16:41:12 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 10/07/92

Active

Project #: E-19-X06 Cost share #: E-19-316 Rev #: 1
Center # : 10/24-6-R7583-1A0 Center shr #: 10/22-1-F7583-1A0 OCA file #:
Work type : RES
Contract#: S10 RR07337-01 Mod #: BR OF 10/7/92 Document : GRANT
Prime #: Contract entity: GTRC

Subprojects ? : N CFDA:
Main project #: PE #:

Project unit: CHEM ENGR Unit code: 02.010.114
Project director(s):
YOGANATHAN A P CHEM ENGR (404)894-2849

Sponsor/division names: DHHS/PHS/NIH / NATL INSTITUTES OF HEALTH
Sponsor/division codes: 108 / 001

Award period: 920817 to 930816 (performance) 931116 (reports)

| Sponsor amount | New this change | Total to date |
|---|---|---|
| Contract value | 0.00 | 187,000.00 |
| Funded | 0.00 | 187,000.00 |
| Cost sharing amount | | 187,000.00 |

Does subcontracting plan apply ?: N

Title: 3-D FLUID FIELDS CARDIOVASCULAR FLUID MECHANICS (EQUIPMENT GRANT)

PROJECT ADMINISTRATION DATA

OCA contact: Kathleen R. Ehlinger 894-4820

Sponsor technical contact

MARJORIE TINGLE
(000)000-0000

BIOMEDICAL RESEARCH SUPPORT PROG
NATL CTR FOR RESEARCH RESOURCES
NIH
BETHESDA, MD 20892

Sponsor issuing office

JENELLE WIGGINS
(301)496-9840

OFFICE OF GRANTS AND CONTRACTS MGT
NATL CTR FOR RESEARCH RESOURCES
NIH
BETHESDA, MD 20892

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : N/A NIH supplemental sheet
Equipment title vests with: Sponsor GIT X

Administrative comments -
ISSUED TO CORRECT COST SHARING AMOUNT FROM $187,400 TO $187,000.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

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Closeout Notice Date 11/12/93

Project No. E-19-X06_____ Center No. 10/24-6-R7583-1A0_

Project Director YOGANATHAN A P_____ School/Lab CHEM ENGR_____

Sponsor DHHS/PHS/NIH/NATL INSTITUTES OF HEALTH_____

Contract/Grant No. S10 RR07337-01_____ Contract Entity GTRC

Prime Contract No. _____

Title 3-D FLUID FIELDS CARDIOVASCULAR FLUID MECHANICS (EQUIPMENT GRANT)_____

Effective Completion Date 930816 (Performance) 931116 (Reports)

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| Closeout Actions Required: | Y/N | Date Submitted |
|---|---|---|
| Final Invoice or Copy of Final Invoice | Y | _____ |
| Final Report of Inventions and/or Subcontracts | Y | _____ |
| Government Property Inventory & Related Certificate | N | _____ |
| Classified Material Certificate | N | _____ |
| Release and Assignment | N | _____ |
| Other _____ | N | _____ |

Comments***NOTE*** USE SPONSOR FORM FOR PATENT REPORT._____

_____

Subproject Under Main Project No. _____

Continues Project No. _____

Distribution Required:

| | |
|---|---|
| Project Director | Y |
| Administrative Network Representative | Y |
| GTRI Accounting/Grants and Contracts | Y |
| Procurement/Supply Services | Y |
| Research Property Managment | Y |
| Research Security Services | N |
| Reports Coordinator (OCA) | Y |
| GTRC | Y |
| Project File | Y |
| Other CARL BAXTER-FMD_____ | Y |
| _____ | N |

NOTE: Final Patent Questionnaire sent to PDPI.

November 5, 1993

# FINAL REPORT

## NIH EQUIPMENT GRANT (# S10 RR07337 - 01)

3-D FLOW FIELDS IN CARDIOVASCULAR FLUID MECHANICS

August 17, 1992 to August 16, 1993

PI: Professor Ajit P. Yoganathan
School of Chemical Engineering
Georgia Institute of Technology
Atlanta, GA 30332-0100
Telephone: (404) 894-2849
Fax: (404) 894-2291

The purpose of the this equipment grant was to purchase a three component Laser Doppler Velocimeter (LDV) system and graphics computer system, in order to conduct three dimensional velocity measurements in models of the cardiovascular system. Furthermore, the computer system was also to be used for conducting numerical blood flow simulation studies on the cardiovascular system, and to animate blood flow data (velocity, pressure and turbulent stresses) obtained from: the model systems using the LDV; the computer simulation studies; and non-invasive in vivo techniques such as Doppler ultrasound and magnetic resonance imaging (MRI).

