DSS 13 Unattended Operations Station Controller Status Report

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In this report, a brief history of the unattended operations program is presented, followed by the status of the Phase II Station Controller implementation. The DSS 13 Station Controller is being developed as a part of the S-X Systems Development work unit under RTOP-68, Station Monitor and Control Technology. This work unit provides the system engineering for RTOP-68.

I. Brief History of the Unattended Operations Program

The first major attempt to automate a Deep Space Station was in 1975 at DSS 14. Three PDP-11/20 Minicomputers and one 8080 based microprocessor computer were used to control the Transmitter, Receiver, Microwave, and SDA subsystems. Communication between the station controller computer, the subsystem computers and the equipment itself was via the JPL standard interface. In some cases, the equipment already had the JPL interface installed, in others the interfaces had to be designed and installed.

The programs for the PDP-11 minicomputers were written in Basic, and the one for the microprocessor computer in PL/M. These programs were debugged as much as possible at JPL. The computers and interface equipment were then shipped to DSS 14 for testing.

Testing was carried out on a noninterference basis at DSS 14 over a period of about a month. Although each subsystem performed nearly as planned, the poor reliability of the hardware and software prevented the entire system from operating successfully for any length of time.

Although this first exercise was not completely successful, it did yield valuable information applicable to the next phase of automation which was to be at DSS 13. In general, the main problem areas were found to be:

(1) Hardware reliability

(2) Software reliability and speed

(3) Communication and protocol

(4) Operator interface

(5) Project personnel control

After the DSS 14 testing was completed, it was decided to move further automation development to DSS 13. Since DSS 13 was an R&D station, the scheduling of station time for testing, and equipment development was much easier than at DSS 14 where the station was largely committed to spacecraft tracking. It was further decided to change from using the PDP-11 minicomputers with their magtape operating systems to ROM-based microprocessor computers. These microcomputers were similar to the one used at DSS 14 which showed greater reliability than the PDP-11s.

The decision to use a microprocessor computer prompted the development of JPL's first "standard microcomputer". This microcomputer used commercially available 1st-generation modules and components. At this early stage in microprocessor development, the software, written in PL/M, had to be cross-compiled on the GPCF 1108 computer and loaded into the microprocessor computers via paper tape, or prom modules. Software development and debugging on these early systems was laborious and slow.

The initial DSS 13 system was similar to the one at DSS 14. The Receiver and Transmitter subsystems at DSS 13 had to have remote control and monitoring interfaces fabricated. Finally the Receiver, Transmitter, Microwave, and SDA systems were automated as per plan. However, as testing progressed, it became apparent that the original plan had operational deficiencies which were gradually corrected.

Prior to the moving of the unattended operation effort to DSS 13, the antenna system at DSS 13 had already been placed under computer (Modcomp minicomputer) control. In order to provide a complete tracking facility, after the RF subsystem had been completed, antenna control was added to the automation effort. Since this was an afterthought, the interface, although workable, was not a clean one.

Another major addition to the system was the capability to download predix and configuration data, as well as remotely operating the station from JPL. This was accomplished by connecting a remote terminal, with cassette tapes, to the station controller using a high speed data line and modems.

After these improvements were added and debugged, the station was operated in an unattended mode. Delivery of data to projects for a period of six months in 1979 was accomplished while the DSS 12 antenna was being enlarged from 26 to 34 meters.

Shortly afterwards, it started becoming apparent that an upgrade of both hardware and software was desired. Since moving to DSS 13, large advances had taken place in improved microprocessor hardware and software development tools. Station operation generated new requirements in the areas of operator interface, system status reporting, and generation and transferring of predix and configuration data. For these reasons, it was decided to implement what is now known as the Phase II system.

II. Phase II Plan

Phase II provides the opportunity to upgrade both the hardware and software of the subsystem controllers as well as the station controller. In general, all of the subsystem controllers will be converted to a MULTIBUS chassis thereby providing the capability to select from the large number of commercially available MULTIBUS compatible modules. Although there are a large number of modules to select from, the unattended operations effort is attempting to standardize on a minimum set of modules in order to reduce spares, and to develop a thorough understanding of the operation of the common modules used. The initial module selection consists of the following:

(1) BLC-80/204 Single board computer

(2) BLC-064 64K RAM module

(3) BLC-8432 32K EPROM module

(4) BLC-8201 Floppy Disk Controller

(5) SBC-534 4 CH RS-232 module

(6) SBC-519 Parallel I/O module

(7) JPL-QSIA JPL designed interface module

One of the major advantages of standardizing on the MULTIBUS chassis and modules, is that with the addition of a set of floppy disk drives, the software can be entered, compiled, debugged, and executed on the target computer in RAM memory. This eliminates the need for separate development systems and means of downloading the compiled programs. Once it has been determined that the program is operating properly in RAM memory, it can then be "burned" into PROMs for greater reliability.

Software improvements will result in improved system monitor, control, and status reporting. The communication protocol between controllers will be changed to readable ASCII and be more generalized.

