3.2.2 Correlation Processing Software

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Abstract

The Key Stone Project (KSP) aims to provide daily crustal deformation monitoring data around the metropolitan area. One of its key technologies is VLBI. Radio signals observed by four stations are recorded on magnetic tapes and sent to a correlation and data analysis center in Koganei. The tapes are played back synchronously and 4×256Mbps data is fed to six baseline KSP correlators. The huge amount of data is processed and radio propagation delays among four stations are extracted and stored in a Mark-III database. Software KATS was developed to provide an operator with a unified graphical user interface (GUI) for operations. It was designed to enable non-expert operators to perform this correlation data processing simply by mouse clicks and a few key strokes. This paper describes the VLBI cross correlation system in KSP and functions of the correlation control software KATS.

1 Introduction

The KSP VLBI system consists of four VLBI stations in Japan each with 11m diameter antenna located in Koganei, Kashima, Miura, and Tateyama.

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Two types of VLBI system are used in the KSP. In one, radio signals observed from radio stars are recorded on magnetic tape. Here we call this type a "tape-based" VLBI. The other type of system uses a optical fiber network to transport observed data from all four stations to a correlation center. Correlation processing is done during the observation. This system is called a "real-time" VLBI[2,8]. In this paper, we describe correlation processing software for the "tape-based" VLBI system.

Radio signals from radio stars are observed and recorded on magnetic tapes at four VLBI stations. After the experiment, magnetic tapes are sent to Koganei VLBI correlation and data analysis center. The huge amount of data (50Tbit : 256 Mbps $\times$ 24 hours of experiment $\times$ 4 stations) is processed and the stations' positions are extracted with an accuracy of a few millimetre.

An ordinary geodetic VLBI experiment (hereafter just called experiment) consists of several hundred observations. Cross correlation is performed from one observation to the other. In the next step, bandwidth-synthesis processing (KOMB) is applied. After all the observations are processed, the group delays are extracted from the KOMB output file and stored in a Mark-III database system, which is widely used in the global geodetic VLBI community.

This data reduction procedure, from synchronized play back of four stations' magnetic tapes up to storing the data in the Mark-III database, is complex and requires many commands to be sent to computers and correlators. It also requires skill and knowledge about VLBI equipment and computers on the part of the operator. The KATS was developed for the KSP VLBI to make this procedure semi-automatic and to help an operator by providing a graphical user interface (GUI).

The CRL was a pioneer of VLBI technology in Japan and K3 system was the first Japanese VLBI system developed by the CRL for Japan-US geodetic VLBI experiments. It has compatibility with Mark-III(A) VLBI system developed by the U.S.A. and is capable of 2 baselines with maximum data processing rate of 128Mbps. The data reduction procedure was operated in step by step by typing command to computer display. The know-how of the K3 correlation system has been introduced in the KATS. The KATS runs on HP-UX operation system. The maximum number of baselines/stations which the KATS can deal with is ten baselines/ five stations. The maximum data processing rate is 256Mbps per one baseline. The role of the KATS can be summarised as (1) correcting information for data processing, (2)

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commanding the execution of correlation process to Correlator Controller,
(3) receiving the correlation output data and applying bandwidth synthesis
process to the data, (4) storing the data in Mark-III database system, (5)
managing the flow of these procedure. The KATS does not calculate the
delays and delay rates of correlator model, but providing the information for
that to each correlator. The correlator model calculations are done by each
correlator in the baseline base.

The next section describes the hardware and software component of the
correlation system. Section 3 explains the principle of operation, and de-
scribes the specifications of KATS, input files, and internal files. Section 4
describes several remarkable features of KATS.

2   System Components

2.1   Hardware Components

Fig. 1 illustrates the KSP VLBI tape-based correlation system with their
hardware components, which is located at the Koganei correlation and data
analysis center. Details of each piece of equipment are given in paper 3.2.1
"Correlation Processor"[1]. Here we review them briefly.

Correlation Process Control Computer (CPCC): KATS runs on a CPCC
(HP9000/735) HP-UX workstation. The CPCC is connected with a
correlator controller (CC) via an RS-232C cable and is also connected
to a local area network (LAN) using Ethernet. The CPCC acts as PC
network file system (PC-NFS) server and receives output data from the
correlators via the LAN.

Correlator Controller (CC): The CC has an MC68040 CPU and con-
trols all the hardware for correlation through GP-IB. It communicates
the status and commands with CPCC via the RS-232C.

DIR-1000 and DMS-24: Data recorder/player DIR-1000 provide 256-Mbps
high speed recording and play-back. It is placed inside a DMS-24 K-4
cassette tape auto-changer, which can hold 24 K-4 tapes, correspond-
ing to 36 hours of 256-Mbps VLBI observation data. The DMS-24 is
controlled by the CC via GP-IB bus and it changes K-4 tapes on the

DIR-1000 automatically. This enables automated 24 hours of VLBI observation and unmanned correlation processing.

Output Interface DFC-2200: The DFC-2200 interfaces between data recorder/player (DIR-1000) and correlator. Four of them are controlled by the CC and synchronously play back data of four stations, respectively.

Correlator: Six single baseline correlators are used in this system. Each correlator receives a synchronised pair of data streams from two DFC-2200s through distributors and performs six baselines correlation processing operation in parallel. The correlators work as clients of the PC-NFS and write correlation data onto the the CPCC's hard disk directly via the LAN.

Bandwidth-Synthesis Processor (BWSP): The bandwidth-synthesis processing software (KOMB) runs on two HP9000/J210 workstations. The hard disks of the BWSP and CPCC is mutually mounted on each other by network file system (NFS). Therefore correlation output data can be seen from both computers, the heavy computation load of KOMB is shared, and the data is processed by multiple workstations in parallel.

2.2 Software Components

Correlator Controller Software (CCS): The correlator control software (CCS) runs on the CC and controls the DMS-24s, DFC-2200s, and correlators. It receives the initialisation and correlation start signals from KATS via the RS-232C and gets other information from KATS internal files (see section 3.2.3) via the PC-NFS. The CCS performs correlation processing by using the information in those files. It manages one observation correlation processing operation using all of the hardware components. After one run has finished, a command to process the next observation is sent from KATS to CCS.

KAnameishi data processing Togo Software (KATS): KATS provides a GUI for easy operation of VLBI data reduction It manages data reduction on a whole experiment, which contains several hundred observations. The working flow is as follows.
KATS gets the schedule file and log files from the central observation

control computer[5] by FTP (File Transport Protocol). Then it reads those files, extract information for correlation processing and saves it in internal files (see section 3.2.3). The operator modifies the process settings via the GUI and starts the correlation process. KATS sends a start signal to the CCS via the RS-232C for every observation. Information necessary for correlation processing is passed to the CCS by the PC-NFS. When one observation correlation processing operation has finished, KATS invokes KOMB for the correlation output files on a local or remote computer. After KOMB has finished for all the observations in the experiment, KATS launches the Mark-III database creation software (db.pl). Then the observed propagation delay information is stored in the database.

