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Andreas H. von Flotow

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The report lists in detail the equipment purchased with this instrumentation grant (granded under the DoD-URIP program). Also summarized is the impact this equipment has had upon the work and the reputation of the affected group at MIT. The appendix includes numerous theses and papers which have benefited from the availability of this equipment.

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Final Report

Grant AFOSR-87-0031

Instrumentation for a Facility for the Test, Analysis and Active Control of Spacecraft Truss Structures

prepared for

Dr. Anthony K. Amos
AFOSR/NA
Building 410
Bolling Air Force Base
Washington, DC 20332-6448

August 18, 1989

A. von Flotow
Andreas H. von Flotow
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A-1

Abstract

This grant was awarded under the terms of the Department of Defense University Research Instrumentation Program (FY 1986/FY 1987). The initial period, 1 October '86 to 31 September '87, was extended, at no cost, to 31 December 1988. this extension permitted a much more orderly purchase of instrumentation, similar in cost and in function to that listed in the original proposal, but significantly more capable and better matched to our needs.

The purchased instrumentation has already enabled several experimental MS and PhD theses. The PhD theses of Daid Miller (May 1989), Javier de Luis (March 1989), and the MS theses of Gary Blackwood (May 1988), Nesbitt Hagood (June 1988, Darryll Pines (May 1988), David Vos (May 1989) and Ron Spangler (May 1989) all report on experimental results which relied upon use of some of the instrumentation purchased with these funds. These theses and the resulting papers are listed in the appendix. Lacking this equipment, at least several of these students would have had to forego experimental work.

The purchased instrumentation has essentially created an effective laboratory in experimental structural dynamics and active control. The presence of this laboratory has contributed to our recent success in attracting continued research funding. As an example of this success, one might mention that this laboratory was chosen by NASA to be a university center for excellence in dynamics and control of precision spacecraft structures.

The foresight of the AFOSR sponsor, Dr. Anthony Amos, in deciding to make this investment of seed money is now paying off.

List of Purchased Equipment

The attached list reflects our record of what instrumentation was purchased, compared to the budgeted amounts.

AIR FORCE GRANT (AFOSR-87-0031) **Authorized total $206,000**

Item	Vendor	Budgeted Amount	Actual Amount
1. DIAGNOSTIC TEST EQUIPMENT		9,800.00	
Oscilloscope with plug in disk drive	Nicolet		11,232 75
Frequency Counter	Kaufman		430.65
Multimeters (2)	Keithly Instrument		944 31
			12,607.71
2. SENSORS & SHAKERS		84,091.00	
Electromagnetic Shakers Model 4809 (3)	Bruel & Kjaer		4,016.51
Structcel Simulator with Differential amplifiers	PCB Piezotronics, Inc		4,614 46
single axis Force transducer & charge amplifiers (2)	Kistler Instrument		2,485.00
7200 Series 8 mm transducer probes, proximeter & cables (2)	Bentley-Nevada		1,033.00
Power amplifiers (3)	La Salle Audio		1,588.14
pillow block (2) & ball bearings (2)	Atlantic Tracy		109.14
Power supplies (3)	Acopian Corp		754.55
Unregulated Power supplies (2)	Acopian Corp		327 43
Accelerometers (2)	Columbia Research Labs		536.00
ESA 10/75 Current Amplifier cards (2)	Galil Motion Control		887.00
UFS 6 Axis Partial Sensor System with signal conditioning	JR3, Inc		5,676.75
Force transducer	Kistler Instrument Corp		758.00
Laser, beam splitter, mirrors, and mount	Newport Corp		2,300.50
EVIS-Electronic vibration Isolation system	Newport Corp		14,655 27
5 Piezo film sheets	Pennwalt Corp		551 45
2 Piezo Stack	Piezo Electric Products		700 00
4 Piezo Stack	Piezo Electric Products		1,400.00
Laser Measurement System	Zygo Corp		35,003.53
Indinometer with Angular rate sensor	Watson Industries		2,534.00
Accelerometers (8) with mounts	Sunstrand Data Control		13,945.50
Crown Amplifier	Lake Systems Corp		755.00
DC Motors with Tach	Infranor		2,182.50
Gears amd pulleys	Atlantic Tracy		228.27
Accelerometer	Endevco		599.00
Unistruts	Unistrut Northeast		103.82
			97,744.82
3. DATA ACQUISITION SYSTEM		77,000.00	
AST-EGA Enhanced graphics adaptor	Microcomputer Center		324.00
Enhanced graphics display monitor	Microcomputer Center		635.00
Signal Processing Base Sys w/ 2 additional input, analog out, zoom, memory & t	Signology		18,482.00
Pixelogic-PIX Proviz Card (color)	Bonsu Corp		1,111.75
Mutlisync Plus with Paradise VGA Plus (see note)	Microbest		534.93
NEC Multi Sync II Monitor (damaged)	Computer Discount Warehouse		603.58
Parallel Interface component kit	Tektronix		3,300.00
Fourier Analyzer with 2 input, 4 channel zoom & 1 output	Tektronix		15,480.00
2-channel variable frequency filter (2)	A.P. Circuit		2,256.50
Lab rack & extension shelf	Inmac Inc		398.10
			43,125.86
4. DATA ANALYSIS SYSTEM		30,500.00	
Vax Station II computer with DEQNA Ethernet Interface, 71 MB disc, TK 50 95 ME	Digital Equipment		
5 MB Ram,19"monitor,graphics subsystem,2 user MVMS license,media& documentation,			
Fortran license, Decnet license,DHUII or 8 line asynchronous communications interface			23,354.80
VT220 terminal	Digital Equipment		572.44
Macintosh SE HD20 with Extended Keyboard	Microcomputer Center		2,372.00
M0160 Apple Laserwriter Printer	Microcomputer Center		3,713.00
M0191 Apple Laserwriter Plus upgrade	Microcomputer Center		689.00
modem cable	Microcomputer Center		15.00
Computer tables (two)	Phase One		261.00
Video Display Terminal--Model GO-235	GraphOn Corp		1,610.47
			32,587.71
5. ACTIVE CONTROL SYSTEM		6,289.00	
40 MB Hard disk for IBM XT	PC Connection		300.71
Adaptive Vibration Control System	Active Noise & Vibration Tech		3,000.00
Adaptive Vibration Control System	Noise Cancellation		14,458.10
			17,758.81
	TOTAL	**207,680.00**	**203,824.91**