III. Phase II Station Controller Hardware

The functions of the Phase II station controller (see Fig. 1) are as follows:

(1) Facilitate remote control of the station.

(2) Provide an interface to the Information Processing Center (IPC). Through this interface, predix and

configuration data can be transferred from the IPC to the station without operator type-ins, and pass log data can be transferred to the IPC for dissemination and distribution to users.

(3) Coordinate the operation of the various subsystems through their respective controllers.

In contrast to the Phase I station controller which contained one microcomputer with a terminal at DSS 13 and a remote terminal at NOCC, the Phase II station controller actually is composed of two microcomputers linked by a 7200 baud data line. The driving factor for having a microcomputer at NOCC is to provide for improved operator interface, and an interface to the IPC.

One significant addition to the Phase II station controller is the floppy disk drives. These are now required for four reasons:

(1) Pass log data must be stored temporarily prior to being transferred to the IPC.

(2) Configuration and predix data from the IPC must be temporarily stored prior to transfer to the DSS-13 controller.

(3) Menus and help prompt frames, which are anticipated to be many, are too large to be stored permanently in the computer memory.

(4) A variety of support programs may need to be loaded and executed (i.e., the program which transfers files to and from the IPC is a separate program from the one which controls DSS 13).

Each controller will have three CRT displays. One of these will be reserved for real time system status, another CRT will be reserved for the display of routine log messages from the subsystem controllers, and the third CRT will be reserved for operator interaction along with the keyboard. The printer is an optional utility which may be used for listing log messages or any other desired file.

Each of the controllers has enough peripherals to function as a software development system. All software entry, compilation, debugging and execution can be performed on either of the station controller computers.

IV. Phase II Microcomputer

Both of the microcomputers used in the station controller are identical with the exception of the JPL-QSIA (Quad Standard Interface Adapter) module loçated in the DSS 13 controller (see Fig. 2). There is no need for this module in the NOCC controller as the NOCC controller does not interface with any hardware having the JPL standard interface.

The microcomputer chassis is a standard MULTIBUS chassis containing commercially available modules with the exception of the specially designed JPL-QSIA module. This computer is configured as a multiprocessor computer in that there are six modules which have microprocessor devices on them. The function of the modules are described below.

1. **BLC-80/204**. These modules are the basic single board computers which run the application programs. One of these modules is dedicated to performing the protocol requirements of the high speed data line between the two controllers and its program is permanently "burned" into proms. The other single board computer performs the primary function of the microcomputer.

2. **BLC-8201**. This module is a floppy disk controller. It controls two disks in single density mode, each disk having a capacity of approximately 250K bytes.

3. **BLC-8229**. These modules are CRT/KEYBOARD controllers. One is required for each of the CRTs. The keyboard is connected to only one of the modules. Although these modules have the capability of executing general subroutines, it is anticipated that they will not be used for that purpose as it would complicate the program unnecessarily.

4. **SBC-534**. This module is a four channel RS-232 module. It supports a variety of baud rates and is used to interface the printer, the IPC modem, and to receive serial station time.

5. **BLC-064**. This is a 64K RAM memory module.

6. **JPL-QSIA**. This module is a four channel interface designed to operate with any equipment equipped with a JPL standard interface, such as the star switch to which it is connected. Other subsystem microcontrollers use this module to interface to the SDAs, the Receivers, and etc.

Since this microcomputer has six "master" modules (BLC-80/204s, BLC-8229s, and the BLC-8201), the normal serial priority bus arbitration scheme must be replaced by a parallel bus arbiter. This function consisting of two ic's is wired on a prototype wirewrap module.

The NOCC Phase II hardware is configured in a five bay wraparound console with a desk top. The displays and keyboard are positioned for best operator viewing and use. The DSS 13 Phase II hardware is presently installed in a standard DSN rack but will be installed in a similar five bay console shortly. The DSS 13 console will be shared with the antenna controller and display. All of the Phase II station controller hardware has been installed and tested.

V. Phase II Station Controller Software

The present software residing in the Phase II controller is a slight modification of the previous Phase I software, primarily because the subsystem controllers have not all been converted to the Phase II hardware configuration, and do not have the Phase II communication and message protocol installed.

The program residing in the NOCC controller for automatically dialing and accessing data files in the IPC has been written and tested; similarly, the transfer of pass logs to the IPC can also be accomplished. Programs which will reside in the IPC that generate the predix and configuration files, and disseminate the pass log data that has not been written.

VI. Future Plans

Future plans for the station controller include the following in order of importance:

(1) Complete the Phase II software sufficient to perform an uplink demonstration in late March 1982.

(2) Complete the Phase II software.

(3) Integrate touch screen, voice recognition, and voice response systems for improved operator control.

(4) Complete the software residing in the IPC for predix generation and pass log dissemination.

