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DEVELOPMENT OF K-3 VLBI AUTOMATIC OPERATION SOFTWARE

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ABSTRACT

Radio Research Laboratory (RRL) has developed a high precision Very Long Baseline Interferometer (VLBI), called K-3 VLBI system, which is compatible with the Mark-III VLBI system of NASA, U.S.A. RRL already successfully performed US/Japan joint VLBI experiments and domestic experiments with Geographic Survey Institute and Nobeyama Radio Observatory.

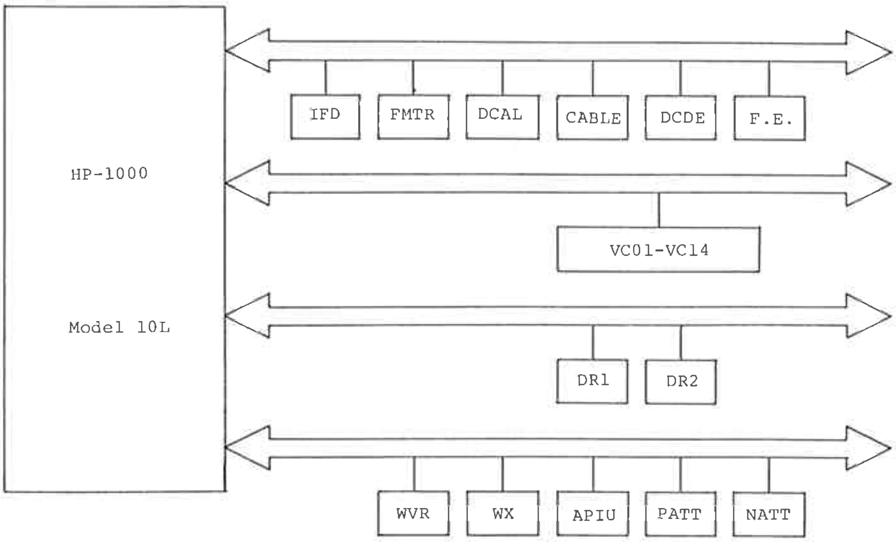
K-3 Automatic Operation Software (KAOS) is the operating system of K-3 VLBI system, and controls many devices of K-3 hardware by IEEE-488 standard interface buses. Meanwhile, Mark-III VLBI system uses serial interfaces, IEEE-488 standard interface buses, and other special interfaces. First the KAOS controls an antenna-frontend subsystem. It automatically points large aperture antenna at radio sources (quasar) precisely and controls wave guide switches and microwave attenuators. Secondly the KAOS controls many kinds of data acquisition terminal devices, for example, video converters, formatter. Thirdly it starts driving or stops driving the high-density data recorders. It also controls a water vapor radiometer and weather measuring instruments. The KAOS has the following three distinguished features. The first is the full compatibility with practical field system of U.S.A. VLBI system so called Field System of Mark-III VLBI system. The second is the unified adoption of IEEE-488 standard interface buses with ASCII characters. The third is the emergency measures by using the Service Request function (SRQ) of IEEE-488 standard interface buses. On the emergency, the KAOS with IEEE-488 standard interface buses can use the status words of SRQ and serial polling intentionally for controlling the system. The KAOS plays the most important role for automatic operation in Japan-US VLBI experiments.

1. Introduction

The principle of VLBI experiment is to determine the delay of the receiving radio signals at different sites. The simultaneous observation of radio sources among the several sites is strictly needed to detect the coherence power from cross correlation of radio signals from radio sources.

U.S. automatic operation software "Field System" is adopted by Mark-III VLBI system of the U.S.A. for the simultaneous and automatic data acquisition at every Mark-III observatory. Field System works to control Mark-III hardware on schedules and to record the logs of experiments. The schedule and log for Field System are special language by SNAP (Standard Notation for Astronomy Procedures) language (see Sec. 3.) and described by SNAP format.

The K-3 VLBI system developed by RRL must naturally be compatible with this inter-



Where IFD: IF distributor, FMTR: Formatter, DCAL: Delay calibrator, CABLE: Cable counter (HP5316A), DCDE: Decoder, F.E.: Frontend, VC01-VC14: Video converters, DR1 and DR2: Data recorders, WVR: Water vapor radiometer, WX: Weather terminal, APIU: Antenna pointing interface unit, PATT: Attenuator driver for phase calibrator pulse generator (HP11713A), NATT: Attenuator driver for noise source (HP11713A).

