The Active Flutter Suppression (AFS) Technology Evaluation Project

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AMTAS

Advanced Materials in Transport Aircraft Structures

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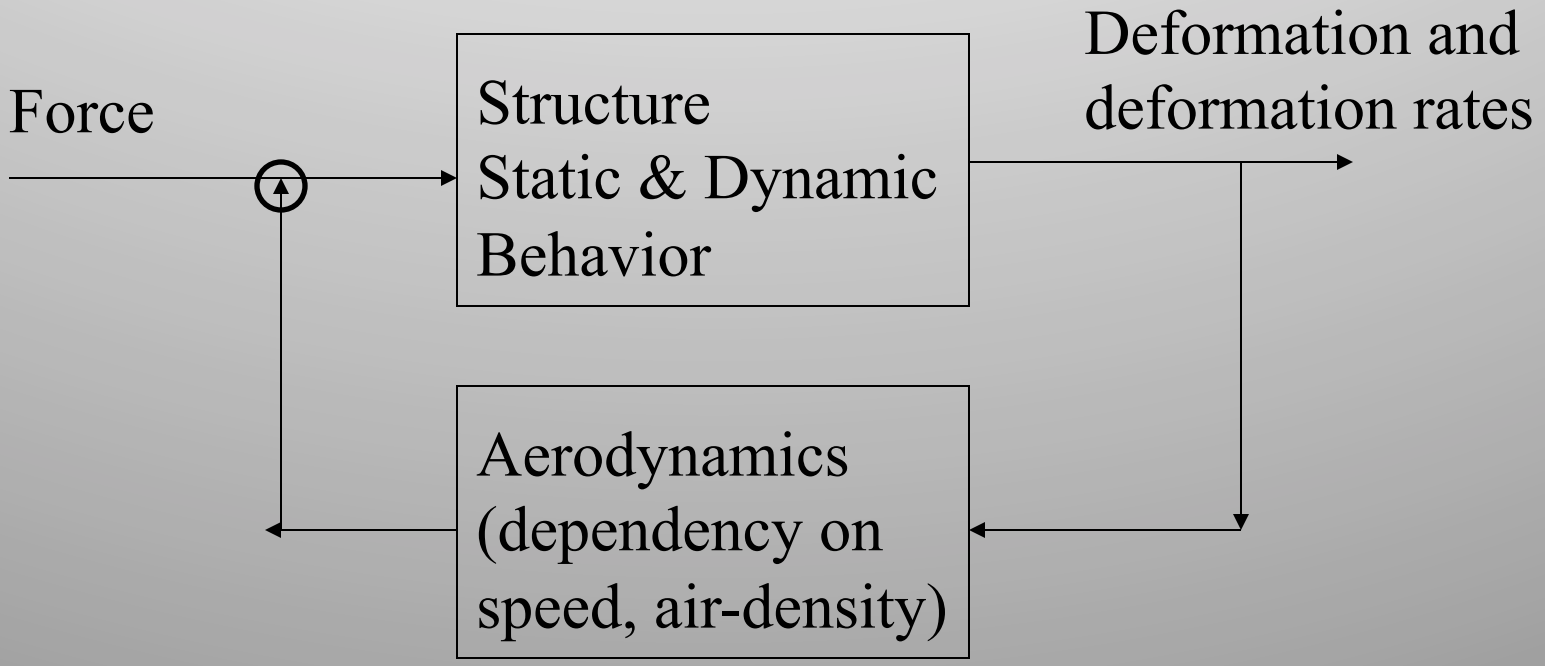
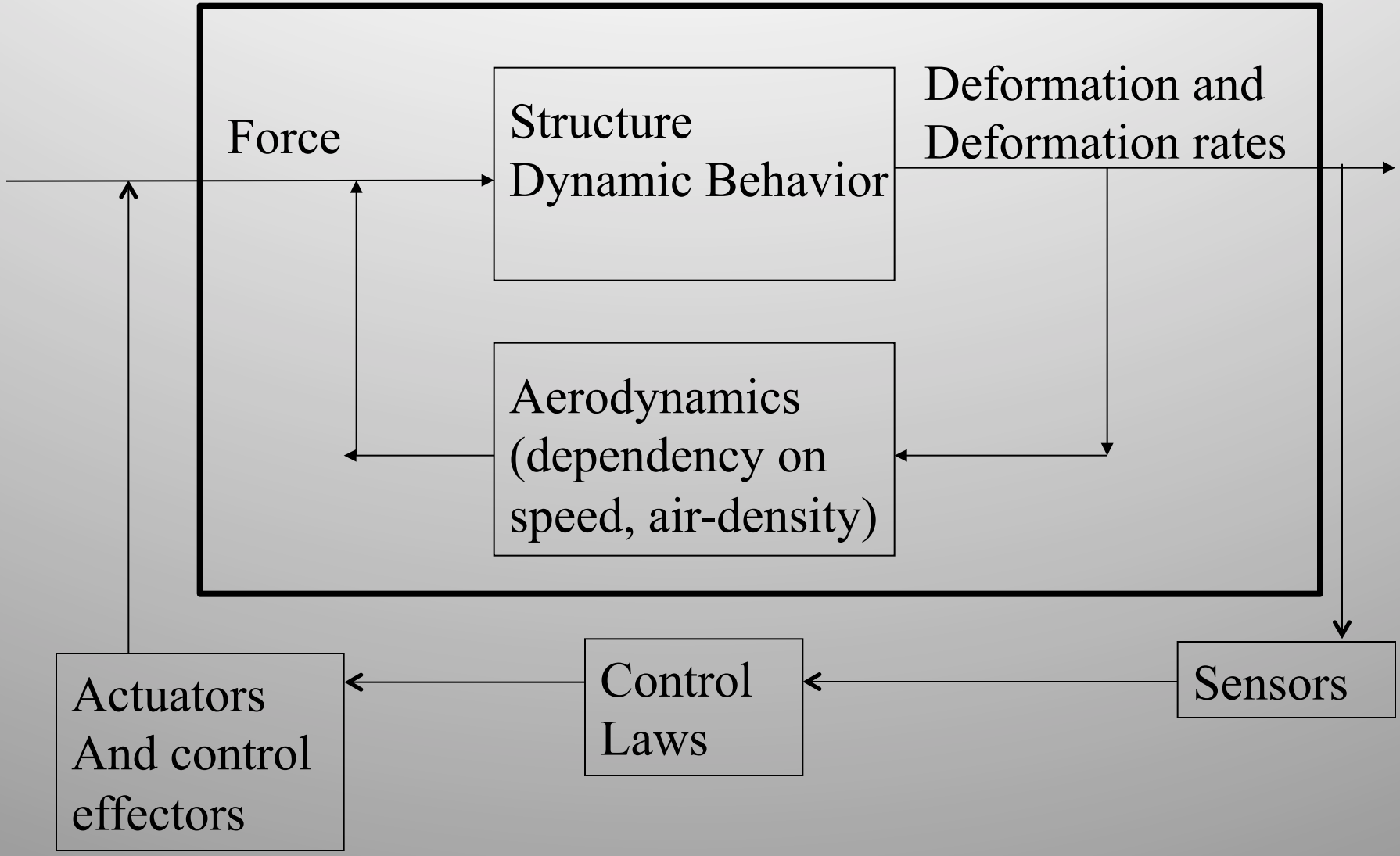
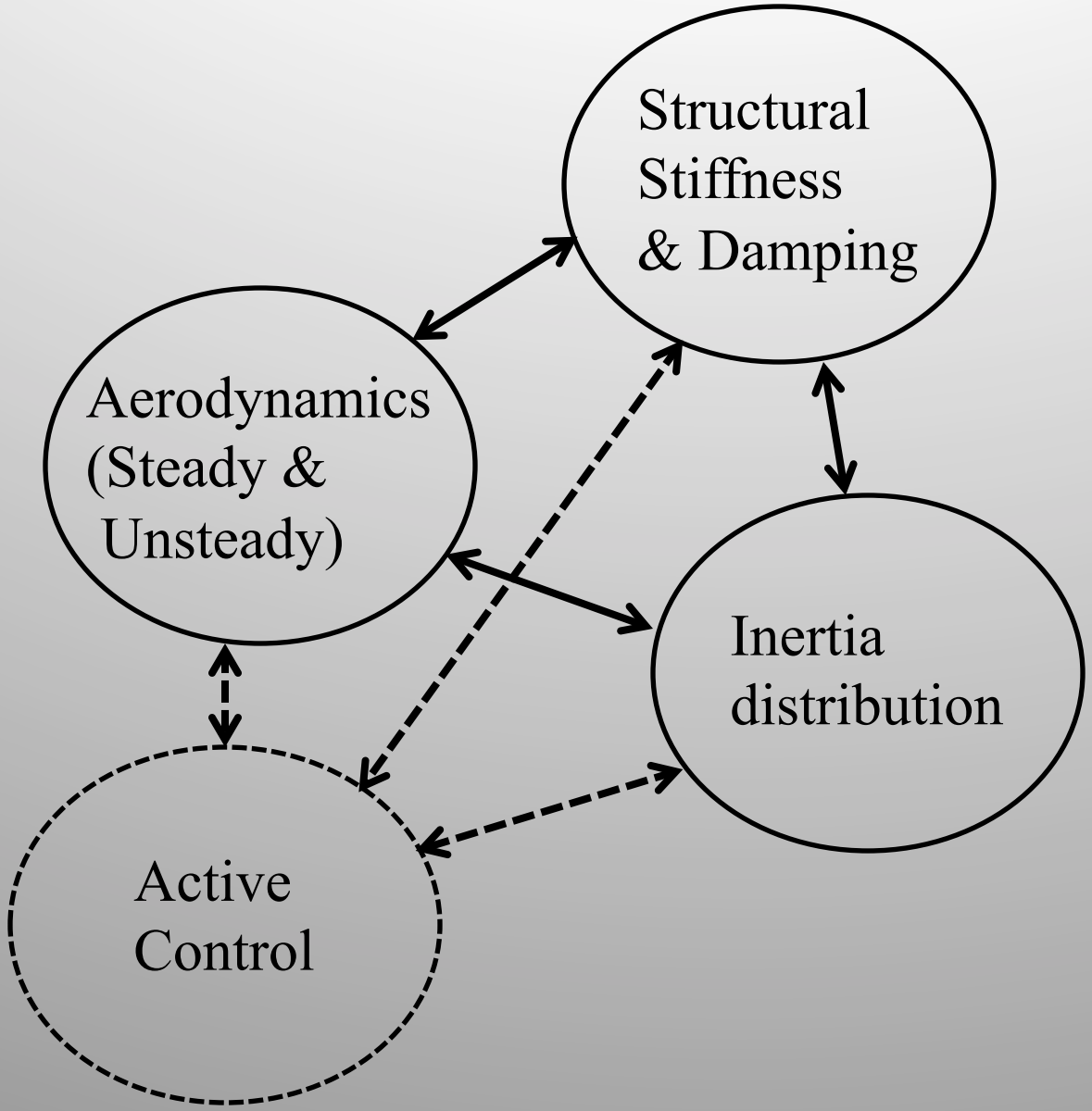
The Aeroelastic (AE) Physical Feedback Loop and Associated Stability Static & Dynamic



