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NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM

MARSHALL SPACE FLIGHT CENTER  
THE UNIVERSITY OF ALABAMA

"DESIGN AND IMPLEMENTATION OF A GROUND CONTROL  
CONSOLE PROTOTYPE FOR OMV"

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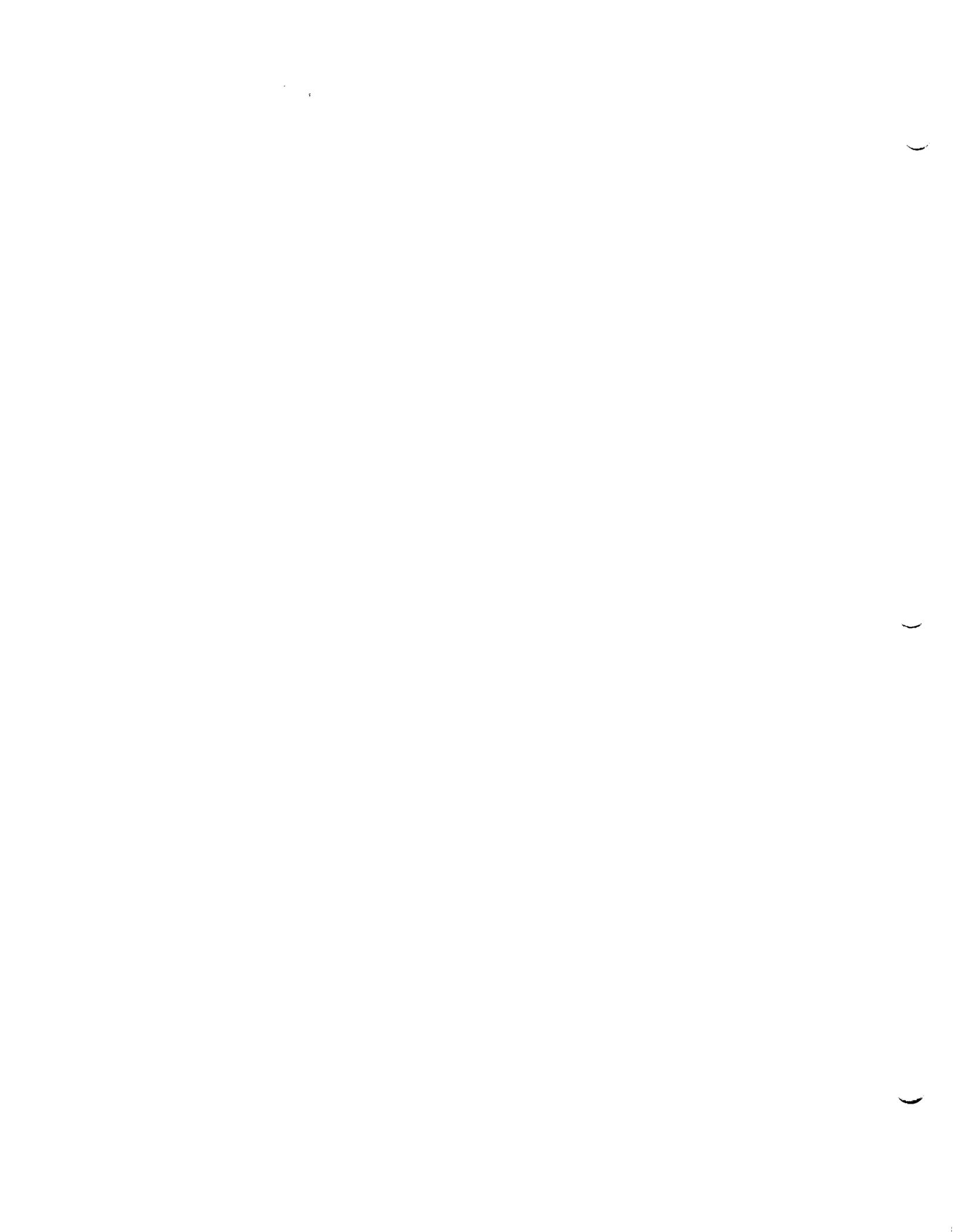
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# 1 Introduction

The Marshall Space Flight Center in Huntsville, Alabama is home to the largest precision flat floor facility in the world. This 4200 square foot floor is constructed of self-leveling black epoxy and is flat to within 1/1000 of an inch over any given square yard and to within 3/1000 of an inch from corner to corner. Two vehicles are used to perform satellite capture and rendez-vous and docking simulations. The first of these is a 2 ton air-bearing vehicle which has a total of 6 degrees of freedom (DOF). The second vehicle is the 8 DOF dynamic overhead target simulator (DOTS). One of the primary uses of the floor is to perform autonomous and teleoperated docking of vehicles similar to NASA's Orbital Manuevering Vehicle (OMV). Using both the air-bearing vehicle and the DOTS in tandem, even the most difficult OMV docking problems can be simulated. It is important to note at this juncture that even though the OMV project was cancelled mid-way through this project, a next generation OMV is slated to return sometime in 1996.