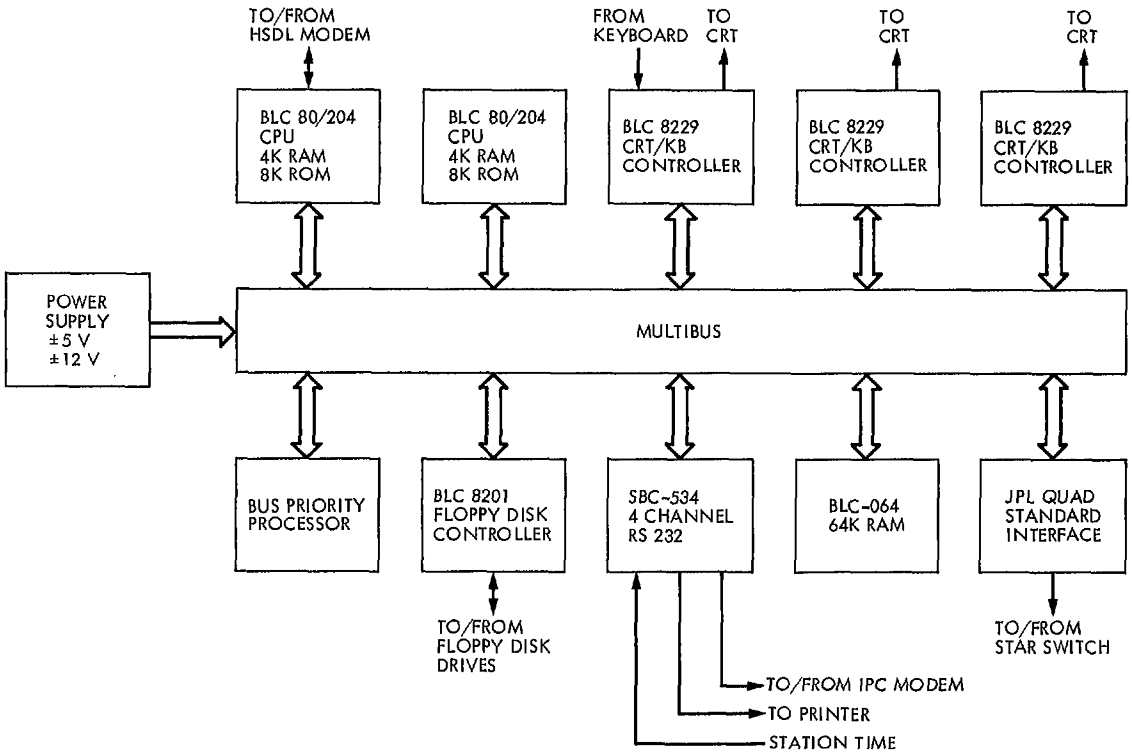

Fig. 1. NOCC/DSS 13 microcomputer block diagram

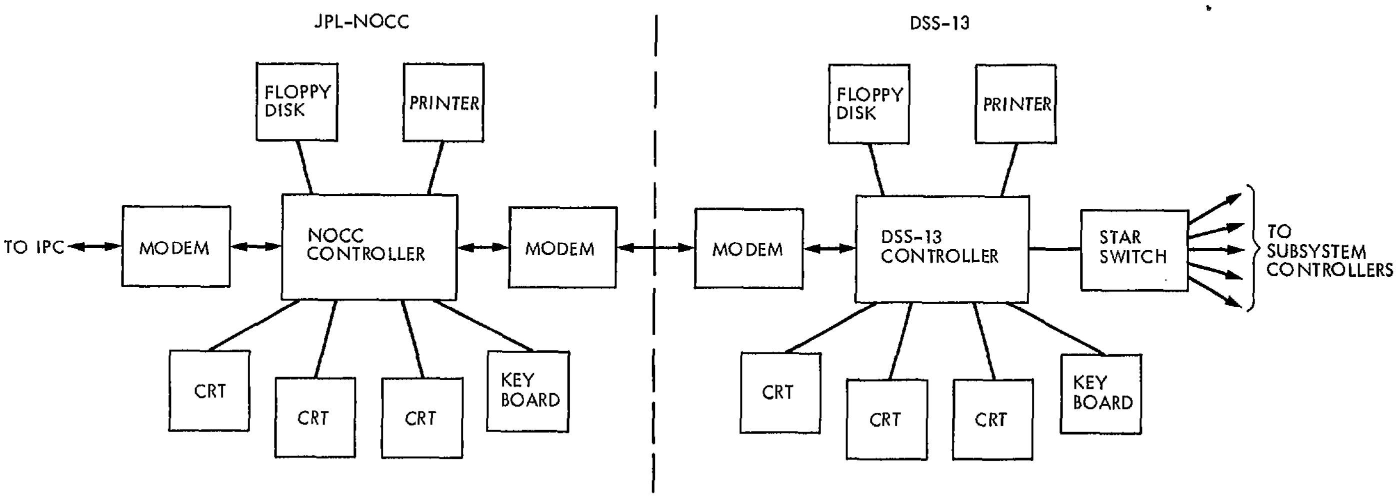

Fig. 2. Phase II station controller