Bandwidth-Synthesis Software (KOMB): KOMB is software for synthesizing 16 channels of correlation output data to extract the propagation delay very accurately. The functions are described in paper 3.2.3 "Data Reduction Software"[3] in detail. Correlation output data is shared by workstations connected to the LAN, then KOMB is invoked on multiple workstations for multiple baseline processing.

Mark-III Database Creation Software (db.pl): After KOMB processing has finished for all observation data, KATS prepares a set of information for storage of the data in a Mark-III database. It invokes db.pl, which create a new entry of Mark-III data base for the VLBI experiment. After that, automatic baseline analysis software (VLBEST) is launched and the baseline lengths and station positions are derived within an accuracy of a few millimetre. A detailed description is given in paper 3.3.1 "Data Analysis Software"[4].

3 KATS Specifications

3.1 Operation Instruction and Flow

The basic flow of instructions is explained below. By following these instructions, an operator, who is not an expert about VLBI, can perform correlation processing for pairs among four stations i.e. six baselines.

1. **Getting Started**
   First of all, the operator must select [Setting] → [Preparation] menu from the KATS main window. Then the "Process Setting" window (see Fig. 2) will pop up. Clicking the button "SCHEDULE SELECTION" causes the schedule selection window (Fig. 3) to pop up offering available VLBI schedules on the local disk (/usr/local/kats/data/skd). If non of them are suitable, the operator clicks "skd,log File Transport", and a file transport window (see Fig. 3) pops up. Here he can get a schedule file and log files from the remote host computer (central observation control computer: see paper 3.1.4 "Observation and System Management Software"[5]) by FTP. KATS reads the schedule file, extract observation information, and stores it in internal files (see section 3.2.3).

2. **Assignment of Stations to Cassette Tape Players**
   The operator mounts K-4 cassette tapes for correlation processing in the DMS-24s. Details of which station's cassette tape was mounted on which DMS-24 should be reported to KATS. This is done in the station assignment window (Fig. 4 right), which pops up from the "Station Assignment" button"(Fig. 4 left). The operator assigns station names and log files to each recorder number and finally clicks "OK". Then KATS reads the log file and extracts /ST/, /TD/, and /LABEL/ data and stores it in KATS internal files (see section 3.2.2).

3. **Process Mode Setting**
   The operator has a choice of two correlation modes: "normal" or "clock search". In the "normal" mode, 16 frequency channels of data are processed normally. In the "search" mode, data of one frequency channel (common channel: see the description of 3.2.3) is distributed among 16 correlation units with a different time delay applied to each unit. The source to be processed is chosen from "Fringe search source list", which is written in the term of $SOURCE in SRCH_INF file. This mode is used for the clock parameter search procedure and the data is not processed by KOMB.

4. **Setting Observation Number**
   An ordinary geodetic VLBI experiment consists of several hundred observations, each lasting several minutes. Sequential numbers are as-

signed to the observations, and the operator can set the range of numbers to be processed in a column in the window (see Fig. 5 left) from the keyboard. Another way to input the observation number is to click the "OBS" button in the window. Then a list of observation number, radio source name, and observation start time will pop up (see Fig. 5). The operator can select the observation number there.

5. **Common Channel Setting**
   The common channel is the channel whose data is distributed to 16 correlation units for fringe search processing. This common channel is necessary even for "Normal" correlation mode. Clicking the "FRINGE SEARCH/DYNAMIC CLOCK SETTING..." button (Fig. 6 left) causes "Fringe Search Setting" window (Fig. 6 right) to pop up. The operator sets the common channel for each baseline using up-down arrows.

6. **Process Execution**
   After setting up the processing, the next step is execution. There are three choices of procedures (see Fig. 7). In the first mode, only correlation processing is done. The second mode is correlation processing and KOMB processing. The third is from correlation processing to database creation, which is the mode usually used in the routine VLBI reduction procedure.

These steps are basic operations for routine work. Additional settings listed below are not necessary for daily routine operation, but some of them are necessary when the first time KATS is run.

1. **Data Line/KOMB Host setting**
   KATS has to know the actual data line connections from data recorders to correlators. This should be registered in KATS when KATS runs for the first time after installation. Clicking the corresponding button (Fig. 8 left) causes the "Data Line Connection /KOMB Host Setting" window (Fig. 8 right) to pop up. The operator sets data line connection information using a mouse. Also the names of host workstations, on which KOMB process is done, can be set here. The priority of the process ("nice" value in UNIX c-shell) should be in the range from 0 (highest priority) to 39 (lowest priority).

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2. **Baseline Selection**

The sets of baselines are selectable in the "Baseline Selection" window (see Fig. 9). All the baselines are selected as a default. The selection function is for cases where a certain baseline is not wanted.

3. **Bandwidth-Synthesis Setting**

Frequency band parameter, S, X, or S/X, has to be specified in bandwidth-synthesis process. The parameter can be set in the window popped up from the KOMB setting button (Fig. 6 left).

4. **ERP/Clock Parameter Setting**

The clock parameter, and Earth Rotation Parameter (ERP) are automatically set from observation log files and the ERP file. The ERP information is obtained from the International Earth Rotation Service (IERS). If the operator needs to modify these values, he can do so in the "ERP/Clock Parameter Setting" window popped up from "ERP/Clock Parameter" button (Fig. 10). The parameter period as correlation integration time is also adjustable in this window.

3.2 Files and Directories

3.2.1 Directory tree

KATS runs in the directory environment shown in Fig. 11. The "bin/" directory contains executable files. The "data/" directory consists of schedule file directory:"skd/", log file directory:"log/", internal file directory:"data/", process history file directory:"prc/", and temporary file directory:"temp/". The rolls of each kind of file are described in the next section.

Output data from a correlator and KOMB is written in the directory structure shown in Fig. 12. An example of directory path name is "/komb1/vlbidata3/kross/KS98171/". The top directory name is host-name where the hard disk is locally mounted. The second directory name shows the directory is used for VLBI data storage. The third name indicates whether the data is correlation output data (kross) or KOMB output data (komb). The fourth name is the experiment code name.

HP9000/J210 workstations "komb1" and "komb2" and HP9000/730 and HP9000/745 workstation "washi" and "eve" are connected to the LAN. Each of them has a large volume of hard disks and share the each other's data disk

via the NFS. Because directory path names follow the rule described above, the data directory path name is exactly the same regardless of which workstations access it. This unification of directory path names is important for parallel processing of KOMB with multiple workstations.

