AUTOMATION OF THE MARK III FIELD SYSTEM

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ABSTRACT

The many capabilities of the Mark III acquisition system have been designed for fully automatic operation. A system comprising both software and hardware components has been developed which will enable hands-off operation, except for the mounting and dismounting of data tapes, for an entire Mark III experiment. Under automatic control, the acquisition system can easily follow a complicated schedule which includes changing operating configurations and recording multiple observations on a tape without waste.

The operation of the field system begins with the scheduling of observations. An interactive program, SKED, has been developed which provides displays of mutual visibility, automatic calculation of telescope slewing times, and the ability to list and edit the schedule. The output of SKED is a schedule file containing commands in the Standard Notation for Astronomy Procedures (SNAP) language which the field system uses for controlling events during the experiment. The most important features of SNAP include sophisticated time-sequencing of events, automatic logging of all commands and responses, and the ability to define often-used sequences of commands as procedures.

The heart of the field system is a control program, BOSS, running in an HP 1000 mini-computer. BOSS reads the SNAP commands from a schedule file and interprets them in terms of commands and requests to devices. Interactive command input is possible through the operator's display terminal. Communication with all of the Mark III electronics modules is done via a small general purpose interface board (a microprocessor-based ASCII transceiver) which has been installed in each module. Additional devices are controlled and monitored using the IEEE 488 General Purpose Interface Bus.

INTRODUCTION

The many capabilities of the Mark III Data Acquisition System were designed to be completely automatically controlled. Except for the mounting and dismounting of tapes, an entire Mark III experiment can be conducted as a fully automated, hands-off operation. This paper describes the parts of the Mark III system which implement the automation concept. These parts include the scheduling program, the SNAP language, the field system control programs, and the interface boards between the control computer and the electronics modules. As used here, the term "field system" includes the control computer hardware and software as well as the interfaces to the data acquisition system.

SKED - INTERACTIVE SCHEDULING PROGRAM

Logically, the first operation of an experiment using the Mark III system is the scheduling of observations. A program called SKED has been developed which enables the user interactively to make a detailed very long baseline interferometry (VLBI) observing schedule. First, the user selects the sources and stations to be used in the experiment. For an individual observation, the program automatically calculates the telescope slewing time taking into account slew rates and cable wrap for the selected stations. Slewing times are calculated iteratively to allow for possible significant motion of the source during the time the telescope is moving. Then, a display is available of the sources which are currently mutually visible and the slewing times to each one so the user can select the next source to be observed. As the schedule of observations is being built up in this manner, any portion of it can be listed, edited, and then automatically shifted in time to readjust the run start times around the observations which were inserted or deleted. A Mark III "configuration" is associated with each observation so that different combinations of bandwidth, LO frequencies, and tape recorder modes can be scheduled. One of the outputs of SKED is a data base with information on the planned observations; during processing, the data base will be augmented by the correlated data.

SNAP CONTROL LANGUAGE

The primary output of SKED is a "schedule file" which will be sent to each telescope participating in the experiment. The method of distribution would normally be to mail a floppy disk with the schedule file; however, if time does not permit this, the file could be transferred by telephone. Since the schedule file is a "human readable" ASCII file, it can be edited before or during an experiment, either at the station or via telephone.

The schedule file contains commands in the Standard Notation for Astronomical Procedures (SNAP) language. These commands are used to control data acquisition during the experiment by sequencing and timing events based on the scheduled observations. Figure 1 shows a sample schedule which illustrates the basic features of SNAP. Using SNAP, events which are to happen at a particular time can be pre-scheduled. For example, the command which starts the tape recording, "ST," could be issued such that it would be executed at a specific time with the SNAP command "ST@120300". If only the command "ST" were issued, it would be executed at once. The pre-scheduling feature of SNAP is not intended for an entire observing schedule but is useful for setting up a few events in advance of their execution time. Another feature of SNAP is the ability to schedule events periodically; devices can be monitored by scheduling a request for data every so often. For example, the command "WX@12H,15M" would schedule a request for weather data at 12:00 UT and every 15 minutes thereafter until the end of the experiment or until cancelled. Sequences of commands which are to be often used can be defined as procedures in SNAP and then simply invoked by name. The commands which set up a particular Mark III configuration for several observations might be defined as a procedure; e.g., CON1 in the sample schedule is used to set up the tape drive for 120 ips in the forward direction, enable record track groups 1 and 2, and set up the formatter for mode B and 4 Mbit sample rate. Finally, SNAP has features for schedule flow control. The "!" command followed by a time is used to halt the processing of schedule file entries until the specified time.

```
DEFINE CON1   TAPE=120,FOR
    ENABLE=G1,G2    FORM=B,4   $
   ....
"THIS IS A SAMPLE SCHEDULE"
WX@12H,15M
CON1
ST@120300    ET@120600    !120600
   ....
```

Figure 1. Sample SNAP schedule.