As stated in the original proposal this equipment has been purchased and is housed in two adjoining laboratories (each of the size 550 sq.ft.) as a shared research facility for the bioengineering program at Georgia Tech. It is being used by investigators who have NIH grant funding - Professors Ku, Wick, Nerem, Vito and Yoganathan, and Drs. Pfieffer, Walker and Fontaine. Professor Giddens and Dr. Jones who were on the original proposal as co-investigators have left Georgia Tech for Johns Hopkins University. They, however, have access to the equipment and plan to use the LDV system in the near future. Their group also has access to the graphics computer via the network.

A three dimensional fiber-optic LDV system with both forward and back scatter capabilities was purchased from Aerometrics Inc. We decided on the Aerometrics system, after one of our research engineers visited both Aerometrics and DANTEC and spent two days at each company evaluating their 3-D fiberoptic systems. The system we finally purchased has: (1) Coherent 4 W Argon-ion water cooled laser; (2) Bragg shift and color separating units for measuring positive and negative multicomponent velocities; (3) transmitting and receiving optics; (4) State-of-the-art digital FFT processors for analyzing the Doppler information. These FFT processors are digitally interfaced to a Gateway 486 microprocessor for on-line data collection. The on-line collected data is then transmitted via the network to the graphics main frame computer (Silicon Graphics 4D/340 VGXT) which is located in the adjoining laboratory from the LDV flow facility.

The LDV system has been installed with the transmitting and receiving optics being placed on a manual traversing system which has three degrees of freedom plus rotational capabilities (of

360 degrees). The system may thus be moved around fairy easily in the laboratory. The lab has been configured in such manner around the fiber-optic LDV system, so that two large and one small flow loop can be operational at the same time. Therefore it is possible that three flow loops can utilize the LDV systems measuring capabilities at any given time, though obviously **not simultaneously.** The LDV system has been operational since June (1993) and has been used extensively over the past four months. The system is essentially complete, except for the fact that Aerometrics is making final upgrades at the present time on the FFT processors, since these are of the very latest electronic designs, and the on-line data collection and processing software. These upgrades should be completed by January of 1994. The FFT processors use the most advanced digital signal processing (DSP) FFT algorithms and hardware together with the best available Doppler burst detection and filtering methods. Furthermore the processor operating software uses the most recent versions of WINDOWS oriented architecture. The LDV system is at present being used to study simulated flow models of the: left heart; right heart; ascending aorta; abdominal aorta; coronary arteries; pulmonary artery; and iliac arteries.

For the graphics computer, a Silicon Graphics 4D/340 VGXT main frame computer was purchased and it has been in operation since March, 1993. The computer is named BOZ, after an illustrious Georgia Tech bioengineer. It was placed in a laboratory immediately adjoining the LDV flow facility laboratory. This laboratory was renovated by Georgia Tech so that it would not only house the graphics computer, but also other work stations and computer items (for the biomechanics research group within the bioengineering program at Georgia Tech). The Silicon Graphics system will be upgraded to an Onyx/4 VTX system (processor speed of 150 MHz) before the end of the year, giving us three to four more computer power for the same initial cost. In this day and age of rapidly advancing computer hardware technology, this upgrade will keep us current for about the next 5 years. The Onyx/4 VTX system also has the potential for future upgrades. As stated previously the Silicon Graphics computer is interfaced via the network to the LDV system. The graphics computer, BOZ, has a variety of graphics packages, such as: Wavefront, Advanced Visualizer , and FAST. In addition, computational fluid dynamic (CFD)

packages such as FLUENT and NEKTON are also run BOZ. Therefore BOZ is currently being utilized for: (1) processing and animating the LDV velocity and turbulence data; (2) running CFD packages to computationally simulate various cardiovascular flows and to animate the resulting flow data; and (3) process and animate blood flow data obtained from MRI imaging and Doppler ultrasound techniques, from in vitro and in vivo studies.

In conclusion, it is very clear that the purchase of the Aerometrics 3-D fiberoptic LDV system and the Silicon Graphics computer have enhanced our capabilities at Georgia Tech for conducting cardiovascular fluid mechanics related research. It is having a major positive impact on the research being performed by the investigators originally listed in the proposal.