3.2.2   KATS Input files

KATS gets information necessary for the correlation process from the schedule file and log files. The KSP VLBI schedule format is based on standard VLBI schedule format[6]. It must contain the terms $EXPER, $SKED, $SOURCES, $STATIONS, and $CODES at least. An example of a log file is shown in Fig. 13. Every log file must contain the following terms:

/LABEL/ Label of the K4 cassette tape. This should be recorded each time a new tape is mounted in recorder.

/TD/ Clock difference between input interface (DFC-2200) and GPS. This term must be entered at least two times in the log file (at the beginning and end of the experiment) for the clock parameter of the correlation process.

/ST/ Tape counter number when recording starts for every observation. This number is necessary for synchronized play back.

/WX/ Temperature, air pressure, and humidity at the station. This environmental data needs be updated frequently, at least several times per hour. This data is used for atmospheric delay calibration and is stored in Mark-III database together with VLBI observation data.

/CABLE/ Cable calibration data is stored in the Mark-III database and used to correct changes in cable length in baseline analysis.

3.2.3   Internal files

KATS uses the following internal files to memorise the current processing information. When KATS shuts down during processing due to some kind of troubles, these internal files help to enable the interrupted process to be continued (see Fig. 14-1 - Fig. 14-4).

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COR_BASE A file for registering correlator-baseline assignment information and the process flag. This file is modified automatically after stations have been assigned to cassette players.

COR_INF This file is made by collecting information from other internal files at every observation, The CCS refers to it for the correlation process.

COR_MSG Error or warning messages are written by CCS when any trouble occurs.

CRSS_PAR Some parameters and flags necessary for correlation processing.

CTL_INF Path name of the internal files are listed.

DB_INF Modified by KATS for making a database and the data is read by db.pl.

ERP_INF Earth rotation parameter is automatically updated by a program called TAKEMIKAZUCHI[4] automatically when a new ERP is sent from IERS.

KHSC_ADR stores hardware GP-IB addresses of equipment.

KOMB_HOST stores candidate of KOMB execution host. This file is used at "Data Line Connection/KOMB Host Setting" (see Fig. 8).

KOMB_SET KOMB execution parameter.

KROSS_NM Cross correlation output data file has a sequential number such as "K12345". This holds current file names.

MAIL_ADR Mail address where error or warning messages should be sent when any trouble occurs.

OBS_DUR Observation start, stop, and parameter reference time (PRT) data for each station.

OBS_INF Observation number, source name, and observation start time are extracted from the schedule file, and tape labels and tape counter numbers for each observation are corrected from the log files.

REC_COR A file to register data cable connection information from recorder to correlator. This file is modified in the "Data Line Connection/KOMB Host Setting" window (Fig. 8).

REC_STAT List of observation stations assignments to cassette tape players.

SRCH_INF Information for fringe search is registered here. In the term $ORDER, station names are listed in the order of dominance in clock parameter determination. In other words, the lower-order station's clock parameter is changed in the fringe search process. Strong flux sources used for fringe search are listed in $SOURCE term. $JDG_LVL is the SNR threshold for automatically judging this fringe detection.

PRC file Correlation and KOMB process history is recorded in this file, which is located in the prc directory (see Fig. 11). This file shows which observations have been processed.

3.2.4 Resource file

KATS uses an X-window system resource file as a KATS set-up file. If KATS is invoked with argument, that is taken as the resource file; otherwise "$HOME/.Xdefaults-<host name>" is used. Some resource items are listed in Table 1. The full resource list is given in the KATS manual[7].

4 Features of KATS

4.1 User Friendly Operation

In the past, VLBI correlation processing required operators to be knowledgeable about VLBI and computers. But KSP must be operated everyday by non-specialists. Therefore routine operations such as correlation processing, bandwidth-synthesis, and Mark-III database creation should be easy to perform and should not require much knowledge about computers. KATS is designed to use a GUI so it can be operated by mouse click and a few keyboard strokes.

4.2   Data Transfer via Ethernet

In the K-3 system, which CRL developed as the first geodetic VLBI correlation system, correlation output data was transferred to the control computer via a GP-IB bus and then transfered to a mini-computer (HP1000/A900) via GP-IB for bandwidth-synthesis (KOMB) processing. Thus the data flow was sequential and the KOMB process needed a lot of computer power. It took two days to process a 24-hour VLBI experiment.

Ethernet was introduced in the KSP correlation system. The correlator writes the output data to the hard disk of the host computer and the data can be accessed from any other computer in parallel. Thus the data transfer time became negligible and KOMB processing could be performed while the correlator was performing correlation for the next observation. Consequently, the time taken for the data reduction process became almost as short as the observation time.

4.3   Parallel Processing of KOMB

Bandwidth-synthesis processing needs the most CPU power for calculation. To distribute the computation load, the correlation system is designed so that KOMB processes can run in parallel for multiple baseline data streams on multiple workstations. The data to be processed is shared among the workstations by the NFS, and multiple KOMB processes can access the data independently. The assignment of the baselines to workstations can be controlled from KATS using a mouse (Fig. 8).

5   Summary

The KSP VLBI system is now running every other day to monitor crustal deformation around the metropolitan area. The correlation process is the key to extracting the radio signal propagation delay between two stations. KATS can perform this procedure easily and quickly. And KATS became a basis of farther development to RKATS, which is a fully automated real-time correlation system [8].

6 Acknowledgements

Table 1: KATS Resource list

Category	Resource name	Meaning	Value
Directory resource	dirSkd	Schedule file	∼/data/skd
	dirLog	Log file	∼/data/log
	dirKRSS1	KROSS dir main	/komb1/vlbidata1/kross
	dirKRSS2	KROSS dir sub	/komb1/vlbidata2/kross
	dirKOMB1	KOMB dir main	/komb1/vlbidata1/komb
	dirKOMB2	KOMB dir sub	/komb1/vlbidata2/komb
Remote host information	rhostFiles	Remote host name	kspkog0
	rhostLogin	Login name	
	rhostpsswd	login Password	
	rhostDirSkd	Schedule file dir	∼/skd
	rhostDirLog	Log file dir	∼/log
Disc change parameter[1]	kbKROSS1	Disc volume threshold	200000 (kByte)
	kbKROSS2	Disc volume threshold	200000 (kByte)
	kbKOMB1	Disc volume threshold	200000 (kByte)
	kbKOMB2	Disc volume threshold	200000 (kByte)

(1) If the residual capacity of dirKRSS1 is less the the value of kbKROSS1 resource parameter, then kross output dir is changed to dirKRSS2 automatically. Similarly for the dirKOMB.

References

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(3) Kondo, T., Sekido, M., Kiuchi, H., "3.2.3 Data Reduction Software", J. Comm. Res. Lab., In this issue.