Fig. 1 Configuration of the K-3 VLBI system

national standard of schedules and logs based on Mark-III VLBI system(1)-(3). KAOS is developed to satisfy this requirement. As shown in Fig. 1, the KAOS controls many devices of K-3 VLBI system, for example, an antenna-frontend subsystem, data acquisition terminal, data recorders and water vapor radiometer.

We have developed the KAOS version 1.0 in 1981. This version is compatible with Field System version 3.1.

After Mark-III group updated Field System from version 3.1 to version 4.2 in 1982, we have updated the KAOS from version 1.0 to version 2.0 in 1983(4). This version is compatible with Field System version 4.2 in the level of SNAP commands except some items which are not used in K-3 VLBI system but used in Mark-III VLBI system.

Although Mark-III group has updated Field System from version 4.2 to version 5.2 in 1984, we have not updated for this version-up (see Table 1)(5).

At first, we describe the program structure of the KAOS, which consists of multi task programs. Secondly we summarize major KAOS commands and them show the compatibility with Mark-III commands. Lastly we show the example of the KAOS schedules and logs.

Table 1 SNAP commands of KAOS and Field System

Compatible command					
AZELOFF	BREAK	CABLE	CAL	CALTEMP	CONT
DECODE	ECHO	ENABLE	ET	FF	FLUSH
FORM	HALT	HPIB	IFD	LABEL	LOG
LOGOUT	NEWTAPE	NOCHECK	ONSOURCE	OP	PERR
PROC	RADECOFF	REPRO	RW	SCHEDULE	SOURCE
ST	SY	TAPE	TAPEPOS	TERMINATE	TI
TPI	TPICAL	TPZERO	TSYS	VC	WAKEUP
WVABORT	WVPOINT	WVR	WARAW	WVTEMP	WX
XDISP	XLOG				
KAOS command					
HPIBIN	IFIN	MAEOFF	NATT	ONOF	PATT
PLO	POL	ROUT			
Field System command					
ANTENNA	CHECK	LIST	LO	MAT	MATLOD
PARITY	PATCH	PCAL	RESET	RX	STATUS
WVDAT	WVSTAT	WVTAKE	XYOFF		

2. Program Structure

The KAOS comprises a set of programs which perform the controlling and monitoring functions during a VLBI experiment. The entire conduct of an experiment is automatically executed by the KAOS so that the operator action required is only the mounting and dismounting of data tapes and log/schedule floppy disks. Operator interface with the KAOS is performed by the SNAP language.

A block diagram of the KAOS programs is shown in Fig. 2. This structure of the KAOS is mostly the same as that of the Mark-III Field System, because we have developed the KAOS paying attention to the compatibility with the Field System. However, the KAOS is independent of the Field System. The kernel software developed by us and the following two items are different from the Field System.

