TASKS OF THE VLBA ELEMENT CONTROL COMPUTER

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This memorandum is intended to provide a complete list of the tasks of the Element Control Computer. I have assumed for the sake of this discussion that as much as possible will be done in the Element Control Computer; although it is likely that some of the tasks described will be carried out either in dedicated microprocessors or in the central Array Control Computer. In the extreme case, no Element Control Computer is required at all (see VLBA Memo 210). I have also assumed that the ability to operate each element locally, without intervention from the Array Control Center, is required.

I have divided operations into the following "tasks":

1. COMMUNICATIONS
2. OPERATOR INTERFACE (COMMAND INTERPRETER)
3. SCHEDULE MANAGEMENT
4. SCHEDULE VERIFICATION
5. MONITOR/CONTROL INTERFACE
6. ANTENNA CONTROL
7. RECEIVER CONTROL
8. RADIOMETRY
9. PHASE CALIBRATION EXTRACTION
10. FRINGE VERIFICATION
11. MONITOR
12. DISPLAY
13. LOGGING
14. ANALYSIS OF LOG
15. DIAGNOSTICS

1.0 COMMUNICATIONS

- Interfaces with the Array Control Computer via either the dedicated or the dial-up telephone lines; switches to dial-up line if dedicated line fails.
- Corrects transmission errors.
- Transfers files from central to remote computer and vice versa (e.g., schedules, programs).
- Provides normal control interface between Array Control Computer and Element Control Computer (commands and responses).
- Provides operator-operator communications ("telex" circuit).

- Permits an operator or engineer at the remote site to log in to the central computer.
- Permits a central operator or engineer to log in to the remote computer for diagnostic work.

Several "channels" should be available to permit all of the above simultaneously. This could be a commercial network software package, e.g., DECnet if Digital Equipment Corporation computers and operating systems are used.

2.0 OPERATOR INTERFACE (COMMAND INTERPRETER)

- Receives commands from three sources: prepared schedules on disk, commands typed on a local console, and commands received in real-time from the Array Control Center.
- Resolves conflicts between different command sources (e.g., can a local operator override a command from the Array Control Center?).
- Parses and checks validity of commands.
- Passes commands to appropriate modules for execution.

It is not strictly necessary to accept commands from all three sources at once, but I don't see why it shouldn't be allowed. Programming is simplest if commands received from all three sources are syntactically identical, i.e., readable ASCII if they are to be typed in by an operator (this is the way the present Mark-III system works), but storage and transmission limitations may require a more compact format for schedules and commands from the Array Control Computer. It should be possible to define "procedures" or "macros" (groups of commands invoked by a single command, with optional parameters) as in the Mark-III system (see VLBA Memo 163).

3.0 SCHEDULE MANAGEMENT

- Receives schedules from Array Control Center, local operator's console, or floppy disk (or other medium).
- Ensures that the correct schedule is active; starts up a new schedule when the current one ends.
- Edits schedules.

Editing will probably be accomplished with the editor of the commercial operating system. In a minimal system, schedules would only be edited at the Array Control Center (see VLBA Memo 163).

4.0 SCHEDULE VERIFICATION

- Checks schedules for syntactic and other errors (e.g., will the source be visible at the requested time?).

In most cases schedule verification will be done at the Array Control Center before the schedule is sent to the dispersed elements, but it is useful to have this capability at each element. The program at the Array Control Center and the remote sites can be identical if the computers are compatible.

5.0 MONITOR/CONTROL INTERFACE

- Sends commands to antenna, subreflector, front end, local oscillator subsystem, hydrogen maser, IF conversion subsystem, record subsystem, etc; and receives reponses, including all monitorable parameters. See VLBA Memos 211, 212 and 215 for the list of equipment which will be controlled and monitored.
- Responds to "alarms" generated by the hardware (but the Monitor and Control Subgroup suggests that no alarms will be generated).

The exact nature of this task depends on the nature of the interfaces. I imagine that all the hardware will be controlled through one or more buses (see VLBA Memo 215), which will provide a uniform interface with the computer.