An important feature of SNAP is that all commands, responses to commands, and operator comments are tagged with the time and their source and logged in a disk file. All events during the experiment are thus recorded and available in a specified machine-readable format for complete accountability and automatic delogging after the experiment.

FIELD SYSTEM PROGRAMS

The field system's main control program is called BOSS. BOSS was written to implement the specifications of SNAP, and in addition some system-dependent features were implemented which were found to be desirable. Figure 2 is a block diagram of the field system programs. BOSS reads SNAP commands from the schedule file and also accepts interactive input from the operator via OPRIN. The SNAP commands are first checked for proper syntax, and if no errors are found, a table is consulted which holds information on the way to interpret this command. BOSS itself interprets commands which deal with the time flow of the schedule, procedure definition, and other control functions. BOSS schedules the external program QUIKR (QUIcK Response) for commands which must be interpreted in terms of parameters to be sent to modules, requests for monitor information from modules, and various testing and display functions. QUIKR parses the parameters in the commands sent to it, formats ASCII messages for electronics modules, and decodes module responses into user-readable responses. QUIKR is organized into segments (or overlays), one for each module or set of related commands. The utility programs MATCN, IBCON, and ANTCN handle communications protocol and control of the ASCII transceivers (described below), HP interface bus devices, and the antenna pointing, respectively. The program OPRIN accepts operator input, displays commands and responses as they are processed by BOSS, and schedules various interactive programs for the operator. Finally, MONIT displays current status information.

```
                        -----------
     status            |           |
     display   <-----  |   MONIT   |
                       |           |
                        -----------
   operator                /|\
       |                    |
      \|/               -----------
  ----------           |           |<----- schedule file
 |          |          |           |-----> log file
 |  OPRIN   |----->    |   BOSS    |
 |          |          |           |
  ----------           |           |
       |                -----------
       |                    |
       |                    |
      \|/                  \|/
  -----------           -----------
 |interactive|         |           |
 | programs  |         |   QUIKR   |
 |           |         |           |
  -----------           -----------

          Utility communications programs

  -----------          -----------          ----------
 |           |        |           |        |          |
 |   MATCN   |        |   IBCON   |        |  ANTCN   |
 |           |        |           |        |          |
  -----------          -----------          ----------
      |                    |                    |
     \|/                  \|/                  \|/
     MATs                 HPIB               antenna
```

Figure 2. Field system programs.

FIELD SYSTEM COMPUTER HARDWARE

The hardware which implements the field system control functions comprises a Hewlett-Packard (HP) 1000 series mini-computer which includes in its minimum configuration 64K words of memory, a CRT terminal, two high-density (0.5M bytes) floppy disk drives, and assorted I/O cards. Additional memory and/or a hard disk would enable more of the field system software features to be supported. It appears that one floppy disk will be adequate to hold the schedule and log files for approximately 1 day of observing. With the floppy disks, HP's RTE-M operating system is used in which all programs are memory-resident and segments are swapped in from disk. This system will be available at Owens Valley and Green Bank. With a hard disk, HP's RTE-IV operating system is used in which all programs and segments are swappable. The field systems at Fort Davis, Haystack, and the ARIES trailer will have this system. In both operating systems, 64K words of memory address space are available at any given time, of which the operating system itself uses approximately half.

INTERFACES BETWEEN COMPUTER AND ELECTRONICS

There are two interfaces between the control computer and the electronics hardware of the Mark III Data Acquisition System. One uses the IEEE-488 General Purpose Interface Bus; commercial devices such as counters and switches are controlled using this interface. The other interface is to the Mark III electronics modules; this interface is accomplished with a small general-purpose board: an 8085 microprocessor-based ASCII transceiver or MAT. There is one MAT per module, and all are daisy-chained together on a "party line." Each MAT has an address between 00 and FF, and when that address is detected in the data stream, the MAT accepts the ASCII characters which follow until a different address appears. The MAT accepts serial teletype-like data from the control computer and presents parallel data and control signals to its module. The MAT interface board has 4K bytes of ROM, 768 bytes of RAM, and 72 I/O pins. Of this capacity, the interface functions use somewhat less than 2K bytes of ROM, 256 bytes of RAM, and 8 I/O pins. By using the additional capacity in the microprocessor on each board, it is intended to augment the capabilities of some of the boards in order to remove the burden of simple control and testing functions from the main computer. Among the functions to be implemented is assistance with the acquisition of correlative information such as radiometry data during the experiment.