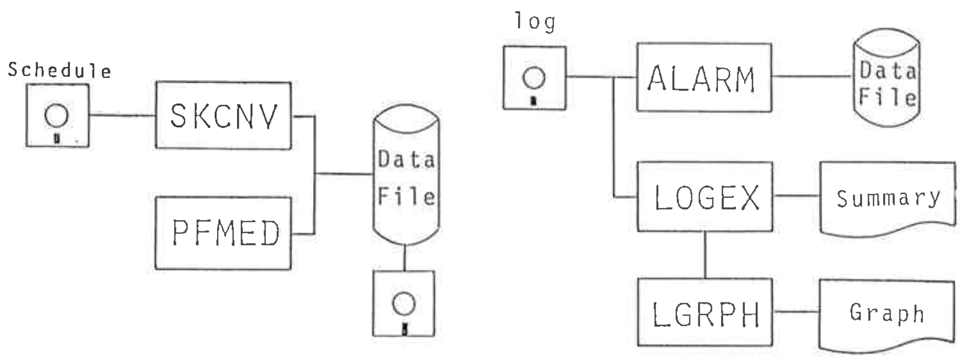


Fig. 2 (a) Block diagram of the KAOS off-line programs

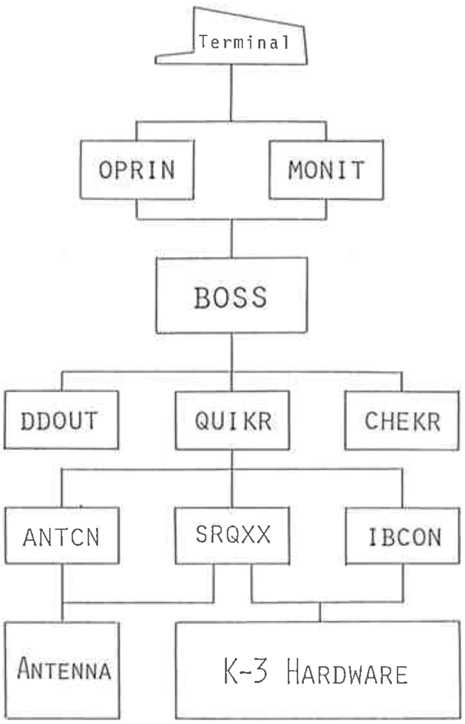


Fig. 2 (b) Structure of the KAOS on-line programs

a) We divided the KAOS into two parts. One is on-line observation program and the another is off-line log-analyzing program. Each program runs with HP-1000/10L computer and HP-1000/45F computer. Our computer system includes DS/1000IV (computer network software), so that the data in each computer can be accessed easily by the other connected computer.

b) Hardware error is detected by using SRQ function. This function is used both in the emergency of devices and the cases of the protocol errors in the SNAP schedules and responses.

Table 2 shows a list of program names in the KAOS.

Table 2 (a) KAOS off-line programs

	Name	Description
Schedule	SKCNV	Schedule converter from F.S. to KAOS
	PFMED	Procedure file manager and editor
Log	ALARM	Alarm data processor of hardware
	LOGEX	Log data processor
	LGRPH	Log data plotting utility

Table 2 (b) KAOS on-line programs

Name	Description
BOSS	Main control program, SNAP interpreter
OPRIN	Operator input to BOSS
QUIKR	Quick response root
IBCON	IEEE-488 bus control interface
ANTCN	Antenna control interface
ANTTR	Antenna tracking program
CATCH	Source initial catching program
DDOUT	Log entry system manager
CLOUT	Clear output class
MONIT	Screen display of monitored value
SETTM	Set computer time for formatter
CHEKR	Status check program of K-3 hardware
PCALR	Phase calibrator data processor
FSKEY	Function keys setting program
SRQxx	Service request processor of K-3 hardware

SKCNV converts schedule file in floppy disk from single density (HP-9885M), which is used by Mark-III VLBI system, into double density (HP-9895A), which is used by K-3 VLBI system. SKCNV also checks the time sequences of schedule data and inserts proper SNAP commands of the KAOS to set the procedure for frontend. ALARM extracts only hardware error from log files and creates alarm file. This file contains multi-experiments data. So it is utilized to confirm the reliability for each hardware. LGRPH is one of the plotting utilities of LOGEX. Log data can be plotted in graphic device by the PLOT command of LOGEX. SRQxx is an IEEE-488 standard interface bus SRQ processing programs of each hardware. SRQ-signal is transferred in the case of hardware emergency and/or protocol error of SNAP command. In addition, we can use SRQ function in order to detect completion of high speed data collection, if we set this function parameter on HPIBIN command. In the KAOS, functions and structures of each program are almost the same as those of the Field System without some exceptions, for example, SKCNV, ALARM, SRQxx.

Typical modifications of the KAOS are as follows: PLOT command output to graphic device in the LOGEX. The status of the frontend and data PCALR are added in the MONIT. All programs varied with K-3 hardwares and IEEE-488 standard interface bus protocols. Main terminal of the KAOS is one of the 264x series, so we use the function keys of terminal to run the KAOS programs.

3. KAOS SNAP Language

There are many kinds of roles which are subject to KAOS. The 59 commands allow us to operate K-3 VLBI system. Our major efforts were spent to make these commands. The KAOS's SNAP commands consist of four groups corresponding to the controlling hardware: System commands, Antenna commands, Data Acquisition Terminal commands, Recording commands, and Weather and Water Vapor Radiometer commands. The System commands give us many tools to operate KAOS conveniently as mentioned in Sec. 3.1. The

Antenna commands control the antenna and frontend subsystem. They point K-3 antenna to a radio source, and calibrate the receiving parameters both of antenna and receivers. The Data Acquisition Terminal commands control many kinds of data acquisition terminal devices, for example, an IF distributor, video converters, a formatter, and a decoder. By these commands we can decide the mode of the observation. The Recording commands control K-3 data recorder which is used most frequently, and is the most delicate hardware in K-3 data acquisition system. The Weather and Water Vapor Radiometer commands control the weather terminal and water vapor radiometer.