(4) Koyama, Y., Heki, K., Takahashi, Y., Furuya, M., "3.3.1 Data Analysis Software", J. Comm. Res. Lab., In this issue.

(5) Koyama, Y., Takaba, T., Iwata, T, "3.1.4 Observation and System Management Software", J. Comm. Res. Lab., In this issue.

(6) Vandenberg, N. R., "Standard Schedule File Format" VLBI Software Documentation NASA/GSFC Crustal Dynamics Project, 1991.

(7) Sato, H., "KATS Manual" 1994.10.11.

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DMS-24

Bandwidth-synthesis processor

DIR-1000

RS-232C

Correlation process control computer

DFC-2200 output interface

Cosmoresearch Co. Ltd.

Cosmoresearch Co. Ltd.

Cosmoresearch Co. Ltd.

Cosmoresearch Co. Ltd.

Correlator Controler Cosmoresearch Co. Ltd.

Correlator controler

Data distributor

GP-IB

KSP Correlator

LAN (Ethernet)
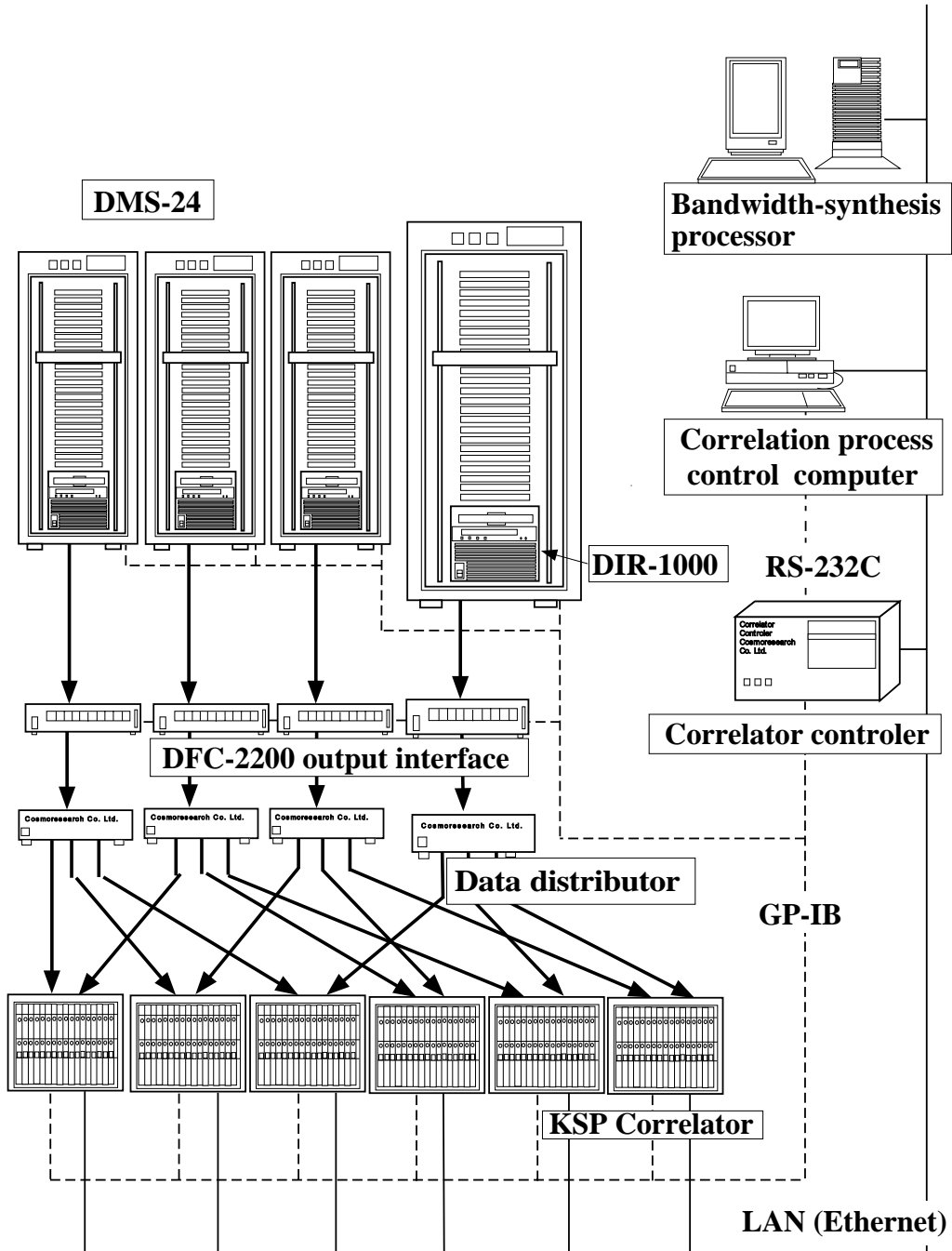
Figure 1: KSP VLBI tape-based correlation system