Aero-servo-elasticity (ASE)




Structural
Stiffness
& Damping
Aerodynamics
(Steady &
Unsteady)
Inertia
distribution
Active
Control

Aeroservoelastic Systems Benefits and Opportunities

- Shape dynamic behavior of the flexible vehicle using active control:
  - Flight mechanics of the vehicle as a “rigid body”
  - Gust load alleviation
  - Ride comfort (Vibrations),
  - Etc.

Aeroservoelasic Systems – Adverse Interactions

- A control system designed for flight mechanics control, gust alleviation, ride comfort, etc., interacts with the dynamic aeroelastic structure to produce instabilities.
- Find ways to decouple the active control system (through filtering of sensor signals) from the dynamics of the aeroelastic system.

Opportunities – AFS as a Response to Flutter Problems

- If flutter (or other aeroelastic problems) show up late in the design process, when solution by revised stiffness / inertia / aerodynamic means becomes impractical:
- Use active control, through the action of control effectors driven by actuators and control laws, to solve the problems.
- In this case Active Flutter Suppression is used as a fix of flutter problems.

Opportunities – AFS As Part Of The Integrated Design From The START

- Allow integrated optimization of the coupled structure / aerodynamic / control system from its early design stages, leading (potentially) to major weight savings and performance improvements.

Technology State of the Art

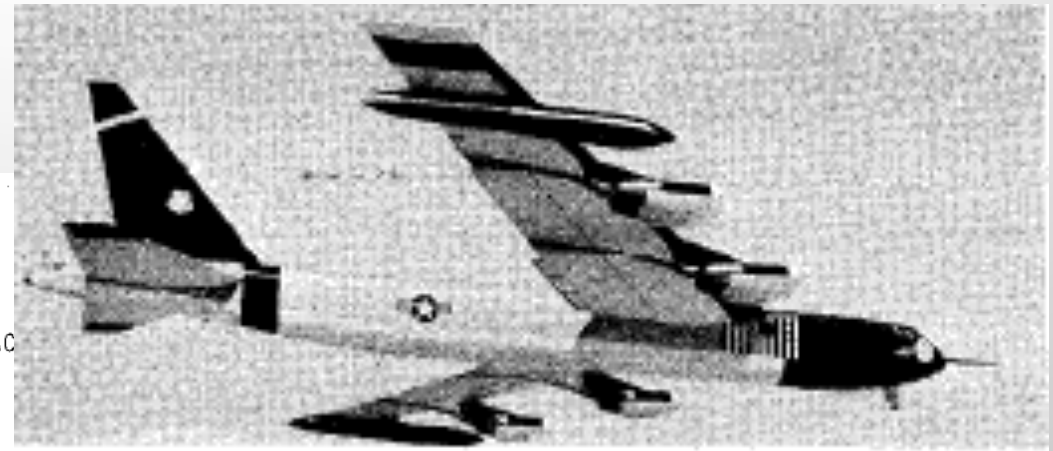
- Gust alleviation systems are already certified on passenger airplanes as well as ride comfort augmentation and maneuver load control systems.

