PHILLIPS LABORATORY
DIRECTORATE OF SPACE AND MISSILES TECHNOLOGY

ADAPTIVE STRUCTURES
FLIGHT EXPERIMENTS

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NASA/DOD Flight Experiments
Technical Interchange Meeting
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ADAPTIVE STRUCTURES
FLIGHT EXPERIMENTS

1. ADVANCED CONTROLS TECHNOLOGY EXPERIMENT (ACTEX)

2. ADVANCED CONTROLS TECHNOLOGY EXPERIMENT II (ACTEX-II)

3. STRV-1B CRYOCOOLER VIBRATION SUPPRESSION FLIGHT EXPERIMENT

4. PRECISION OPTICAL BENCH (PROBE)

5. OTHER SDIO FLIGHT PROGRAMS
   - MODULAR CONTROL PATCH
   - ADVANCED COMPOSITE STRUCTURAL COMPONENTS FOR CLEMENTINE
   - TECHSAT ALL-COMPOSITE SPACECRAFT

6. INEXPENSIVE STRUCTURES AND MATERIALS FLIGHT EXPERIMENT (INFLEX)
Enhanced Resolution Using Active Vibration Suppression....

- Pixel smearing due to jitter
- Enhanced image using active vibration suppression
Advanced Controls Technology Experiment (ACTEX)

OBJECTIVE
On-Orbit Demonstration of Embedded Piezoceramic Sensors and Actuators for Active/Passive Vibration Suppression

DESCRIPTION
- 1 ft x 1 ft x 2 ft Tripod Structure
- Piezos for Active Control Layered in 1 inch Advanced Composite Tubes
- Passive Damping Using Piezos with Resistor Shunt
- On-Orbit System ID/Structural Characterization
- Dynamic Change Mechanism with On-Orbit Adaptive Control
- Launch Restraint Using Nitinol Non-Pyrotechnic Release Device
ACTEX PROGRAM STATUS

- PROGRAM FULLY FUNDED BY SDIO

- TRW HAS COMPLETED EXPERIMENT FABRICATION

- EXPERIMENT DELIVERED TO NAVAL RESEARCH LABORATORY IN AUGUST 1992 FOR SPACECRAFT INTEGRATION

- LAUNCH ANTICIPATED IN 1994
OBJECTIVE
System Application of Piezoceramic Sensors and Actuators to Damp Solar Array Vibrations

DESCRIPTION
- Solar Array Yoke with Embedded Piezoceramic Sensors and Actuators
- 6 ft x 2.5 ft Simulated Solar Deployable Aluminum Framework Modal Frequencies of 0.5-10 Hz
- Vibration Suppression Using Digital Control Electronics
- Electronics Miniaturized Into Multichip Module Mounted on Yoke
- Advanced Solar Array Drive Motor with Viscoelastic Damped Interface
- On-Orbit System ID/Structural Characterization
ACTEX-II PROGRAM STATUS

- PROGRAM FULLY FUNDED BY SDIO

- TRW IS FINALIZING FLIGHT HARDWARE DESIGN

- EXPERIMENT TO BE DELIVERED IN EARLY 1994 FOR INTEGRATION ON STEP-3 SPACECRAFT

- LAUNCH ANTICIPATED IN EARLY 1995
Modular Control Patch

OBJECTIVE
Develop a Miniaturized, Modular Vibration Suppression System Having Sensing, Actuation, and Control/Power Conditioning Components Integrated into a Self-Contained Package

PAYOFF
Miniaturized, Lightweight, Retrofittable Vibration Suppression System
STRV-1b Cryocooler
Vibration Suppression Experiment

OBJECTIVE
Vibration Suppression of Cryocooler Cold Finger Using Active Control Technologies

DESCRIPTION
- Stirling-Cycle Cryocooler Traceable to SDI Class Systems
- Piezo Stack Actuators for 3-Dimensional Control of Cryocooler
- Actuation Using Piezo Applique Bonded to Base of Cold Finger
- Eddy Current Transducer to Measure Cold Finger Tip Motion
- Integrated Digital and Analog Control Electronics
STRV-1B PROGRAM STATUS

• PROGRAM FULLY FUNDED BY SDIO

• EXPERIMENT FABRICATION IN PROGRESS AT THE JET PROPULSION LABORATORY

• EXPERIMENT TO BE DELIVERED TO THE ROYAL AEROSPACE ESTABLISHMENT EARLY 1993 FOR SPACECRAFT INTEGRATION

• ARIANE LAUNCH ANTICIPATED IN MID 1994
OBJECTIVE
Integration of Active/Passive Control Technologies to Create a Vibration Isolated Optical Bench

DESCRIPTION
- Advanced Composite Platform with Passive Damping Treatment
- Vibration Isolation of Platform Using Active Control Components
  - Vibration from Spacecraft Bus
  - Disturbances on Platform (Slewing Sensors, Cryocoolers, etc.)
- Active/Passive Vibration Suppression at Optical Sensors
- Correlation of Vibration Suppression to Sensor Performance
Clementine Candidate Structural Components

- INTERSTAGE
- ADAPTER
- UPPER DECK
- MID DECK
- OPTICAL BENCH
- LOWER DECK
- FRAME
Clementine Spacecraft Configuration

LAUNCH CONFIGURATION

INTERSTAGE

ADAPTER

ON-ORBIT CONFIGURATION

SENSOR VIEW

X

Y

Z
Inexpensive Structures and Materials Flight Experiment (INFLEX)

OBJECTIVE
Integrated On-Orbit Demonstration of Advanced Structures, Materials, and Controls Technology for Precision Space Structures

DESCRIPTION
- 16-Foot Advanced Composite Deployable Antenna, Sized for Pegasus Launch
- Optical Sensing System for Antenna Shape Control
- Piezo Strut for Coupled 2-Body Dynamics
- High-Capacity Processor for Advanced Control Algorithms
- Structural Change Capability for Controller Reconfiguration
INFLEX PROGRAM STATUS

• $1.1M AIR FORCE FUNDING THROUGH PHASE II

• HARRIS CORP HAS COMPLETED ENGINEERING DRAWINGS FOR PRELIMINARY FLT EXP DESIGN

• EXPERIMENT FABRICATION TO COST $12M AND REQUIRE 2 YEARS FROM START DATE

• EXPERIMENT FABRICATION IN PHASE III IS CURRENTLY UNFUNDED
INFLUX (PL-101)
VALIDATES KEY TECHNOLOGIES

JPL PIEZO STRUT

HARRIS PROOF MASS ACTUATOR

LESCO SPI-GONE TELESCOPE (POSITION SENSOR)

CSA PIEZO ELASTIC MATERIALS
CONCLUSIONS

• ON-ORBIT DEMONSTRATIONS ESSENTIAL TO TRANSITION ADVANCED TECHNOLOGY TO OPERATIONAL SPACE SYSTEMS

• SUCCESSFUL FLIGHT EXPERIMENTS ADDRESS SPECIFIC OPERATIONAL CONCERNS IN SMALL, NEAR-TERM TECHNOLOGY DEMONSTRATIONS

• JOINT EFFORTS GREATLY FACILITATE EFFORTS, E.G., SDIO FUNDING, AF TECHNOLOGY, NRL FLIGHT

• SDIO HAS PROVIDED STRONG SUPPORT FOR FLIGHT EXPERIMENTS IN AREA OF ADAPTIVE STRUCTURES