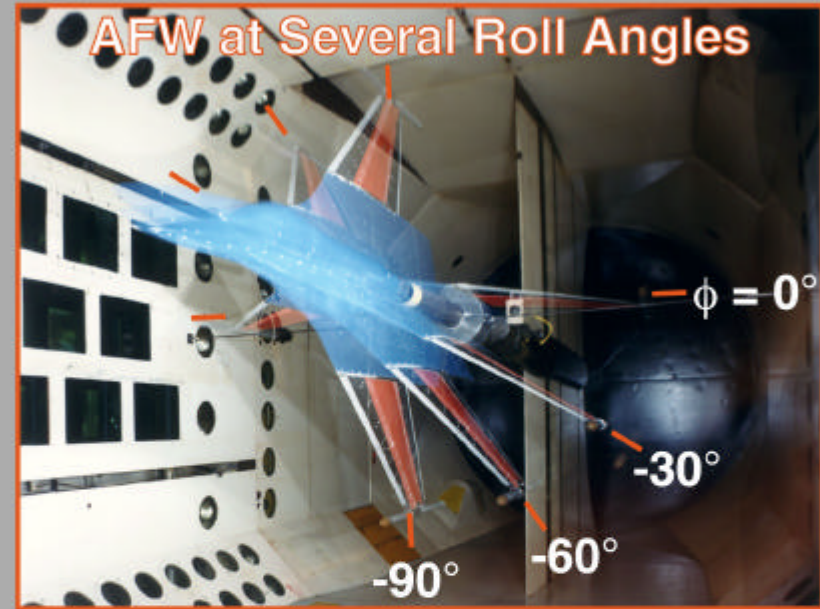
Gust Load Alleviation



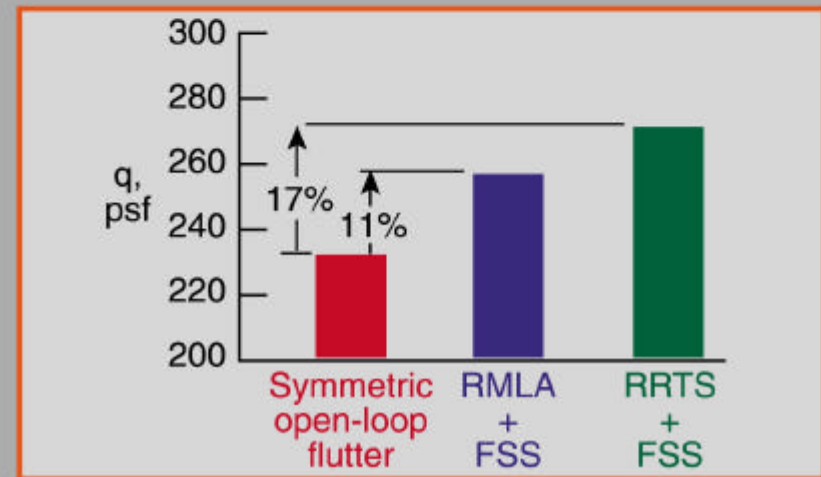
# AEROELASTIC BUFFETING AND LIMIT CYCLE OSCILLATIONS



# ROLL MANEUVERS BEYOND FLUTTER DEMONSTRATED WITH AFW MODEL IN TDT



Flutter Suppression Only



Flutter Suppression and Roll Control

**SOME BASIC CONSIDERATIONS**

**FOR**

**AEROELASTIC WIND TUNNEL TESTING**

# **TEST OBJECTIVES**

**The absolute, most important first step in preparing for a wind-tunnel test is determining the test objectives**

**TEST OBJECTIVES CAN CHANGE  
TEST OBJECTIVES CAN DEVELOP**

**HOWEVER...**

**Without early test objective definition  
it will be difficult to achieve a successful wind-tunnel test**

# MEETING TEST OBJECTIVES

- Speed range considerations
- Calibration definition
- Evaluate facility options
  - Cost
  - Facility capabilities

# SPEED RANGE CONSIDERATIONS

- Transonic conditions are generally greatest concern
- Would subsonic information be sufficient?
- Supersonic testing adds burden of handling start-up loads

# FACILITY CAPABILITIES

- Speed range
- Pressure variation
- Test medium
- Model-mount options
- Built-in safety features
  - Model constraints
  - Blockage doors
  - Bypass valves
  - Catch screens
- Productivity
  - Model access
- Model excitation systems
- Temperature range/control

# TEST MEDIUM

- Air
- Nitrogen
- R-134a
- SF6

# FACILITY RECOMMENDATIONS\*

## Flutter wind tunnels

Criteria	Subsonic			Transonic			Supersonic		
	M/C 8x12	UWAL	BVWT	TDT	16T	Calspan	BSWT	NTS	LTV
Schedule access	4.0	2.0	2.0	3.0	1.0	3.0	3.0	3.0	
Productivity	4.0	3.0	3.0	2.0	2.0	3.0	3.0	3.0	3.0
Flow quality	4.0	1.0		1.0	1.0	2.0	3.0		1.0
Data quality	4.0	3.0	3.0	2.5			3.0	2.0	
Attitude > customer	4.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	
Size (existing models)	3.0	3.0	5.0	4.0	4.0	3.0			
Test section shape	3.0	2.0	4.0	4.0	4.0	2.0	3.0		
Half-model capab.	4.0	4.0		4.0	4.0	2.0	2.0	3.0	3.0
Model design/fab	3.0	2.0	3.0	3.0	1.0	2.0	4.0	2.0	3.0
Emergency stop	4.0	2.0	1.0	2.5	2.0	2.0	4.0	3.0	
<b>Weighted score</b>	3.73	2.45	2.19	2.84	2.06	2.00	2.61	1.84	1.11

\*Boeing internal evaluation- 5=world class, foreseeable future; 1=seriously deficient