



GEORGIA INSTITUTE OF TECHNOLOGY  
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 02/26/92

Project No. E-21-F52 \_\_\_\_\_ Center No. 10/24-6-R6787-0A0\_

Project Director DORSEY J F \_\_\_\_\_ School/Lab ELEC ENGR \_\_\_\_\_

Sponsor NATL SCIENCE FOUNDATION/GENERAL \_\_\_\_\_

Contract/Grant No. MSS-8907779 \_\_\_\_\_ Contract Entity GTRC

Prime Contract No. \_\_\_\_\_

Title ENGINEERING RESEARCH EQUIPMENT GRANT: A BASIC HARDWARE CONFIGURATION FOR

Effective Completion Date 910131 (Performance) 910430 (Reports)

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

Comments BILLING VIA NSF LINE-OF-CREDIT. 98A COVERS THE "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 Management	Y
Research Security Services	N
<del>Reports Coordinator (COCA)</del>	Y
GTRC	Y
Project File	Y
Other _____	N
_____	N

**NATIONAL SCIENCE FOUNDATION**  
**1800 G STREET, NW**  
**WASHINGTON, DC 20550**

**BULK RATE**  
**POSTAGE & FEES PAID**  
**National Science Foundation**  
**Permit No. G-69**

**P/VPD Name and Address**

Drs. John F. Dorsey, Frank L. Lewis & David G. Taylor  
 School of Electrical Engineering  
 Georgia Institute of Technology  
 Atlanta, GA 30332

# NATIONAL SCIENCE FOUNDATION FINAL PROJECT REPORT

## PART I - PROJECT IDENTIFICATION INFORMATION

<b>1. Program Official/Org.</b>	Elbert L. Marsh
<b>2. Program Name</b>	Engineering Research Equipment
<b>3. Award Dates (MM/YY)</b>	<b>From:</b> 8/89 <b>To:</b> 1/91
<b>4. Institution and Address</b>	Georgia Tech Research Corporation Georgia Institute of Technology Atlanta, GA 30332-0420
<b>5. Award Number</b>	MSS-8907779
<b>6. Project Title</b>	Engineering Research Equipment: A Basic Hardware Configuration for Robotics Research

**This Packet Contains**  
**NSF Form 98A**  
**And 1 Return Envelope**

**NSF Grant Conditions (Article 17, GC-1, and Article 9, FDP-II) require submission of a Final Project Report (NSF Form 98A) to the NSF program officer no later than 90 days after the expiration of the award. Final Project Reports for expired awards must be received before new awards can be made (NSF Grants Policy Manual Section 677).**

**Below, or on a separate page, provide a summary of the completed projects and technical information and attach it to this form. Be sure to include your name and award number on each separate page. See below for more instructions.**

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### **PART II - SUMMARY OF COMPLETED PROJECT (for public use)**

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**The summary (about 200 words) must be self-contained and intelligible to a scientifically literate reader. Without restating the project title, it should begin with a topic sentence stating the project's major thesis. The summary should include, if pertinent to the project being described, the following items:**

- The primary objectives and scope of the project**
- The techniques or approaches used only to the degree necessary for comprehension**
- The findings and implications stated as concisely and informatively as possible**

SEE ATTACHED

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### **PART III - TECHNICAL INFORMATION (for program management use)**

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**List references to publications resulting from this award and briefly describe primary data, samples, physical collections, inventions, software, etc. created or gathered in the course of the research and, if appropriate, how they are being made available to the research community.**

SEE ATTACHED

SEE ATTACHED	SEE ATTACHED
<b>Principal Investigator/Project Director Signature</b>	<b>Date</b>

**IMPORTANT:  
MAILING INSTRUCTIONS**  
**Return this *entire* packet plus all attachments in the envelope attached to the back of this form. Please copy the information from Part I, Block I to the *Attention line* on the envelope.**

**PART IV — FINAL PROJECT REPORT — SUMMARY DATA ON PROJECT PERSONNEL**

(To be submitted to cognizant Program Officer upon completion of project)

The data requested below are important for the development of a statistical profile on the personnel supported by Federal grants. The information on this part is solicited in response to Public Law 99-383 and 42 USC 1885C. All information provided will be treated as confidential and will be safeguarded in accordance with the provisions of the Privacy Act of 1974. You should submit a single copy of this part with each final project report. However, submission of the requested information is not mandatory and is not a precondition of future award(s). Check the "Decline to Provide Information" box below if you do not wish to provide the information.

Please enter the numbers of individuals supported under this grant.  
Do not enter information for individuals working less than 40 hours in any calendar year.

NOT APPLICABLE — EQUIPMENT GRANT	Senior Staff		Post-Doctorals		Graduate Students		Under-Graduates		Other Participants <sup>1</sup>	
	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.
<b>A. Total, U.S. Citizens</b>										
<b>B. Total, Permanent Residents</b>										
<b>U.S. Citizens or Permanent Residents<sup>2</sup>:</b>										
American Indian or Alaskan Native . . .										
Asian . . . . .										
Black, Not of Hispanic Origin . . . . .										
Hispanic . . . . .										
Pacific Islander . . . . .										
White, Not of Hispanic Origin . . . . .										
<b>C. Total, Other Non-U.S. Citizens</b>										
Specify Country										
1.										
2.										
3.										
<b>D. Total, All participants (A + B + C)</b>										
<b>Disabled<sup>3</sup></b>										

Decline to Provide Information: Check box if you do not wish to provide this information (you are still required to return this page along with Parts I-III).