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Figure 2: Example of correlation setting GUI in computer display. Japanese characters in display has been translated into English in this paper.
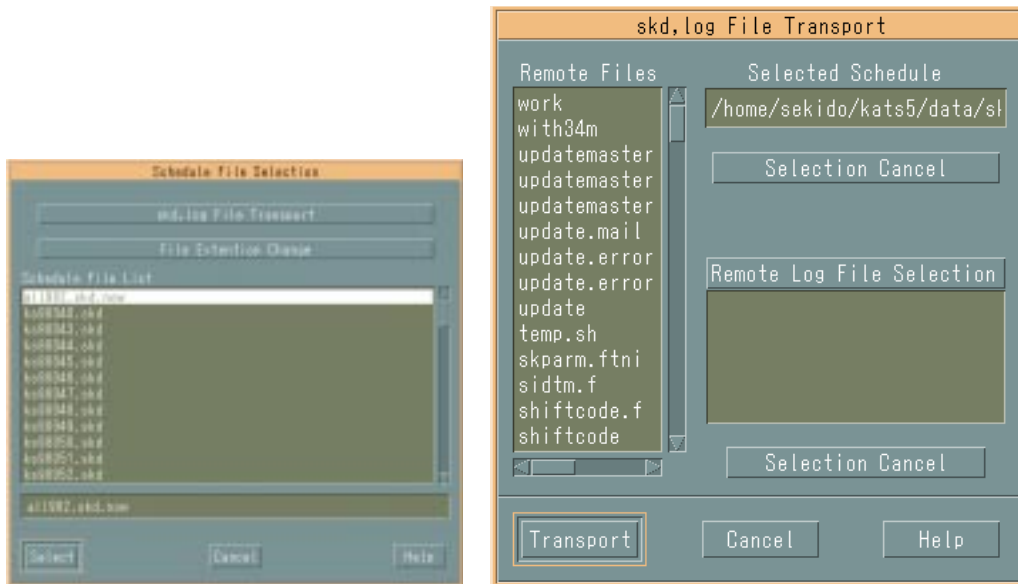
Figure 3: Example of schedule file selection window (left) and file transport operation window (right). Japanese characters in the windows are translated into English.
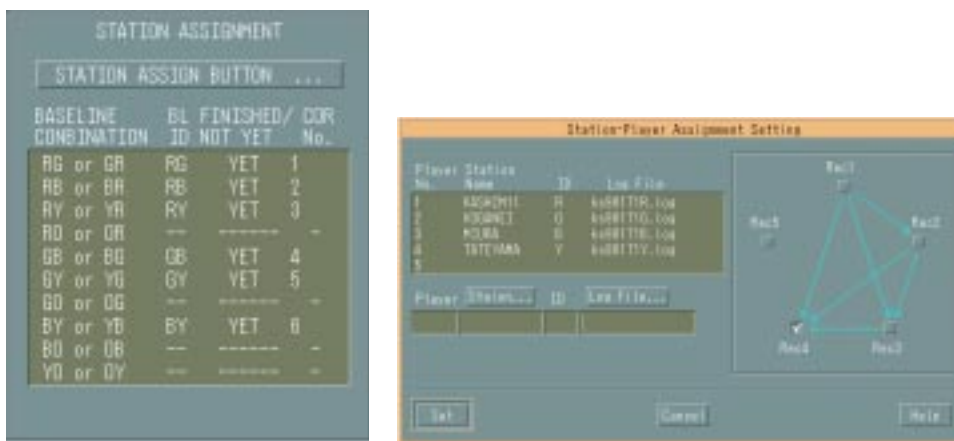
Figure 4: Example of Station assignment window. Japanese characters in the window are translated into English.
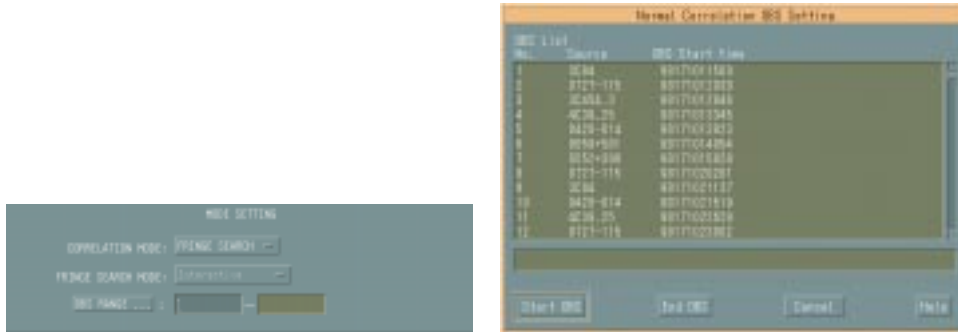
Figure 5: Observation range setting windows. Columns to set range of observation numbers (left) and observation number selection window (right). Japanese characters in the windows are translated into English.
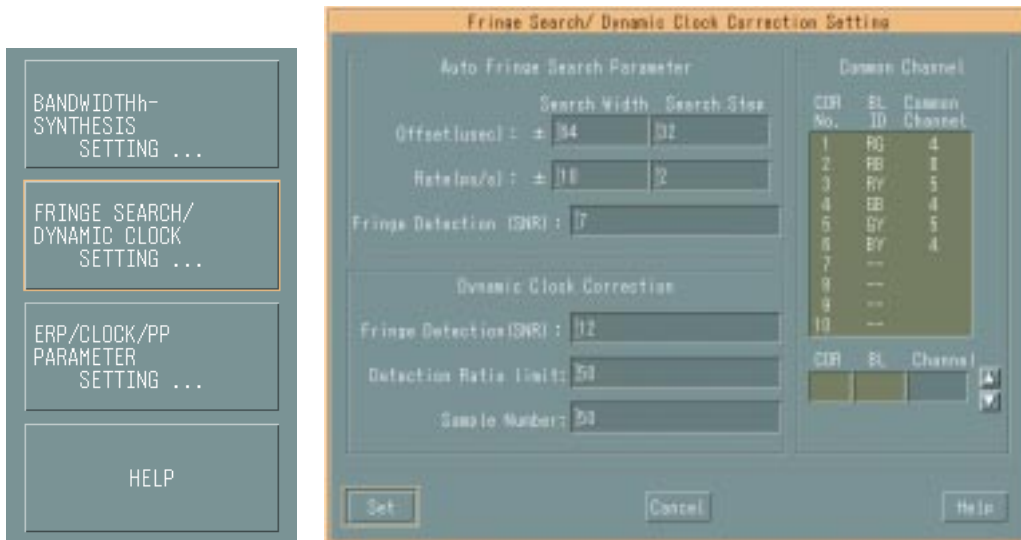
Figure 6: Fringe search setting button (left) and common channel setting window (right). Japanese characters in the windows are translated into English.
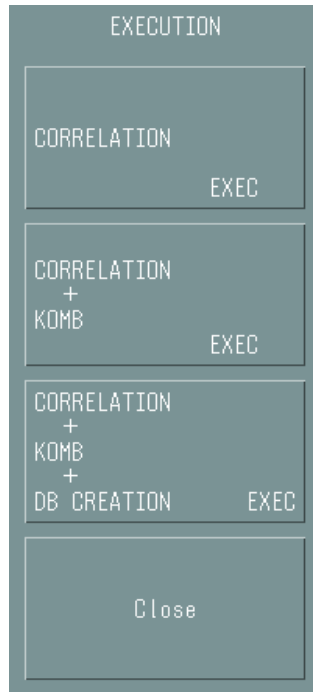
Figure 7: Execution selection buttons.
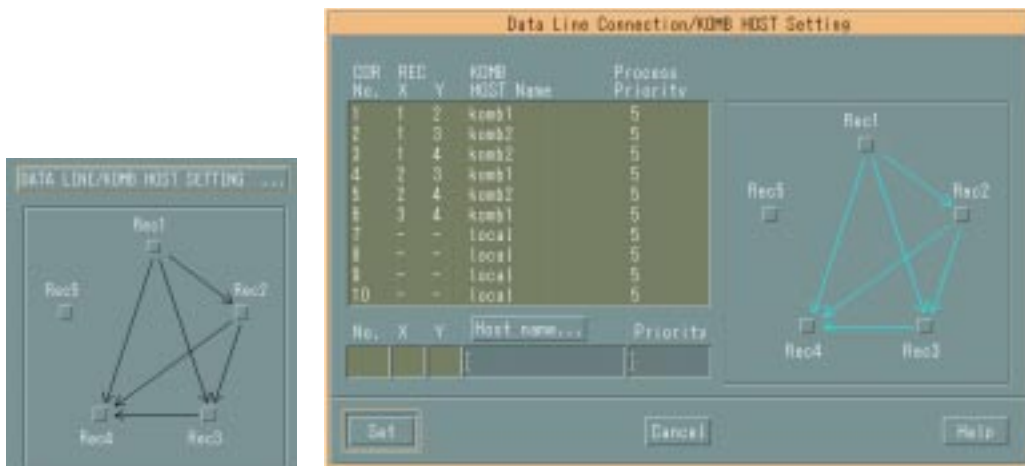
Figure 8: Data Line Connection/KOMB HOST Setting window
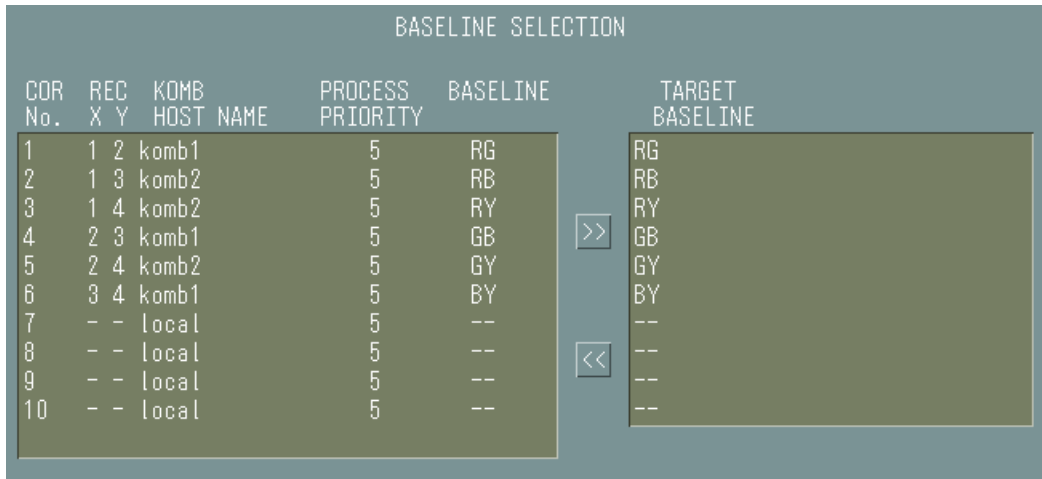
Figure 9: Baseline selection window
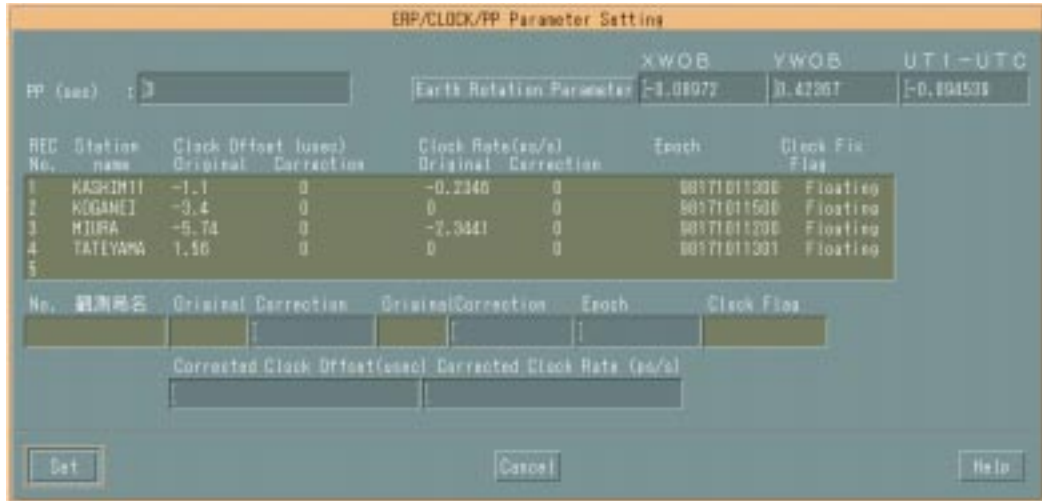
Figure 10: Example of ERP/CLOCK/PP Parameter Setting window. Japanese characters in the windows are translated into English.