3.1 System Commands

There are 19 commands for KAOS system.

(1) BREAK: This command breaks and initializes the SNAP schedule. The currently-excuting procedure, which is a group of SNAP commands, is stopped after the current command is finished. The procedure stack is then stopped to the next higher level.

(2) CONT: This command must be issued after a HALT to get the schedule going again. It has no effect if no HALT was actually issued.

(3) ECHO: This command displays the communication protocol from KAOS to each device. In the case of trouble, this command clarifies the problem of the interface between HP-1000 and each module.

(4) FLUSH: This command re-initializes the operator procedure stack, unblocks the operator command stream, and terminates the execution of current procedure in the operator command stream (see Sec. 5).

(5) HALT: This command halts the execution of schedule until a CONT command is issued by the operator.

(6) HPIB: This command sends arbitrary ASCII characters to every device. The response from the device is not allowed in this command.

(7) HPIBIN: This command sends arbitrary ASCII characters to the every devices. The response from the device is allowed in this command.

(8) LOG: When the KAOS is initialized, a certain system log file was automatically opened or created on the disk. This command is issued to change from the previous one in use to new log file.

(9) LOGOUT: This command set log-output displays.

(10) NOCHECK: This command rejects the name of the module from the list of periodic check devices.

(11) OP: This command records the name of operator on the log file to memorize the responsibility of the observation.

(12) PROC: This command opens new station-procedure library. Since each station has different conditions, each station has its own station-procedure library.

(13) SCHEDULE: This command starts a new schedule file. If the schedule is started successfully, a log file having the same name as the schedule is automatically started, and the procedure file having the same name as the schedule is automatically used as the schedule procedure library.

(14) SY: An operator can send a system message of HP-1000 (e.g. run or suspend programs) by prefix "SY" command to system command.

(15) TERMINATE: This command is used for the end operation of the KAOS. Schedule execution is ended. The log, procedure and schedule files are closed and all programs are

removed from the system.

(16) TI: The current time-scheduled commands are listed on the terminal.

(17) WAKEUP: This command rings the internal bell on the terminal to alert the operator.

(18) XDISP: Extended display. ON to turn on extended display, OFF to turn off. When OFF, commands included in the procedures are not displayed. All responses are always displayed. When ON, all commands and responses are displayed.

(19) XLOG: Extended logging. ON to turn on extended logging, OFF to turn off. When OFF, commands within procedures are not logged. All responses are always logged. When ON, all commands and responses are logged.

3.2 Antenna commands

There are 18 commands for the antenna and frontend subsystem.

(1) AZELOFF: The antenna will move to the offset position when this command is issued. The angle offsets are set in azimuth and elevation separately. If the offset of this command is converted into zero, the antenna return to the on-source position (predict position of a radio source).

(2) CABLE: This command sends a request to the cable counter which is connected to the phase calibration cable and with calibration the delay of a receiver, and cables.

Both S- and X-band receivers at the antenna site and the data acquisition terminal in the ground building are connected by cables of about 62 meters. The variation of the cable delay is calibrated by a K-3 delay calibrator.

(3) CAL: This command controls a noise diode on/off in order to measure the total power of received signals (see TPI and TPICAL command).

(4) CALTEMP1, CALTEMP2: Two calibration temperatures for X and S bands may be specified with these two commands. Normally these would be used for IF1 (X-band) and IF2 (S-band) respectively. The commands TSYS1 and TSYS2 also use the temperatures specified by CALTEMP1 and CALTEMP2 respectively.

(5) MAEOFF: The antenna will move to the modified azimuth offset position when this command is issued. The modified azimuth offset is computed and displayed. The formula is:

$$DAz = DAz0 \,/\, COS\,(El)$$

where DAz = modified azimuth offset, DAz0 = original azimuth offset, El = elevation angle.

(6) NATT: This command controls the attenuation of noise source, which is used for total power calibration.

(7) ONOF: This command sets parameters of device controller for measuring the system temperature by using Dicke wave guide switching method in KAOS.

