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OCA PAD INITIATION - PROJECT HEADER INFORMATION

10/07/88

Active

Project #: E-16-699
Center #: R6603-OA0

Cost share #: E-16-335
Center shr #: F6603-OA0

Rev #: 0
OCA file #:
Work type : RES
Document : GRANT
Contract entity: GTRC

Contract#: DAAL03-88-G-0082
Prime #:

Mod #:

Subprojects ? : N
Main project #:

Project unit: AE Unit code: 02.010.110
Project director(s):
HODGES D H AE

Sponsor/division names: ARMY / ARO, RES TRIANGLE PARK, NC
Sponsor/division codes: 102 / 001

Award period: 881001 to 890930 (performance) 891130 (reports)

Sponsor amount	New this change	Total to date
Contract value	66,000.00	66,000.00
Funded	66,000.00	66,000.00
Cost sharing amount		22,114.00

Does subcontracting plan apply ? : N

Title: SYMBOLIC COMPUTATION LABORATORY

PROJECT ADMINISTRATION DATA

OCA contact: Ina R. Lashley 894-4820

Sponsor technical contact

Sponsor issuing office

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RESEARCH TRIANGLE PARK NC 27709-2211

Security class (U,C,S,TS) : U
Defense priority rating : N/A
Equipment title vests with: Sponsor
PER PARA. 8.C, P. 3.

ONR resident rep. is ACO (Y/N): Y
N/A supplemental sheet
GIT X

Administrative comments -

INITIATION OF EQUIPMENT GRANT. ARO WILL PAY MAXIMUM OF 75% UP TO \$86,000 OF TOTAL PROJECT COST (PARA 4, P.2). SEE PARA 8.B, P.3 RE: SUBSTITUTE EQUIPMENT



Final Report on an Equipment Grant Entitled:

**Symbolic Computation Laboratory
(Grant DAAL03-88-G-0082)**

**The Department of Defense
University Research Instrumentation Program**

Submitted by:

**Dr. Dewey H. Hodges, Principal Investigator
Professor, School of Aerospace Engineering
Georgia Institute of Technology
College of Engineering**

Grant Period: October 1, 1988 – September 30, 1989

Submitted to:

U.S. Army Research Office
P.O. Box 1221
Research Triangle Park, NC 27709
Attn.: Dr. Gary L. Anderson

Summary

A new computing facility at Georgia Institute of Technology was created, in which faculty, research staff, and students can make use of the latest technology in symbolic computation. A room in the A. French Building, where most of the College of Engineering computers are located, was designated as the **Symbolic Computation Laboratory**. Therein are now housed a networked group of 4 Sun Series 3 Workstations equipped with the powerful symbolic manipulation software MACSYMA, several NEXT workstations supplied by the College of Engineering which include the software package Mathematica, a network capable of connection to the Suns from any node within the Georgia Tech network, an Apple laser printer, and other hardware and software that allows for a wide range of symbolic computational research. This laboratory is directed by Dr. Dewey H. Hodges, the principal investigator. The equipment was purchased with the \$66,000 received from the U.S. Army Research Office and from an additional \$22,000 supplied by the Institute through cost sharing. The Institute has undertaken the task of maintaining the equipment and software appropriately.

In accordance with the requirements for the final report contents, a breakdown of how the money was spent is attached along with a brief summary of the research projects that are presently using the equipment.

Research for Which the Equipment Will be Used

At Georgia Tech there are literally dozens of research projects within the College of Engineering which will be strongly enhanced now that such equipment is available. Perhaps nearly as significant as its use in research is the potential use of the system by undergraduate students. These systems are certain to become more common in industry, and experience gained by students will no doubt translate into increased marketable skills for them. For the sake of brevity, only a few examples of current research are described below.

Principal Investigator: The P.I.'s recent work in rotorcraft stability has focused on the application of multibody dynamics and the finite element method to rotorcraft stability analysis. Rotorcraft systems are modeled as both solid and fluid components, and thus fluid-solid interaction is important. Equations of motion for these systems are noted for their complexity, and a Symbolic Manipulator is not only helpful in their derivation but in their solution as well.