$HOME/

bin/ **data/**

skd/ **log/** **data/** **prc/** **temp/**

kats kats_make_db * *

ks98044.skd ks98045.skd * * *

ks98044R.log ks98044G.log ks98044B.log ks98044Y.log * * *

CTL_INF OBS_INF COR_INF COR_BASE COR_MSG CRSS_PAR REC_COR DB_INF ERP_INF KHSC_ADR KOMB_SET KROSS_NM REC_STAT RHOST_INF SRCH_INF

prcKS98044 prcKS98045 * * *
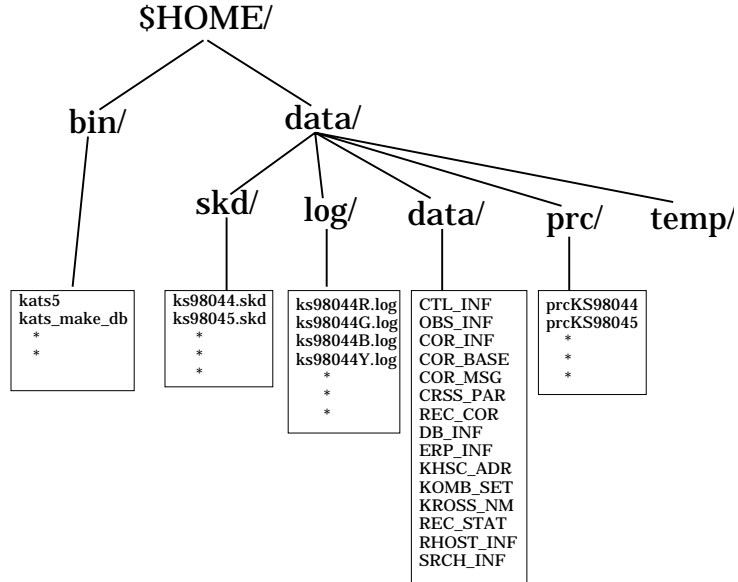
Figure 11: KATS home directory structure.

/komb1/ .... **/komb2//washi/**

vibdata1/ vlbidata2/ vlbidata3/... **vlbidata6/**

kross/ **komb/** **kross/ komb/**

KS98272/.... **KS98272/....** ... .

KS98171/ **KS98171/**

K12345 K12346 K12347	456 457 458 ......

B12345 B12346 B12347	456 457 458 ......

Figure 12: Output data directory structure.