(8) ONSOURCE: This command confirms the pointing status of antenna. If one issues new SOURCE command, one should confirm the pointing status by this command.

(9) PATT: This command controls the attenuator of a pulse injector for phase calibration. This phase-calibration is used for the bandwidth synthesis.

(10) PLO: This command monitors the status of PLO (Phase Locked Oscillator) and X-band LNA (Low Noise Amplifier), because this status is very important for the experiments.

(11) POL: This command selects each of RHCP (Right Handed Circularly Polarized signal) or LHCP (Left Handed Circularly Polarized signal) for X-band polarizer.

(12) RADECOFF: The antenna will move to the offset position of right ascension and declination when this command is issued. If the offset of this command is converted into

zero, the antenna return to the on-source position.

(13) ROUT: This command selects each of single X-band receiver or multi X-band receivers by changing the route of receiving signals in the frontend.

(14) SOURCE: The antenna will begin moving to the new source when this command is issued. After completion of the slue to the source, the response of "CATCH" is returned from the antenna.

(15) TPI: This command measures total power of received signals, when the calibration noise is off (CAL = OFF).

(16) TPICAL: This command measures total power, when the calibration noise is on (CAL = ON).

(17) TPZERO: This command measures zero levels of total power. The zero levels are subtracted from all readings taken on the same module before system temperatures are computed.

(18) TSYS1, TSYS2: This command computes system temperatures. The calculations for TSYS1 and TSYS2 use the values of CALTEMP1 and CALTEMP2 respectively. The formula is:

$$Tsys = (V - Vzero)\ Tcal / (Vcal - V)$$

where V = calibration noise is off reading (TPI command), Vzero = zero level reading (TPZERO command), Vcal = calibration noise is on reading (TPICAL command), Tcal = noise calibration temperature (CALTEMP command).

3.3 Data Acquisition Terminal Commands

There are 5 commands for data acquisition terminal.

(1) DECODE: Decoder is used to confirm the quality of reproducing signals from data recorder. This command controls and monitors the status of the decoder.

(2) FORM: This command controls the observation mode and the sampling rate of the formatter.

(3) IFD: This command controls the attenuators and input-selector of the IF distributor.

(4) IFIN: IF distributor has two channels A and B. This command chooses the input of IF distributor's B channel from S-band or X'-band (7860–8280 MHz) of the K-3 VLBI system.

(5) VCnn: This command controls and monitors many items and status of these video converters. The nn covers from 01 to 14.

3.4 Recording Commands

There are 11 commands for data recorder. The KAOS can record observation data to two data recorders simultaneously and can select one of two recorders by contents in a KAOS's address file or an auxiliary program.

(1) ENABLE: This command fixes the record-enable tracks of the recorder. This command can control dual recorders in KAOS.

(2) ET: Tape motion is stopped when this command is issued. Record is disable. This command can control dual recorders in KAOS.

(3) FF: The tape is moved forward at high speed (270 inch/sec). Record is disabled. This command can control dual recorders in KAOS.

(4) LABEL: To prevent the misloading, the operator reads the check-number from the label on the tape and inputs the number into KAOS by this command. The KAOS judges the

misloading or not and notifies the operator. The log of this command is also used to reconfirm the content of recorded tape.

(5) NEWTAPE: This command is in effect the same as the HALT command. Execution will continue after the LABEL command has been successfully completed.

(6) PERR: This command sets up the appropriate track for reproduce, and then reads the data of parity error from the decoder.

(7) REPRO: This command sets up reproduce tracks.

(8) RW: This command rewinds the tape at high speed. Record is disabled. This command can control dual recorders in KAOS.

(9) ST: The tape is started moving by this command. Record is enabled. This command can control dual recorders in KAOS.

(10) TAPE: This command controls low-tape sensor, resets footage counter, and then gets the status of the data recorder. This command can control dual recorders in KAOS.

(11) TAPEPOS: This command starts the tape moving fast forward or rewind the tape. In K-3 VLBI system, this command is interpreted and then executed automatically by internal processor of the recorder. The positioning accuracy is ± 0.1 feet. This command can control dual recorders in KAOS.

3.5 Weather and Water Vapor Radiometer Commands

There are 6 commands for a weather terminal and water vapor radiometer.

(1) WVABORT: This command stops the current water vapor radiometer process. In KAOS this command takes no action for other processes.