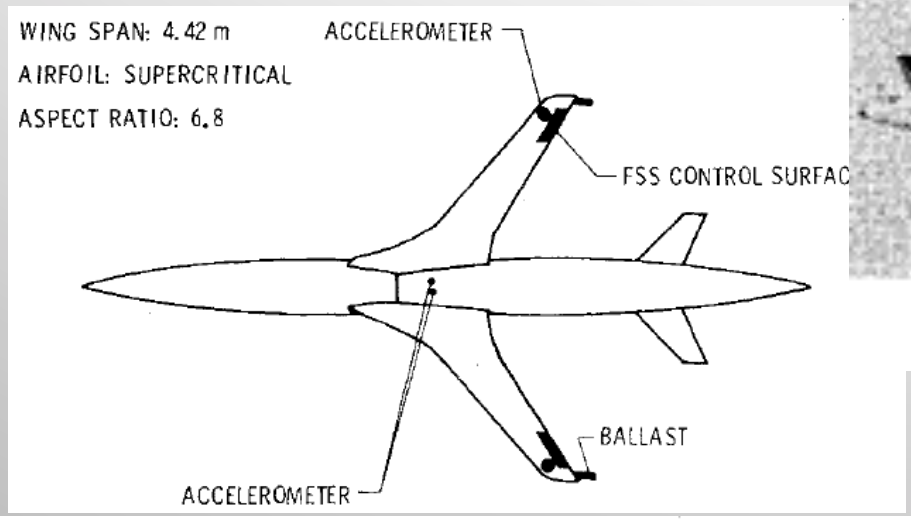
- Those aeroservoelastic systems operate in harmony with the aircraft flight control system (FCS).

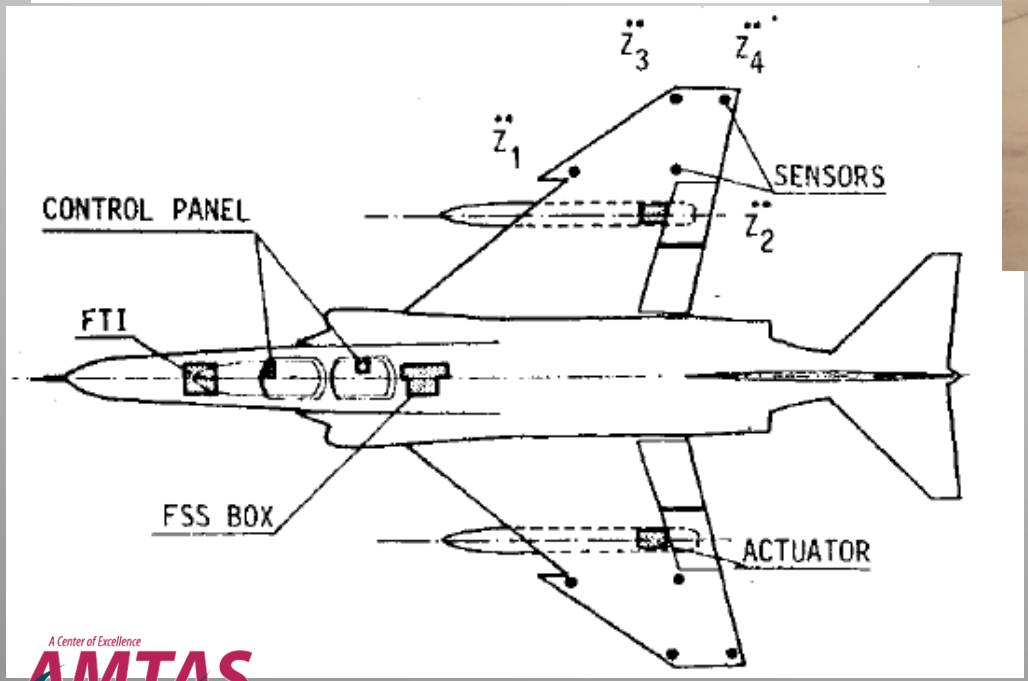
- Active Flutter Suppression has been thoroughly researched since the mid 1960s (when flight control systems began to become powerful and high bandwidth).