Appendix

List of Papers and Theses enabled by this grant:

Papers:

von Flotow, A.H., Miller, D.W., "A Travelling Wave Approach to Power Flow in Structural Networks," J. Sound and Vibration, 128, 145-162, Jan. 1989.

Crawley, E. F., Sigler, J. L., van Schoor, M. c., Gronet, M. J., "Hybrid Scaled Structural Models and Their Use in Damping Prediction," to appear in the AIAA J. Guidance, Control and Dynamics

Peterson, L. D., Crawley, E. F., Hansman, R. J., "The Nonlinear Dynamics of a Spacecraft Coupled to the Vibration of a Contained Fluid," to appear in the AIAA J. Guidance, Control and Dynamics

von Flotow, A.H., Miller, D.W., and Hall, S.R., "Optimal Control of Power Flow at Structural Junctions," Proceedings of the American Control Conference, Pittsburgh, PA, June 1989.

von Flotow, A.H., Sievers, L.A., and Scribner, K.B., "Isolation of a Vibrating Machine Mounted on a Flexible Structure," Proceedings of the American Control Conference, Pittsburgh, PA, June 1989.

von Flotow, A.H. and Pines, D.J., "Active Control of Bending Wave Propagation at Acoustic Frequencies," Proceedings of the American Control Conference, Pittsburgh, PA, June 1989.

Crawley, E.F., Hagood, N.W., "A Frequency Domain Analysis for Damped Space Structures," presented at the 30th AIAA/ASME/ASCE/AHS Structures, Structural Dynamics, and Materials Conference, Mobile, Alabama, April 1989.

von Flotow, A.H. and Hagood, N.W., "Damping of Structural Vibrations with Piezoelectric Materials and Passive Electrical Networks," Proceedings of the Air Force Damping Workshop, March 1989.

von Flotow, and Blackwood, G., "Guidelines for Component Mode Synthesis of Structures with Slpppy Joints," Proceedings of the AIAA SDM Conference, April 1988.

von Flotow, and Sievers, L.A., "Active Control of Machinery Mounts for Vibration Isolation," Proceedings of the CDC, Austin, TX, Dec. 1988.

Hagood, N.W., Crawley, E.F., de Luis, J., Anderson, E.H., "Development of Integrated Components for Control of Intelligent Structures," presented at ARO Workshop on Smart Materials, Structures and Mathematical Issues, Virginia Polytechnic Institute, Blacksburg, VA, September 15, 1988.

Crawley, E.F., de Luis, J., Hagood, N.W., Anderson, E.H., "Development of Piezoelectric Technology for Applications in Control of Intelligent Structures," 1988 American Control Conference, Atlanta, GA, June 1988.

von Flotow, A.H., Miller, D.W., and Hall, S.R., "Active Modification of Wave Reflection and Transmission in Flexible Structures," Proceedings of the American Controls Conference, Minneapolis, MN, June 10-12, 1987 (invited paper)

Miller, D. W., Hall, S. R., "Experimental Results Using Travelling Wave Power Flow Techniques," Proceeuings of the 1989 ASME Winter Annual Meeting, San Francisco, Dec., 1989

S. M. Theses:

Vos, David, "Dynamics and Active Control of a Robot Unicycle," expected June 1989.

Anderson, E. H., "PiezoCeramic Actuation of One- and Two-Dimensional Structures," May 1989

Lazarus, K. B., "Induced Strain Actuation of Composite Plates," March 1989
Hagood, N. W., "Development and Experimental Verification of Damping Enhancement Methodologies for Space Structures," Sept. 1988

Sigler, J. L., "Prediction and Measurement of Damping in Hybrid Scaled Space Structure Models," July 1988

Pines, Darryll, "Active Control of Bending Wave Propagation at Acoustic Frequencies," June 1988.

Blackwood, Gary, "Experimental Component Mode Synthesis of Structures with Non-Linear Joints," June 1988.

PhD Thesis:

Miller, David, "Modelling and Active Modification of Wave Scattering in Structural Networks," May 1988.

Peterson, L. D., "The Nonlinear Coupled Dynamics of Fluids and Spacecraft in Low Gravity," Sept 1987

van Schoor, M. C., "The Coupled Nonlinear Dynamics of Spacecraft with Fluids in Tanks of Arbitrary Geometry," April 1989

de Luis, J., "Design and Implementation of Optimal Controllers for Intelligent Structures Using Infinite Order Structural Models," Jan. 1989