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```
dddhhmmss/LABEL/KSR1201A
dddhhmmss/TD/ 1.0
dddhhmmss/WX/ 27.4, 1002.3, 84.3
dddhhmmss/CABLE/0.1
dddhhmmss/ST/12345
```

Figure 13: Example of log file. ddd: day of the year, hh: hour, mm: minutes, ss: seconds in UT.

```
# Correlator Controler initialize files
$INI_FILES
#
# Files     Full Path
  AD_FILE   /usr/local/kats/data/data/KHSC_ADR
  MS_FILE   /usr/local/kats/data/data/COR_MSG

# Correlator Controler Files
$FILES
#
# Files       Full Path
  KRS_DIR   /komb1/vlbidata1/kross/KS98216R
  AD_FILE   /usr/local/kats/data/data/KHSC_ADR
  RC_FILE   /usr/local/kats/data/data/REC_COR
  CB_FILE   /usr/local/kats/data/data/COR_BASE
  RS_FILE   /usr/local/kats/data/data/REC_STAT
  CI_FILE   /usr/local/kats/data/data/COR_INF
  KN_FILE   /usr/local/kats/data/data/KROSS_NM
  MS_FILE   /usr/local/kats/data/data/COR_MSG
  KRSS_IP   172.17.1.183
```

CTL_INF file

KRS_DIR: Correlation output dir
AD_FILE: GP-IB addresses of devices
RC_FILE: Recorder-Correlator connection
CB_FILE: Correlator-Baseline assignment
RS_FILE: Recorder-Station assignment
CI_FILE: Information for correlation
KN_FILE: Correlation output file names
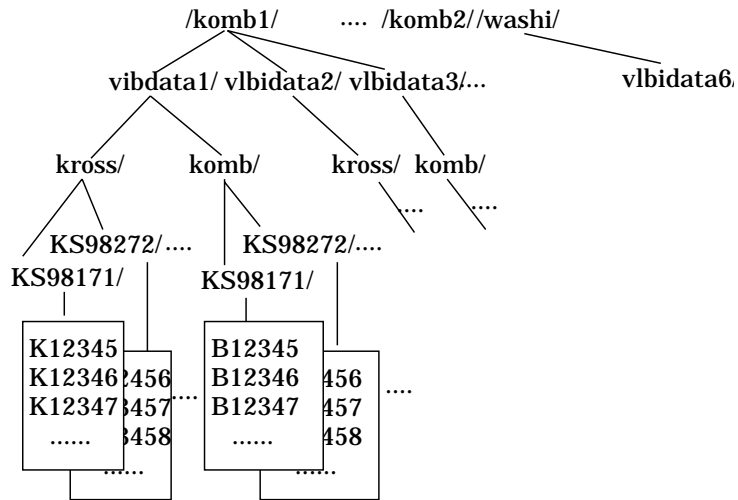MS_FILE: Error or warning messages from
         correlator
KRSS_IP : IP address for PC-NFS server

```
# KROSS name file
$KROSS_FNM
#
# Baseline   KROSS NAME
  RG       K30354
  RB       K30355
  RY       K30356
  GB       K30357
  GY       K30358
  BY       K30359
```

KRSS_NM

```
# Correlator.baseline/assignment
$COR?BASELINE
#
# Correlator Baseline Process Flag
   1         RG        1
   2         RB        1
   3         RY        1
   4         GB        1
   5         GY        1
   6         BY        1
   7         --        0
   8         --        0
   9         --        0
  10         --        0
```

COR_BASE

```
#Corelator-Recorder connection information
$COR_REC
#
# Correlator X-Recorder Y-Recorder
   1          1          2
   2          1          3
   3          1          4
   4          2          3
   5          2          4
   6          3          4
   7          -          -
   8          -          -
   9          -          -
  10          -          -
```

REC_COR file

```
#KROSS.KOMB file information
$FILEINFO   RG       RB       RY     RO    ......
#
# OBS number File name
   1        K12345  K12346  K2347  K12348 .....
   1        B12345  B12346  B2347  B12348 .....
   2        K12355  K12356  K2357  K12358 .....
   2        B12355  B12356  B2357  B12358 .....
   3        K12365  K12366  K2367  K12368 .....
   3        B12365  B12366  B2367  B12368 .....
```

PRC file

```
# Experiment name
$EXP  KS98171 /usr/local/kats/data/skd/ks98171.skd

#Correlation mode
$MODE  N

# Paramenter period
$PP   3

#OBS range
$SE_OBS
#
# Start OBS   Stop OBS
   1             247

# Earth Rotation Parameter
$ERP
#
#XWOB    YWOB     UT1-UTC
 -0.08972 0.42367  -0.094539

# Clock Parameter
$CLK_PAR
#
# Station Name Offset Adjust Rate     Adjust Epoch         Clock Flag
  KASHIM11    -1.1   0      -0.2346  0      98171012300    M
  KOGANEI     -3.4   0       0       0      98171011500    0
  MIURA       -5.7   0      -2.3441  0      98171011200    0
  TATEYAMA    1.56   0       0       0      98171011301    0
```

CRSS_PAR file

```
# Experiment name
$EXP  KS98171

# DB Execution flag
$EXEFLAG_DB  0

# KOMB file directory
$KOMB_DIR  /komb1/vlbidata3/komb/KS98171

# DB History file
$HIST_DB   xxx.his

# DB Station Info
$STATION_DB  4
#
# Station name    Log file
  KASHIM11     ks98171R.log
  KOGANEI      ks98171G.log
  MIURA        ks98171B.log
  TATEYAMA     ks98171Y.log
```

DB_INF file

Figure 14: -1 Example of internal files.

```
# Experiment name
$EXP  KS98171  /usr/local/kats/data/skd/ks98171.skd

#Observation Information
$OBSINFO                                        R          G          B          Y
#
#OBS Number  Source name  Start time   Stop time      Tape label/ID
  1           3C84         98171011500 98171011630  KSR1201A   KSG0101A   KSB1201A   KSY1201A
                                                       223        218        224        252
  2          0727-115      98171012030 98171013510  KSR1201A   KSG0101A   KSB1201A   KSY1201A
                                                      5146       5144       5142       5174
  3          3C454.3       98171012848 98171013018  KSR1201A   KSG0101A   KSB1201A   KSY1201A
                                                      20483      20486      20482      20259
```

OBS_INF