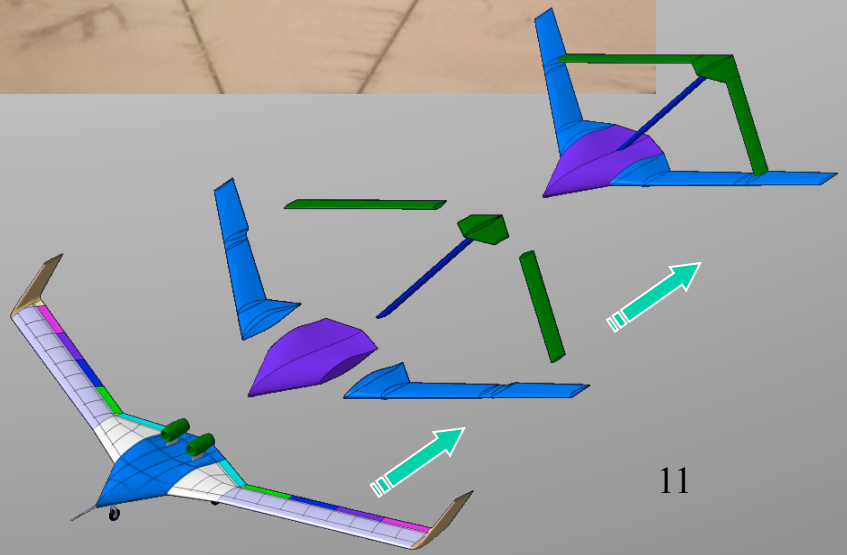
Technology State of the Art (continued)

- Many academic / theoretical studies.
- Quite a number of wind tunnel tests using dynamically / aeroelastically scaled models of production or test aircraft with active controls.
- A few AFS flight tests of AFS-configured test vehicles – A B52 in the early 1970s, an F4F with external stores in the 1970s, NASA DAST UAV in the 1970s-early 1980s, Lockheed / USAF X56 UAV recently.









A Center of Excellence AMTAS Advanced Materials in Transport Aircraft Structures

AIAA 80-0770R

Active Flutter Suppression on an F-4F Aircraft

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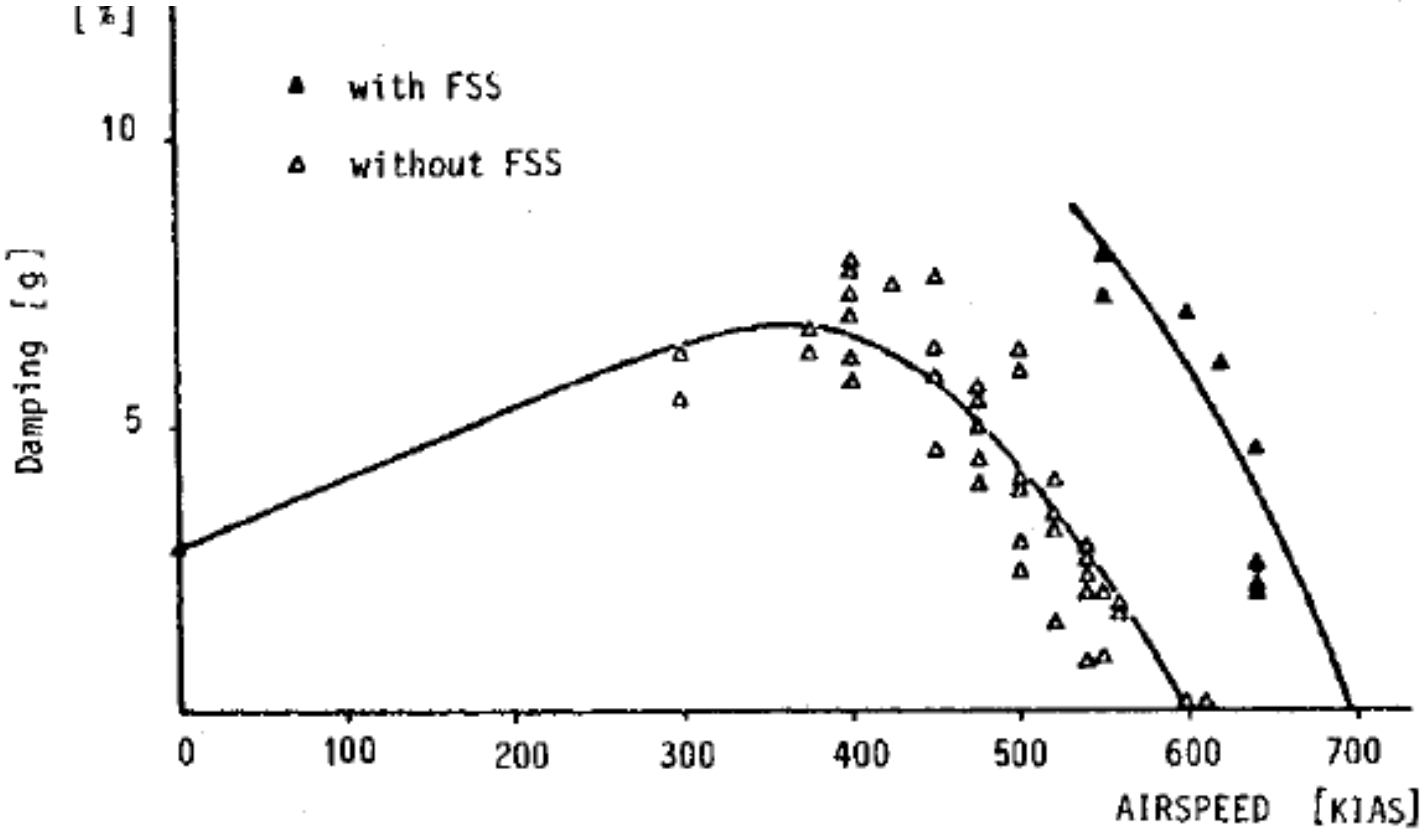

