K-3 VLBI SYSTEM (II) SOFTWARE

Tetsuro KONDO, Fujinobu TAKAHASHI, Taizoh YOSHINO,
Kunimasa KOIKE, Hiroh KUNIMORI, Yukio TAKAHASHI,
Akihiro KANEKO and Kosuke HEKI

Kashima Space Communication Center, Radio Research Laboratories
893-1 Hirai, Kashima, Ibaraki 314, Japan

1. Introduction

Radio Research Laboratories (RRL) has been developing the K-3 software system since 1979 for VLBI experiments, and it has been in operation because the first Japan-US joint experiment was successfully carried out in January, 1984.

The developement has been performed with the policies as follows (Takahashi et al., 1982):

(1) keep consistency of comprehensive data processing and analysis software,

(2) realize the compatibility between K-3 and Mark-III VLBI system, and

(3) exhibit the originality, such as a priori models, of the VLBI analysis in the Japanese group.

2. Overview of K-3 software

One of the distinguished features of K-3 VLBI software is that all software including the process from data acquisition to data analysis are operated in the same place (Kashima), while Mark-III's software are operated in the different places, for example data reduction is carried out at Haystack and data analysis is done at GSFC. We can then treat the data consistently throughout the data reduction and analysis by using the unified data base in a computer.

Figure 1 shows the overview of K-3 software system. As shown in this figure, all the software except for KAOS are directly linked to the K-3 data base (KASTL). K-3 software system has eight sets of software whose initial letters are all "K".

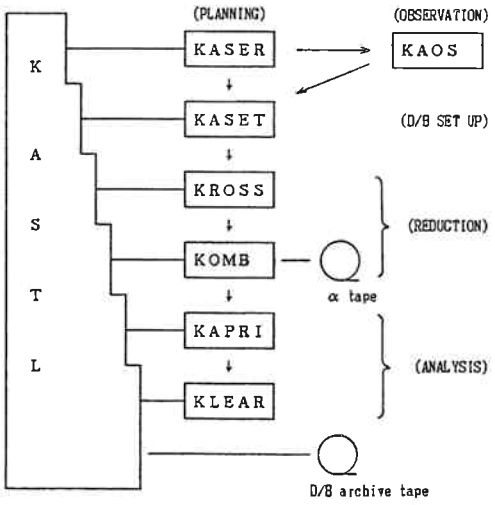

Fig.1 Overview of K-3 software

Control of each software is performed by interactive operator

commands or by a procedure file in which operator commands are stored.

3. Scheduling software "KASER"

Scheduling software KASER creates a VLBI observation plan. All information (e.g. star position, site position, frequency, etc.) required for making a schedule are provided from K-3 data base. Created schedule file possesses the full compatibility with the Mark-III's schedule file. We are then able to use the schedule file not only on the K-3 system but also on the Mark-III system without any problems.

4. Automatic operation software "KAOS"

According to the schedule file created by KASER, each observation is performed automatically by KAOS. KAOS controls the all K-3 hardware using the only IEEE-488 bus (GP-IB) interface. For any trouble, it is easy to check each hardware by a desk-top computer.

After the all observations, KAOS creates a log file including various calibration data in an experiment, for example weather data, water vapor radiometer data and cable counter data. This log file is needed for the following KASET software.

5. Data base setting-up software "KASET"

KASET sets up the K-3 data base. Before the data reduction, the data base relating to the experiment must be set up by KASET. Setting up items are as follows:

(1) observation information and calibration data extracted from the original schedule file and KAOS's log (including Mark-III's log),

(2) UT1 and polar motion table from International Latitude Observatory of Mizusawa (ILOM) or BIH, and

(3) planetary ephemeris of Jet Propulsion Laboratory (JPL).

These are necessary for the correlation processing and for the data analysis.

6. Correlation processing software "KROSS"

Before starting the correlation processing, KROSS calculates the a priori parameters of delay, delay rate, delay acceleration and delay rate acceleration using the data getting from the K-3 data base, which are neccesary to cross-correlate two tapes. After a priori parameter calculation, by using the IEEE-488 buses and their DMA function, KROSS controls two recorders to achieve the synchronization between two tapes and gets cross-correlated data from the K-3 correlator.

We can not process multi-baseline data simultaneously now, but we are planning to enhance the capability of correlation

processing to process at least three baselines simultaneously.

7. Bandwidth synthesizing software "KOMB"

KOMB searches and finds the observed values (e.g. delay, delay rate, fringe amplitude, etc.) using raw correlator output data obtained by KROSS. The processing of KOMB is divided into two steps. At the first step, KOMB searches for the maximum correlation amplitude (fringe-search), and finds a coarse delay residual with the time resolution of about 10 nsec. After fringe-search processing, the bandwidth synthesis technique is used to find the fine delay residual with the time resolution of better than 0.1nsec.

After KOMB processing, an archive tape called "ALPHA tape" is created, in which all raw correlator output data and obtained observables (such as delay, delay rate, fringe amplitude and so on) are included.

8. A priori model software "KAPRI"

KAPRI calculates the a priori values of delay, delay rate and their partial derivatives. These values are used in the following software KLEAR in order to estimate the station positions, polar motion and so on, by using the least squares estimation method. Since VLBI has capability to measure baseline vectors accurately, it is necessary to calculate the a priori values with the precision of better than 0.1nsec for delay and 0.1ps/sec for delay rate. All astronomical and geophysical models to attain the required precision are used in KAPRI. Besides the physical models used in the Mark-III software, we adopt the unified physical models of earth orientation parameters, the ocean loading effect and earth tide proposed by ILOM. Furthermore, J2000.0 system and VLBI coordinate system are used in KAPRI.

9. Least squares estimation software "KLEAR"

KLEAR is located at the last stage in the K-3 softwares. The observed residual delay and delay rate with respect to KAPRI's a priori values are analyzed by KLEAR, and finally we can get the baseline vector. The least squares estimation method is used for this analysis. Before the estimation, bad data caused by failure in bandwidth synthesis are rejected according to quality code labeled by KOMB. Ambiguity included in observed delay, which was caused by bandwidth synthesis processing, is also rejected. After these data rejection process, the weighted least square estimation is carried out by solving the normal equations. Estimating parameters, for example station positions, clock parameters and polar motions, can be selected arbitrarily by an operator according to the purposes of analysis. The estimation progresses iteratively until systematic errors disappear in the residuals.

10. Data base system "KASTL"

We use the general purpose data base H.P. IMAGE/1000 as the nucleus of our data base system named KASTL. Moreover, some utility software are added, whose functions are displaying the state of processing, deleting the data set and making the interface between application software and data base, respectively. One of features of KASTL is that the data are classified according to its characteristics. Furthermore, it takes little time for sorting the data along the observation order. KASTL can create an archive tape of data base compatible with a Mark-III's data base tape. KASTL can also read the Mark-III's archive tape into the K-3 data base.

11. Conclusion

We have mentioned the outline of all K-3 softwares. We can conclude it as follows:

(1) from planning phase to data analysis phase, the common data base is used,

(2) compatibility between K-3 and Mark-III is realized at three stages; i.e. observation schedule file, log file and data base archive tape and

(3) we attained the adoption of some original works of Japanese VLBI group, such as a priori models used in KAPRI.

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Reference

Takahashi, F., Yoshino, T., Murakami, H., Koike, K., Kunimori, H. and Kondo, T.; "K-3 VLBI software development for international experiments", NOAA Tech. Report Nos.95 NGS 24, pp.177-183,1982.