```
51386  -0.01410  0.28600  0.351630  32.0  51179  0  1.20  3.02  IERS-EOP97C04
51387  -0.01460  0.28630  0.351080  32.0  51179  0  1.15  1.59  IERS-EOP97C04
51388  -0.01560  0.28660  0.350380  32.0  51179  0  0.98  1.69  IERS-EOP97C04
51389  -0.01610  0.28690  0.349490  32.0  51179  0  1.39  1.94  IERS-EOP97C04
51390  -0.01660  0.28720  0.348400  32.0  51179  0  1.62  2.36  IERS-EOP97C04
51391  -0.01710  0.28760  0.347130  32.0  51179  0  1.91  2.70  IERS-EOP97C04
51392  -0.01760  0.28790  0.345720  32.0  51179  0  2.13  3.04  IERS-EOP97C04
51393  -0.01810  0.28830  0.344240  32.0  51179  0  2.10  3.45  IERS-EOP97C04
```

ERP_INF file

```
#DMS-24 Address
$TAP_CHNG
#
#CHNG  ADR  ID
  1     13   A
  2     14   B
  3     15   C
  4      2   D

#Recorder Address
$REC
#
#REC  ADR  ID
  1    9    A1
  2    10   B1
  3    11   C1
  4    12   D1

#Correlator Address
$COR
#
#COR  ADR
  1    3
  2    4
  3    5
  4    6
  5    7
  6    8

#RCI
$RCI  4
```

KHSC_ADR file

```
# Station Order
$ORDER
#
# Station Name
 KASHIM11
 KOGANEI
 MIURA
 TATEYAMA

# Source Name
$SOURCE
 3C84
 3C273B
 4C39.25
 3C454,3

# Common Channel
$CMMN_CH
#
# Baseline  Channel
 RG      4
 RB      6
 RY      5
 GB      4
 GY      5
 BY      4

# Clock Search
$CLK_SCH
#
# Offset  search width  Rate width  Offset steps  Rate steps
   64                    10           32            2

# Fringe detection level
$JDG_LVL
#
# SNR threshold
   7
```

SRCH_INF file

```
komb1
komb2
washi
eve
....
```

KOMB_HOST file

```
# Recorder.Station/assignment
$REC_STATION
#
# Recorder    Station name  Logfile name
  1           KASHIM11      ks98171R.log   R
  2           KOGANEI       ks98171G.log   G
  3           MIURA         ks98171B.log   B
  4           TATEYAMA      ks98171Y.log   Y
  5           -             -
```

REC_STAT

```
#OBS  Source   Start time PRT time, Stop time
  1   3C84
          R  98171011500  981711545 98171101630
          G  98171011500  981711545 98171101630
          B  98171011500  981711545 98171101630
          Y  98171011500  981711545 98171101630
          O  98171011500  981711545 98171101630
  2   0727-115
          R  98171012030  981712250 98171102510
          G  98171012030  981712250 98171102510
          B  98171012030  981712250 98171102510
          Y  98171012030  981712250 98171102510
  3   3C454.3
          R  98171012448  981712933 98171103018
          G  98171012448  981712933 98171103018
          B  98171012448  981712933 98171103018
          Y  98171012448  981712933 98171103018
```

OBS_DUR file

Figure 14: -2 Example of internal files continued.

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```
#Experiment name
$EXP      KS98171      /usr/local/kats/data/skd/ks98171.skd

#Station Position
$STATION_POS
#
# Station name   X             Y             Z            Statiaon ID
   KASHIM11      -3997505.70170 3276878.40455 3724240.70314 R
   KOGANEI       -3941937.47909 3368150.90799 3702235.28815 G
   MIURA         -3976130.02585 3377927.89696 3656753.83841 B
   TATEYAMA      -4000983.68000 3375276.15000 3632213.38000 Y

#Source Position
$SOURCE_POS
#
# Source name  Ra(h)  Ra(m)  Ra(s)      Dec(deg) Dec(m)  Dec(s)
   0059+581     01     02     45.762413  +58      24      11.13656
   3C84         03     19     48.160104  +41      30      42.10288
   0420-014     04     23     15.800729  -01      20      33.06462

# Frequency Table
$FRQTAB
#
# C Code Subgp Freq Pcal VC Mode Bandwidth Pass(track1, track2)...
F LSP-SX  KS
C KS X 7714.99 1000.0  1 C 8.000 1(15) 2(16)
C KS X 7724.99 1000.0  2 C 8.000 1(1) 2(2)
C KS X 7754.99 1000.0  3 C 8.000 1(17) 2(18)
C KS X 7814.99 1000.0  4 C 8.000 1(3) 2(4)
C KS X 8034.99 1000.0  5 C 8.000 1(19) 2(20)
C KS H 8234.99 1000.0  6 C 8.000 1(5) 2(6)
C KS H 8414.99 1000.0  7 C 8.000 1(21) 2(22)
C KS H 8524.99 1000.0  8 C 8.000 1(7) 2(8)
C KS H 8564.99 1000.0  9 C 8.000 1(23) 2(24)
C KS H 8584.99 1000.0 10 C 8.000 1(9) 2(10)
C KS S  2154.99 1000.0 11 C 8.000 1(25) 2(26)
C KS S  2164.99 1000.0 12 C 8.000 1(11) 2(12)
C KS S  2234.99 1000.0 13 C 8.000 1(27) 2(28)
C KS S  2294.99 1000.0 14 C 8.000 1(13) 2(14)
C KS S  2384.99 1000.0 15 C 8.000 1(29) 2(30)
C KS S  2414.99 1000.0 16 C 8.000 1(15) 2(16)

# Earth Rotation Parameter
$ERP
#
# XWOB    YWOB   UT1-UTC
 0.02788  0.08708 -0.082901

# Parameter Period
$PP   3

# Correlation Mode
$MODE   N

# Clock parameter
$CLK_PAR
#
# Station name Offset   Adjust  Rate Adjust  Epoch       Clock Flag
   KASHIM11    -1.1E-6  0       0            98171011300 M
   KOGANEI     -3.4E-6  0       0            98171011500 0
   MIURA       -5.7E-6  0       0            98171011200 0
   TATEYAMA    1.56E-6  0       0            981710111301 0

# Common Channel
 $CMMN_CH
#
# Baseline  Channel
  RG        4
  RB        6
  RY        5
  GB        4
  GY        5
  BY        4                                26

#Observation Information
$OBSINFO                                        R       G       B       Y
#
# OBS Number  Source name  Start time  Stop time  Tape label/ID
  126         1929+226     98171025145 98171025745 KSR1201A KSG0101A KSB1201A KSY1201A
                                                   159573   159642   159690   159730
```

COR_INF file

Figure 14: -3 Example of internal files continued.

```
$KOMB_HOST        komb1

#Process nicce value
$NICE         0

# KOMB simultaneous flag
$SIMUL    Y

# Frequency band
$BAND     S/X
```

```
"Mamoru Sekido" <sekido@crl.go.jp>
"kats"  <kats@eve>
```

KOMB_SET file   **MAIL_ADR file**

Figure 14: -4 Example of internal files continued.