Fig. 24 Increase of flutter speed with FSS.

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Active Flutter Suppression—A Flight Test Demonstration

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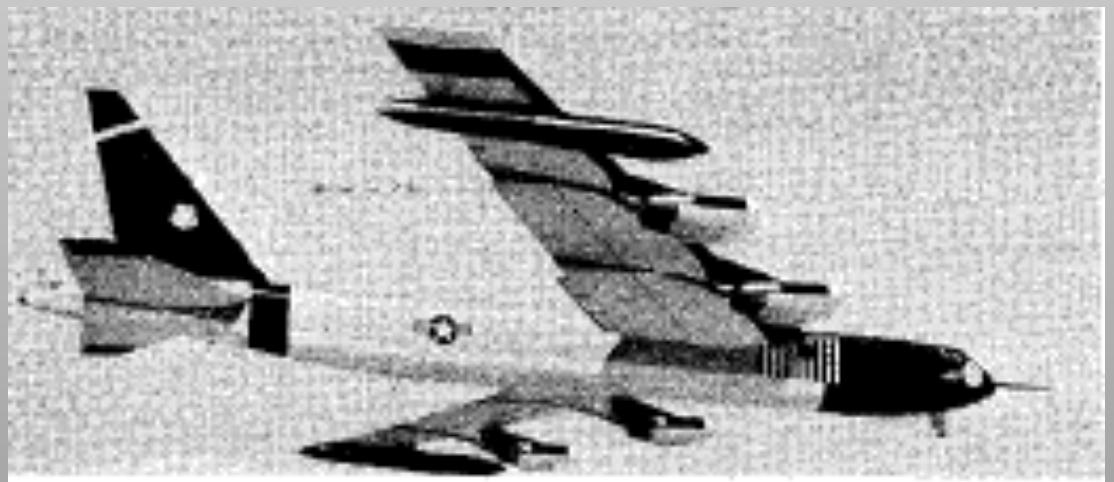
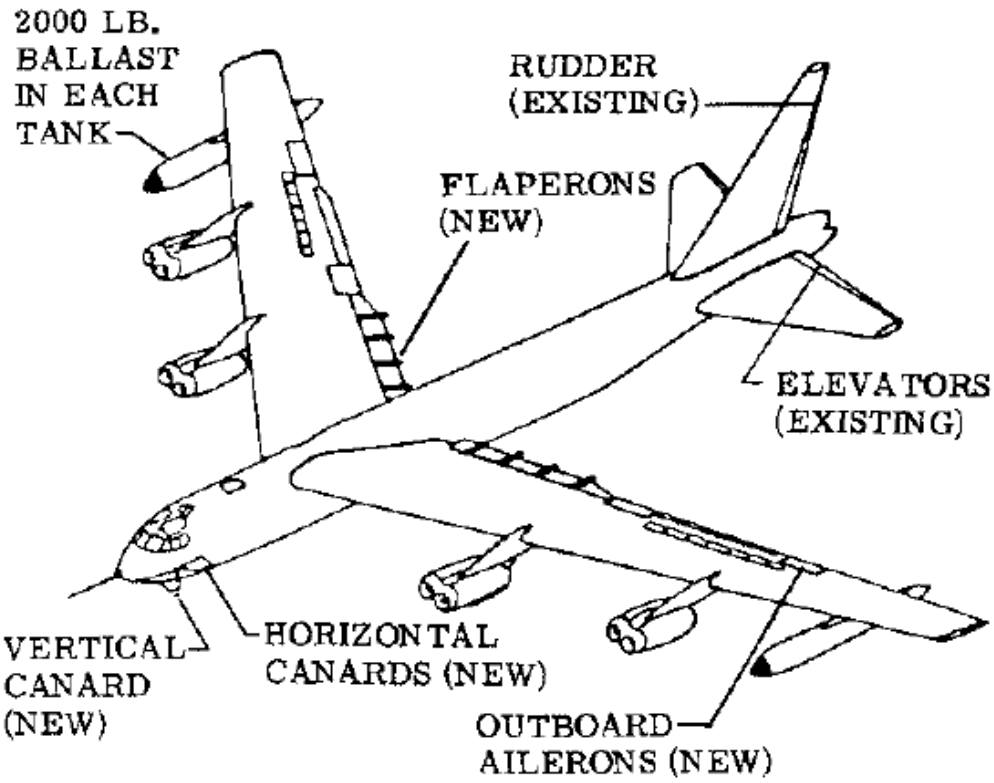