(2) WVPOINT: This command points the water vapor radiometer to the designated direction.

(3) WVR: This command gets brightness temperatures, and computes path delay and zenith path delay. The path delay formula is:

$$\text{path} = a + b\,(c\,b1 - b2)$$

where path = path delay, a, b, c = constants, b1 = 20 GHz brightness temperature, b2 = 26.5 GHz brightness temperature. And zenith path delay formula is:

$$\text{zpath} = \text{path} \cdot \text{SIN}\,(E1)$$

where zpath = zenith path delay, path = path delay, E1 = elevation angle of the water vapor radiometer.

(4) WVRAW: This command gets water vapor radiometer raw data.

(5) WVTEMP: This command gets water vapor radiometer physical temperatures.

(6) WX: This command gets current weather parameters (Temperature, Pressure, Humidity).

4. Example of KAOS Observation schedule, procedure and logs

An example of KAOS observation schedule file and an example of KAOS observation procedure file are shown in Fig. 3 and Fig. 4, respectively. The schedule file inputted the KAOS by SCHEDULE command. After the SCHEDULE command is issued, all time-scheduled procedures are canceled, the files of schedule, procedure, and log, which are previously used, are closed and new schedule/procedure library are opened. Fig. 5 is an example of log file. This log file is necessary both for LOGEX, and for ALARM software of KAOS and also for data analysis software.

```
SOURCE=2216-038,221852.0,-033536.9,2000.0 -----------------------------
SX2C1                                                          |
READY                                                          |
!022235910                                                     |
PREOB                                                          |
!023000000                                                     |
TAPE                                                   1 observation
ST=FOR,120                                                     |
MIDOB                                                          |
!023000620                                                     |
ET                                                             |
!+3S                                                           |
TAPE                                                           |
POSTOB -----------------------------------------------------------------
SOURCE=3C454.3,225357.7,160853.5,2000.0 -- Radio source set command
SX2C1 ------------------------------------ procedure
!023000700 ------------------------------- Time flow control command
PREOB ------------------------------------ procedure
!023000750
TAPE ------------------------------------- Gets the status of Data Recorder
ST=FOR,120 ------------------------------- Data Recorder is started moving
MIDOB ------------------------------------ procedure
!023001410
ET --------------------------------------- Data Recorder is stopped
!+3S ------------------------------------- Time suspend
TAPE
POSTOB ----------------------------------- procedure
SOURCE=VR422201,220243.2,421639.9,2000.0
MIDTP
SX2C2
!023001450
PREOB
!023001540
TAPE
ST=REV,120
MIDOB
!023002200
ET
!+3S
TAPE
POSTOB
```

Fig. 3 An example of a SNAP shcedule file

```
DEFINE  SX2C1 ------------------ Definition of procedure SX2C1
VCSX                   |
FORM=C,4.000           |
IFDSX              Contents of procedure SX2C1
ENABLE=G1,G3           |
TAPE=OFF               |
ENDDEF ......................... End of definition

DEFINE  SX2C2 ------------------ Definition of procedure SX2C2
VCSX                   |
FORM=C,4.000           |
IFDSX              Contents of procedure SX2C2
ENABLE=G2,G4           |
TAPE=OFF               |
ENDDEF ......................... End of definition

DEFINE  PREOB ------------------ Definition of procedure PREOB
ONSOURCE           Contents of procedure PREOB
ENDDEF ......................... End of definition

DEFINE  MIDOB ------------------ Definition of procedure MIDOB
ONSOURCE               |
WX                     |
CABLE              Contents of procedure MIDOB
UPDAT                  |
PARITY                 |
ENDDEF ......................... End of definition
```

An operator can use the procedures directly in SNAP schedule.