6.0 ANTENNA CONTROL

- Performs coordinate conversion (including precession) for positioning the antenna. It should be possible to point the antenna in J2000.0 RA/Dec or ALTAZ coordinates. Other systems (e.g., B1950.0, galactic coordinates) can be converted to J2000.0 at the Array Control Center.
- Updates coordinates of moving objects (e.g., planets, satellites, solar features).
- Corrects coordinates for known pointing errors (e.g., refraction, parallax, mechanical deformation). The algorithm will make use of monitored parameters (e.g., surface meteorological conditions for refraction; tilt-meter readings, antenna structure temperature, and wind speed and direction for mechanical deformation).
- Reads shaft encoders to determine current pointing, and generates signals to control the drive motors (software servo loop); the details of this algorithm will depend on the antenna drive system.
- Switches frequency by moving sub-reflector or feed assembly, and/or dichroic plates.
- Optimizes focus by moving subreflector or feed assembly.

- Controls heaters, de-icers, etc.
- Monitors tracking errors.

I have specified J2000.0 coordinates, rather than apparent coordinates of date, for convenience in local operation. If precession can only be calculated at the Array Control Center, local operation becomes very difficult.

7.0 RECEIVER CONTROL

- Turns on and off calibration signals for measuring system temperature.
- Other control and monitor functions to be determined by the hardware design.

8.0 RADIOMETRY

- Measures pointing offsets and applies corrections to the antenna pointing model.
- Measures antenna temperatures (on-off).
- Measures and records continuous system temperature.

These procedures require cooperation between the antenna, receiver, and IF systems.

9.0 PHASE CALIBRATION EXTRACTION

- Extracts the phase calibration signal from digitized data in order to obtain a real-time check on receiver operation.

10.0 FRINGE VERIFICATION

- Records data and transmits data back to Array Control Center on demand.

11.0 MONITOR

- Monitors all parameters accessible to the monitor/control hardware, and other parameters such as pointing offsets.
- Sends selected parameters to the DISPLAY task.

- Identifies error conditions.
- Sends selected parameters to the LOGGING task to be recorded and sent to the central operator.
- Raises an alarm and stows the antenna in high wind or snow.
- Monitors intrusion and fire detectors, and initiates appropriate action. Some remotely-operated telescopes use remotely-controlled TV cameras to transmit pictures back to the Array Control Center (though at a slow frame rate).
- Detects failure of the computer system itself (!) and switches to backup if necessary.

12.0 DISPLAY

- Generates a continually-updated, formatted display of selected parameters on a TV monitor.

A local display is not needed during normal operations, but is very useful during debugging and diagnosis. An alphanumeric display would suffice, but a medium-resolution graphic display would be better (e.g., for displays of tracking errors vs. time, spectrum of phase-cal signal). The display may be generated on either the operator's terminal or a separate device.

13.0 LOGGING

- Records all commands executed.
- Records all monitored parameters at regular intervals. Parameters include signal levels, supply voltages, switch positions, pressure and temperature in the cryogenic systems, local weather conditions: temperature, pressure, humidity, wind speed and direction, cloud cover, etc.

The log file will be recorded at the site for later use; each entry will also be sent back to the Array Control Center. Local storage of the log is required to cover communications failures, and for local analysis (see below). The format and content of the log files is not yet defined: see VLBA memos 128, 133, and 163.

14.0 ANALYSIS OF LOG

- Extracts selected entries from the log file, displays on terminal or in graphical form (e.g., system temperature versus elevation, wind speed versus time).

This program only runs when requested by an operator. The program should be available both at the Array Control Center and at each element. It would be nice to have a graphics terminal available at each element for this, but this is a luxury (see VLBA Memo 166); a hardcopy

graphics device would also be nice.

15.0 DIAGNOSTICS

Diagnostic programs should be provided for aid in debugging hardware failures. These programs are difficult to specify in advance; they may be stand-alone programs run instead of the normal observing program, or specially modified versions of the observing program. I have found that programs of this sort can greatly simplify diagnosis of hardware problems; for example, a continuous display of encoder readings makes malfunctioning bits readily apparent, and driving the antenna with a square wave can help diagnose servo problems. This is the only area where an ability to modify the control program locally might be useful. In normal operation, all editing and compilation of programs should be done at the Array Control Center.