Fig. 9 Modified test airplane.



SURFACES	CCV CONCEPTS				
	RCS	FMC	MLC	AS	FR
RUDDER				X	
ELEVATOR			X	X	X
FLAPERON		1 SEGMENT	X		
OUTBOARD AILERON		X	X		X
HORIZONTAL CANARD	X				
VERTICAL CANARD	X				

Fig. 1 B-52 CCV control surfaces.

CCV B52 Flight Tests With and Without AFS

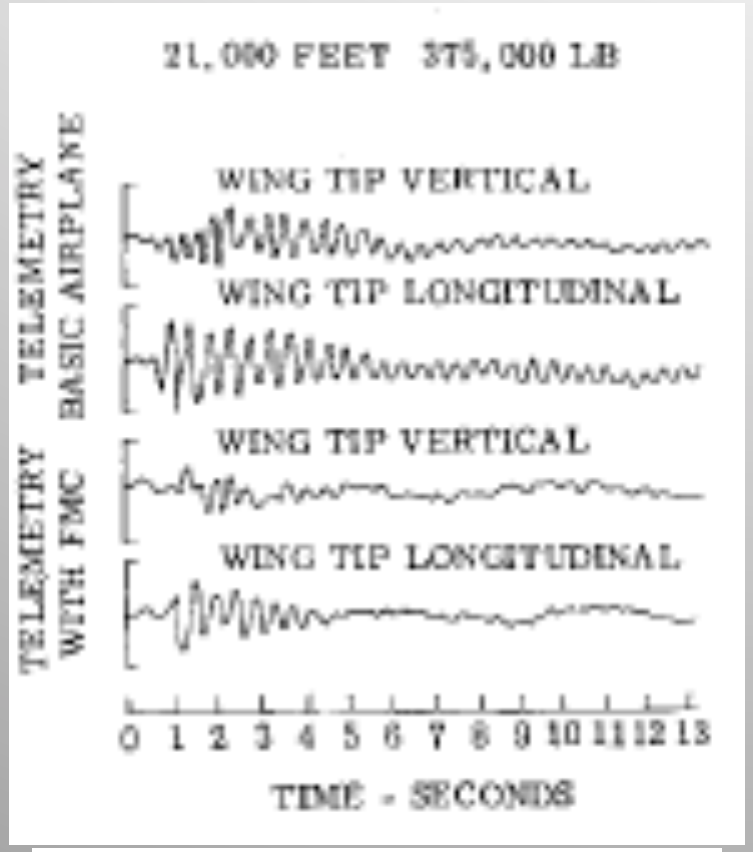


Fig. 18 Test transient response, 2 knots below flutter, with and without FMC.