Fig. 4 An example of a procedure file including four procedures

```
022234949;VLBI K3 SYSTEM        VERSION 2.0 KASHIMA  1984
022234950;"11:49 PM  SUN., 22  JAN.  1984
022234950:SOURCE=2216-038,221852.0,-033536.9,2000.0
022234952:SX2C1
022234955:READY
022234958/NEWTAPE/"To continue, use LABEL command"
022235012#CATCH# "TRACKING START
022235021;LABEL=RRL00001,?
022235023/ST/9996.85
022235032/ET/55.13
022235035/TAPE/OFF,0000,NORM,STOPPED,STOP,UNLOCK,READY,REM
022235036/LABEL/RRL00001,6EBC
022235036:!022235910
022235910:PREOB
022235911/ONSOURCE/TRACKING
022235912:!023000000
023000000:TAPE
023000000/TAPE/OFF,0000,NORM,STOPPED,STOP,UNLOCK,READY,REM
023000000:ST=FOR,120
023000001/ST/0.00
023000002:MIDOB
023000004/ONSOURCE/TRACKING
023000006/WX/0.9,1011.3,87.1
023000012/CABLE/+3.49754E-02
023000015/TAPE/OFF,0137,NORM,MOVING,NOSTOP,LOCKED,READY,REM
023000016/FORM/C,4.0,NOR,ON,OK,+,RUN,REM,OK,84023000017.100
023000017/IFD/16,2,NOR,NOR,REM,1.8,0.5
023000021/VC01/130.99,2.0,U,5,5,REM,LOCK,1.6
023000022/VC02/140.99,2.0,U,5,5,REM,LOCK,1.5
023000024/VC03/170.99,2.0,U,5,5,REM,LOCK,1.7
023000025/VC04/230.99,2.0,U,5,5,REM,LOCK,1.7
023000026/VC05/340.99,2.0,U,5,5,REM,LOCK,1.4
023000027/VC06/420.99,2.0,U,5,5,REM,LOCK,1.2
023000028/VC07/470.99,2.0,U,5,5,REM,LOCK,1.1
023000030/VC08/490.99,2.0,U,5,5,REM,LOCK,1.1
023000031/VC09/197.99,2.0,U,5,5,REM,LOCK,0.7
023000032/VC10/202.99,2.0,U,5,5,REM,LOCK,0.7
023000032/VC11/217.99,2.0,U,5,5,REM,LOCK,0.8
023000034/VC12/247.99,2.0,U,5,5,REM,LOCK,1.6
023000035/VC13/272.99,2.0,U,5,5,REM,LOCK,1.2
023000036/VC14/282.99,2.0,U,5,5,REM,LOCK,1.0
023000047/PERR/1,A,2,0.5,REC,0.0,0
023000051/PERR/3,A,2,0.5,REC,0.5,0
023000055/PERR/5,A,2,0.5,REC,0.5,0
023000058/PERR/7,A,2,0.5,REC,0.5,0
023000102/PERR/9,A,2,0.5,REC,0.0,0
023000106/PERR/11,A,2,0.5,REC,13.5,0
023000110/PERR/13,A,2,0.5,REC,560.5,0
023000113/PERR/15,A,2,0.5,REC,0.0,0
023000117/PERR/17,A,2,0.5,REC,0.0,0
023000121/PERR/19,A,2,0.5,REC,277.5,0
023000125/PERR/21,A,2,0.5,REC,1.0,0
023000128/PERR/23,A,2,0.5,REC,0.0,0
023000132/PERR/25,A,2,0.5,REC,24.0,0
023000136/PERR/27,A,2,0.5,REC,166.0,1
023000137:!023000620
023000620:ET
023000620:!+3S
023000623:TAPE
023000624/TAPE/OFF,4257,NORM,STOPPED,STOP,UNLOCK,READY,REM
023000625:POSTOB
023000623/ET/4242.59
023000625:SOURCE=3C454.3,225357.7,160853.5,2000.0
023000627:SX2C1
023000637:!023000700
```

Fig. 5 An example of a SNAP log file corresponding to the first observation of the SNAP schedule in Fig. 3

5. Conclusion

The structure and major characteristics of KAOS and its operation commands were described in this paper. We also showed same typical examples of schedules, procedures, and logs used in KAOS.

The system-level experiments between Japan and US were performed in January and February, 1984. The experiments showed a quite good compatibility with Mark-III of United States. In the summer campains of Crustal Dynamics Project of NASA, KAOS showed an excellent ability and presented us the high quality data. Geographic Survey Institute introduced KAOS as well as K-3 VLBI system for the domestic VLBI experiment.

The unified adoption of IEEE-488 standard interface buses makes the maintenance and check of the K-3 VLBI system very easy, because small personal computers can communicate with each module of K-3 VLBI system through IEEE-488 standard interface buses.

We are planning to develop the new automatic operation software on the personal computer. This software will control many kinds of K-3 hardware using IEEE-488 standard interface buses.

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