In the past, prestigious high-tech corporations such as General Electric, TRW, and Martin Marietta have utilized the flat floor and the DOTS to develop and validate docking and rendezvous strategies as well as to investigate contact dynamic problems. Recently, Grummond has developed and shipped a Tumbling Satellite Retrieval System to the Flat Floor which has been installed on the front of the 8 DOF Dynamic Overhead Simulator. These companies have future commitments to the flat floor facility thereby making continual operation and functionality enhancement a high priority of NASA.

New developments in the evolution of the Flat Floor Facility include refurbishing of the Dynamic Overhead Target Simulator, a 70 x 30 flat concrete extension yielding a total of 125 feet of length, and the installation of a high fidelity lighting system, which is currently in progress. These improvements further add to the capability of the Flat Floor to recreate a realistic environment for autonomous and tele-operated vehicle operation.

# 2 Task Description

The OMV was planned to be flown from the ground by a pilot via tele-operation. TRW, the primary contractors on the OMV, have developed specifications for a prototype Ground Control Console (GCC) from where the vehicle will be flown. In order for testing of the OMV to occur at the Flat Floor facility, this Ground Control Con-

sole must be replicated. The project for the 10 week duration of the NASA/ASEE Summer Faculty Fellowship is to perform system design and development on a prototypical Ground Control Console to be used in conjunction with the 8 DOF Dynamic Overhead Target Simulator. Unfortunately, funds at Marshall Space Flight Center are limited thus the equipment available for the project is very limited in capability.

The equipment on hand for the project includes

#### Hardware

- 1 IBM AT (80286) Clone running at 12 MHz.
- 1 640 x 512 RGB monitor
- 1 Matrox PIP 640 frame grabber and processor
- 8 Micro Switch Programmable Display Pushbutton Switches
- 1 IBM Personal Computer Data Acquisition and Control Adapter
- 2 3 DOF Handcontrollers

#### Software

- Matrox PIP EZ
- Microsoft C 5.1
- Microsoft Assembler 5.1

The project was divided into three primary tasks: The design and development of the Video Display using the RGB monitor and the Matrox PIP 640 frame grabber; the design and development of the switch panel using the Micro Switch Programmable Display Pushbutton Switches; and finally the design and development of the hand controllers using the 3 DOF hand controllers and the IBM control adapter. Of course, a final task is to perform system integration on the results of these three primary tasks.

### 3 Project Summary

Due to the limited space available for this final report (4 pages maximum), only the highlights of the project will be outlined.

The first task – design and implementation of the Video Display – began the last few days of last Summer's Fellowship Program (circa, August 1989). The engineering challenges presented by this task included learning the PIP-EZ library routines and their functions. Also, a scheme had to be devised in which graphic overlays could be placed over live incoming video. This was accomplished by using scaling and keying. First, all incoming video was scaled to the upper 64 pixels values out of a possible 256. Next, the remaining 192 pixels were used as a palette from which colorful graphics could be created by means of scaling and a look-up table. These graphics were preserved by utilizing the keying function in the PIP-EZ library. The last challenge in constructing the Video Display was to perform real-time metering using the graphic overlays. To accomplish this feat, the current meter values had to be rewritten in the background color (i.e., erased), then new values written in the correct meter color. Due to the primitive and slow graphics capabilities of the PIP 640, all meter updates had to be performed using standard text commands.

The second task – utilizing the programmable switches to implement the GCC switch panel – presented major engineering challenges. Most prevalent among these was the development of an RS-232 interrupt driven interface for the switch controllers. After spending most of the 10 weeks trying to debug such an interface, it is recommended that in future the RS-422 parallel interface be used when communicating to the switches.

The last task of interfacing the two 3 DOF hand controllers was relatively straight forward. The IBM control adapter had been used in last years project and NASA engineer, Charles Oliver, had developed a number of routines which proved to be invaluable. The GCC specifications required that the analog handcontrollers be used in pulse mode. This was easily accomplished via use of a quad comparator and the digital inputs on the IBM control adapter.

The completed prototype can be viewed at the Flat Floor Facility of EB24 in building 4619.

## 4 Future Work

Future work on the GCC includes the incorporation of a new, inexpensive high resolution Matrox imaging board called the Illuminator 16. The Illuminator 16 has real-time video insert capabilities built-in as well as hardware pan and zoom. Furthermore, the Illuminator 16 will support a high resolution (1024 x 1024) monitor.

Next, the GCC must be interfaced to the Dynamic Overhead Target Simulator driver program written by Control Dynamics Corporation which currently resides on the VAX 3602 at the Flat Floor facility.

## 5 Acknowledgements

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