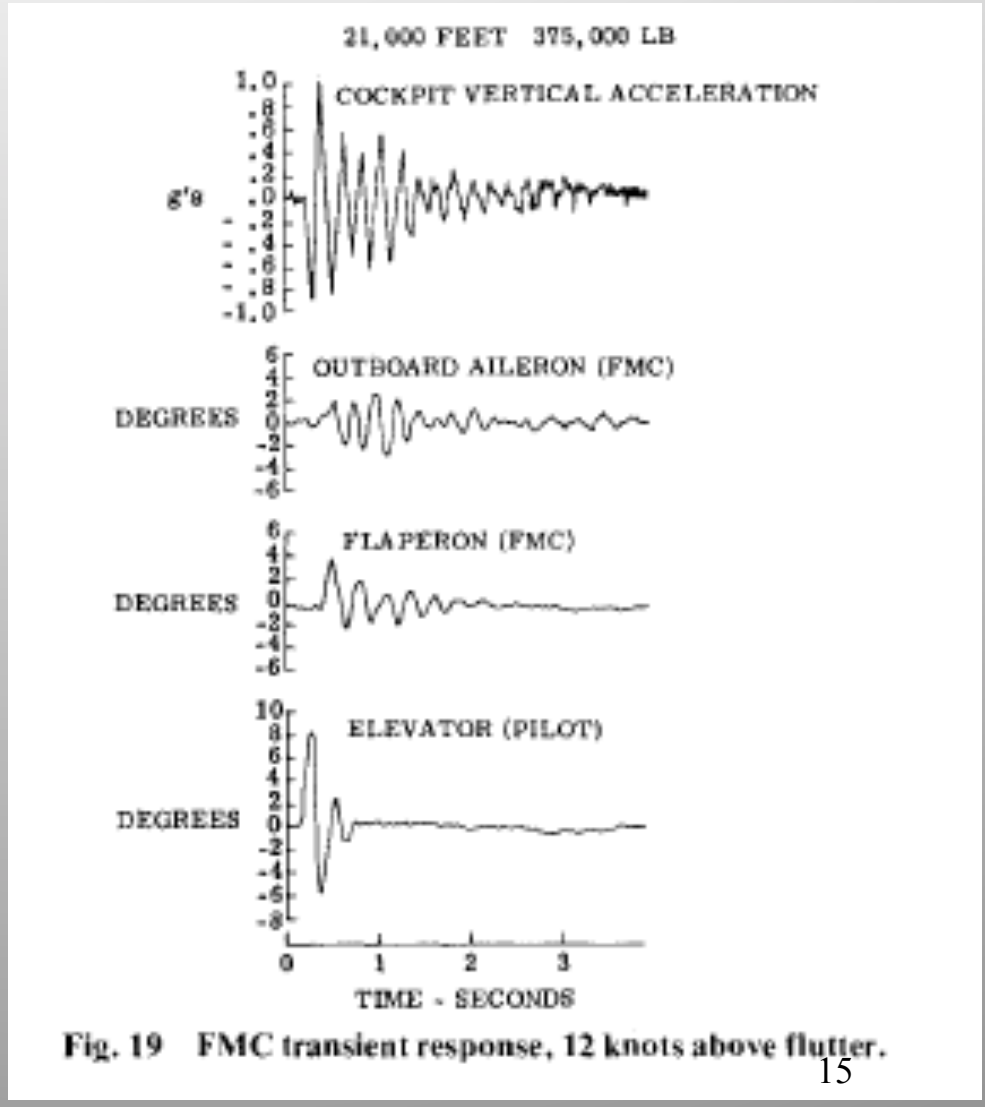


Fig. 19 FMC transient response, 12 knots above flutter.

The FAA / AMTAS Active Flutter Suppression Project

- Assess the state of the art of the technology and its level of readiness for integration into actual airplane development.

- Work with industry, government research agencies, government regulation & certification agencies in the U.S. and abroad, as well as academia to develop a plan of action that would lead, via development of analysis, design, tests, operations, and maintenance process to established FAA policies regarding AFS on civil aircraft.

The FAA / AMTAS Active Flutter Suppression Project

- Year 1: state of the art assessment and the development of an R&D plan.

- Years 2&3: Analysis and design studies followed by tests of representative configurations to study technology readiness, identify key issues, and create a data base of test results for future design & analysis methods validation.

- Conclusion: New FAA policies / certification requirements (or not…)

Project Status

- Study of the state of the art via a comprehensive literature survey and past-work technical source data base generation – completed.
- Currently, launching an industry / government research agencies consultation phase for gathering views from lead experts in this area as well as more information (unpublished) on existing industry experience.