Another noteworthy example of the P. I.'s work involves the nonlinear theory of beams such as in modeling helicopter rotor blades. The equations for determination of elastic constants of nonhomogeneous, anisotropic beams are extremely complex. This work will proceed more efficiently with a Symbolic Manipulator.

In still other work, the P. I. is involved in application of advanced unsteady aerodynamic analyses to rotor blade aeroelasticity and application of classical dynamics and finite elements in time to trajectory optimization problems. In both projects, ways of simplifying the formulation are being sought, and a Symbolic Manipulator will make a big difference.

Other Research Impacted by the New Equipment: Dr. David A. Peters is known for his work in the area of rotorcraft response, vibration, and unsteady aerodynamics. Currently he is developing a new unsteady aerodynamic theory based on potential flow and finite states. This model should be simpler than previously developed theories in that it can easily be incorporated into existing aeroelastic analyses. Its main advantage, however, is its expandability. More state variables (*i.e.*, degrees of freedom) can easily be added to increase the accuracy. The implementation of this theory requires the calculation of several matrices which, if they can be determined in closed form, will minimize the computational effort. The process of determining these matrices will be greatly expedited by a Symbolic Manipulator.

Another area of Dr. Peters' current interest is the development of time domain finite elements. His previously developed time finite elements are actually competitive with time-wise integration of ordinary differential equations. Extension of these elements to nonlinear systems with a mixed formulation is being investigated jointly with the P. I. The progress of this work would also be greatly enhanced by a Symbolic Manipulator. (A proposal for extending this work is in preparation.)

Several other investigators in the School of Aerospace Engineering are supported by the U.S. Army Research Office through the Center of Excellence for Rotary Wing Aircraft Technology. Those whose work would be benefitted by a Symbolic Manipulator are Prof. E. A. Armanios (composite materials), Prof. S. V. Hanagud (nonlinear dynamics and system identification), and Dr. A. J. Calise (control theory).

In the School of Mechanical Engineering, Prof. Wayne Book and his co-workers are undertaking the modeling of flexible manipulator arms. Their work has historically relied on SMP running on a VAX. Now that the new equipment is available, his work should benefit greatly.

How the Grant Money was Spent

Items	Cost (\$)
<u>Hardware:</u>	
Sun Microsystems, Inc.:	
Sun 3/260HM-P1J Server with 575MB, 8MB EEC RAM, 64KB Cache	35,897
Option 150A / Floating Point Accelerator Board	
Option 450A / Ethernet Controller for Server	
SYSL2 / Sun OS2 Release 4.0	
SM2-01 (1/4" media documentation)	
FOR-1.1-4-3-5 / Sun FORTRAN	
FOR-1.1-4-3-0 / FORTRAN documentation	
3 Sun 3/60M-12M Workstations with 19 in. Screens and Mice	25,883
3 Option SYSL Sun OS2 Release 4.0 for Workstations	
<u>LaserWriter Interface kit</u>	<u>1,800</u>
Total for Sun Microsystems	63,580
Apple Computer	
Macintosh IIX160 (equipped to run Mathematica)	7,942
<u>Apple LaserWriter Printer</u>	<u>3,550</u>
Total for Apple Computer	11,492
Digital Equipment Corporation	
Ethernet transceivers and cables	638
Miscellaneous hardware	157
<u>Software:</u>	
Symbolics, Inc.:	
4 MACSYMA Software Packages (including 1 year contract)	5,430
Sun Microsystems:	
Sun Mathematica	995
Arbortext:	
The Publisher	1385
UK Atomic Energy Authority:	
Harwell subroutine library plus documentation on tape	350
International Mathematical and Statistical Library:	
IMSL mathematical group source plus 1 year service	3,950
Miscellaneous software	60
Total	88,037