<sup>1</sup>Category includes, for example, college and precollege teachers, conference and workshop participants.  
<sup>2</sup>Use the category that best describes the ethnic/racial status for all U.S. Citizens and Non-citizens with Permanent Residency. (If more than one category applies, use the one category that most closely reflects the person's recognition in the community.)  
<sup>3</sup>A person having a physical or mental impairment that substantially limits one or more major life activities; who has a record of such impairment; or who is regarded as having such impairment. (Disabled individuals also should be counted under the appropriate ethnic/racial group unless they are classified as "Other Non-U.S. Citizens.")

**AMERICAN INDIAN OR ALASKAN NATIVE:** A person having origins in any of the original peoples of North America, and who maintain cultural identification through tribal affiliation or community recognition.

**ASIAN:** A person having origins in any of the original peoples of East Asia, Southeast Asia and the Indian subcontinent. This area includes, for example, China, India, Indonesia, Japan, Korea and Vietnam.

**BLACK, NOT OF HISPANIC ORIGIN:** A person having origins in any of the black racial groups of Africa.

**HISPANIC:** A person of Mexican, Puerto Rican, Cuban, Central or South American or other Spanish culture or origin, regardless of race.

**PACIFIC ISLANDER:** A person having origins in any of the original peoples of Hawaii; the U.S. Pacific Territories of Guam, American Samoa, or the Northern Marianas; the U.S. Trust Territory of Palau; the Islands of Micronesia or Melanesia; or the Philippines.

**WHITE, NOT OF HISPANIC ORIGIN:** A person having origins in any of the original peoples of Europe, North Africa, or the Middle East.

**THIS PART WILL BE PHYSICALLY SEPARATED FROM THE FINAL PROJECT REPORT AND USED AS A COMPUTER SOURCE DOCUMENT. DO NOT DUPLICATE IT ON THE REVERSE OF ANY OTHER PART OF THE FINAL REPORT.**

## **Part II - Summary of Completed Project (for public use)**

This project developed the basic hardware to conduct robotics research within the School of Electrical Engineering at Georgia Tech. The hardware includes:

1. Six direct drive motors and the necessary links for configuring several robots.
2. High speed digital processing systems for implementing the control algorithms developed by robotics researchers. The equipment purchased included:
  - (a) Two(2) Texas Instruments TMS320C25 systems.
  - (b) One(1) Texas Instruments TMS320C30 evaluation module.
  - (c) Two(2) Texas Instruments TMS320C30 systems.
  - (d) One(1) Texas Instruments XDS500 Simulator.
3. The necessary interface hardware to link the processors to the robots. This interface hardware was developed at Georgia Tech.

## **Part III - Technical Information**

The funding requested in the proposal was for the purchase of four direct drive motors and two TMS320C25 hardware systems. Through some fairly lengthy negotiations we were able to purchase six direct drive motors and the Texas instruments described in Part II. The total value of this equipment is in the neighborhood of \$90,000. The fact that we were able to purchase it for \$30,000 is an indication of the generosity of the manufacturers.

The main difficulty in developing a working system was the interface between the processor and the robot. We embarked upon three separate development programs.

First, we needed to develop the interface system for the TMS320C30 systems. Texas Instruments does not provide any parallel interface for this processor. As a consequence, we had to develop one. This project turned out to be very, very difficult. Around July of 1991 we sent a design to a vendor in Houston, Texas, TNT Designs. This vendor was chosen by Texas Instruments who had agreed to pay for the manufacture of three prototypes. At the present time we are still awaiting the arrival of these prototypes.

In parallel with the TMS320C30 project we developed an interface for the so-called 'evaluation model' version of TMS320C30. In this system the processor communicates with the outside world through a high speed, synchronous, serial port. What was needed

was a interface board to communicate between the serial port and the actual physical process. This interface device is now completed.

Finally, to use the TMS30C25 systems for robotics, it was necessary to expand the the analog interface board (AIB ) that Texas instruments supplies from one analog input and one analog output, to two digital inputs and two analog outputs. This expanded interface is now completed.

Currently, we have one two degree of freedom robot under the control of a TMS30C25 system with the expanded interface. This two degree of freedom robot is satisfactory for testing a wide range of theoretical control schemes. We have started construction of the links for a second robot, to be controlled by the TMS320C30 evaluation module. The second robot will allow us to look at some more complex problems such as robot cooperative effort and collision avoidance.

In March of this year we will use the first robot to provide validation for a robust control scheme that will be submitted for publication. If and when the paper is published, we will include in it, an offer to share our interface electronics with other academic researchers. We also intend to publish, through Texas Instruments, technical application notes that describe the various interfaces discussed above. Several papers are also planned for submission to the *IEEE Transactions on Education* describing how the various Texas Instruments Systems can be used in an educational control systems laboratory.

	2/14/92
Principal Investigator/Project Director Signature	Date