AT 39.2/024

ATCA reconfiguration calibration and implications for new configurations and stations

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Contents

1 Introduction

The Australia Telescope Compact Array (ATCA)[2] consists of 6 × 22 m antennas located on two sections of railway track. One track stretches for 3000 m and has 35 stations placed along it, the other is 61 m in length with one station at each end.

Operating in an aperture synthesis mode, the ATCA can provide increased $u - v$ coverage by the relocation of the antennas along the railway tracks (*reconfiguration*) and repeating an observation. The antennas are self-propelled and an efficient reconfiguration plan allows the completion of all antenna moving in a few hours.

The price that is paid for this flexibility is the need to recalibrate aspects of the ATCA before observations can recommence. This document outlines the procedures necessary to complete the ATCA calibration after a reconfiguration. It concludes with a discussion of the ramifications of new array configurations and the proposed new stations on these calibration procedures.

2 Current station configurations

The ATCA stations are arranged as follows: there are 35 on the 3km track and 2 on the 61m track. The stations are numbered sequentially from east to west, starting at 1. They are named according to their number, CS01, CS02, ... CS37. When placed, the stations were set to integer multiples of an approximately 15.3 m increment; over the 6km, there are exactly 392 of these increments. The station locations are tabulated in Table 1.

Station	Increment	Distance	Station	Increment	Distance
CS01	0	0.000	CS20	112	1714.286
CS02	2	30.612	CS21	113	1729.592
CS03	4	61.224	CS22	128	1959.184
CS04	6	91.837	CS23	129	1974.190
CS05	8	122.449	CS24	140	2142.857
CS06	10	153.061	CS25	147	2250.000
CS07	12	183.673	CS26	148	2265.306
CS08	14	214.286	CS27	163	2494.898
CS09	16	244.898	CS28	168	2571.429
CS10	32	489.796	CS29	172	2632.653
CS11	45	688.776	CS30	173	2647.959
CS12	64	979.592	CS31	182	2785.714
CS13	84	1285.714	CS32	189	2892.857
CS14	98	1500.000	CS33	190	2908.163
CS15	100	1530.612	CS34	195	2981.694
CS16	102	1561.224	CS35	196	3000.000
CS17	109	1668.367			
CS18	110	1683.673	CS36	388	5938.776
CS19	111	1698.980	CS37	392	6000.000

Table 1: ATCA station locations. The *increment* is a multiple of $\frac{6000m}{392}$ (≈ 15.3 m). The *distance* is the distance in metres from the eastern-most station, CS01. Note that CS36 and CS37 are on the 61 m track; the others are all on the 3 km track.

At present, the following array configurations are offered to astronomers. In general, the ATCA spends about 3 weeks on each configuration, although this depends on the demand for any given antenna arrangement [8, 9].

The "standard" configurations are those which are routinely offered to astronomers, outlined in Table 2.

Config	Station numbers					
6A	3	11	16	30	34	37
6B	2	12	25	31	35	37
6C	1	6	21	24	31	37
6D	5	10	13	28	30	37
1.5A	15	18	25	28	35	37
1.5B	19	21	27	31	34	37
1.5C	14	22	30	33	34	37
1.5D	16	17	24	31	35	37
750A	25	27	29	33	34	37
750B	14	17	21	24	26	37
750C	12	13	15	18	21	37
750D	15	16	22	24	25	37
375	2	6	8	9	10	37
122B	5	6	7	8	9	37
244	1	3	5	7	9	37
210	14	15	16	17	20	37
122A	1	2	3	4	5	37

Table 2: ATCA standard configuration names and the station numbers for antennas 1 to 6 respectively. The configurations 6A, 6B etc. are sometimes referred to as 3A, 3B, etc.. The 244, 210 and 122A are examples of "special" configurations that have been/will be scheduled.

These can be represented graphically in terms of both the station layout, and the resultant baselines that they define. These are shown in Figures 1 and 2.

On request to the Time Allocation Committee, it is possible to have other configurations scheduled. A recent example is the scheduling of the 244 array (stations 1,3,5,7,9,37) and the forthcoming 210 array (discussed later).

3 Recalibration procedure

3.1 Reconfiguring the software

The following operations must be completed:

- Create an `AT$ANTENNA:CONNECTION.FILE`, which is used by CAOBS to fill the global common with the station numbers. The format is given in Appendix A. The creation of this file is done using STATION_SETUP[1]
- Reset all the delays. This is done using the program CAOBS_PARAM[2].
- Reset the pointing parameters [3]. This is done by running the program PPLOAD, to reset the "default" values, but then CAIN must be run in order to download them into the ACCs.

[1] At the time of writing only an executable of this program seems to be in existance.

[2] CAOBS_PARAM is old code that should be retired. It's functionality should be transferred to CACAL

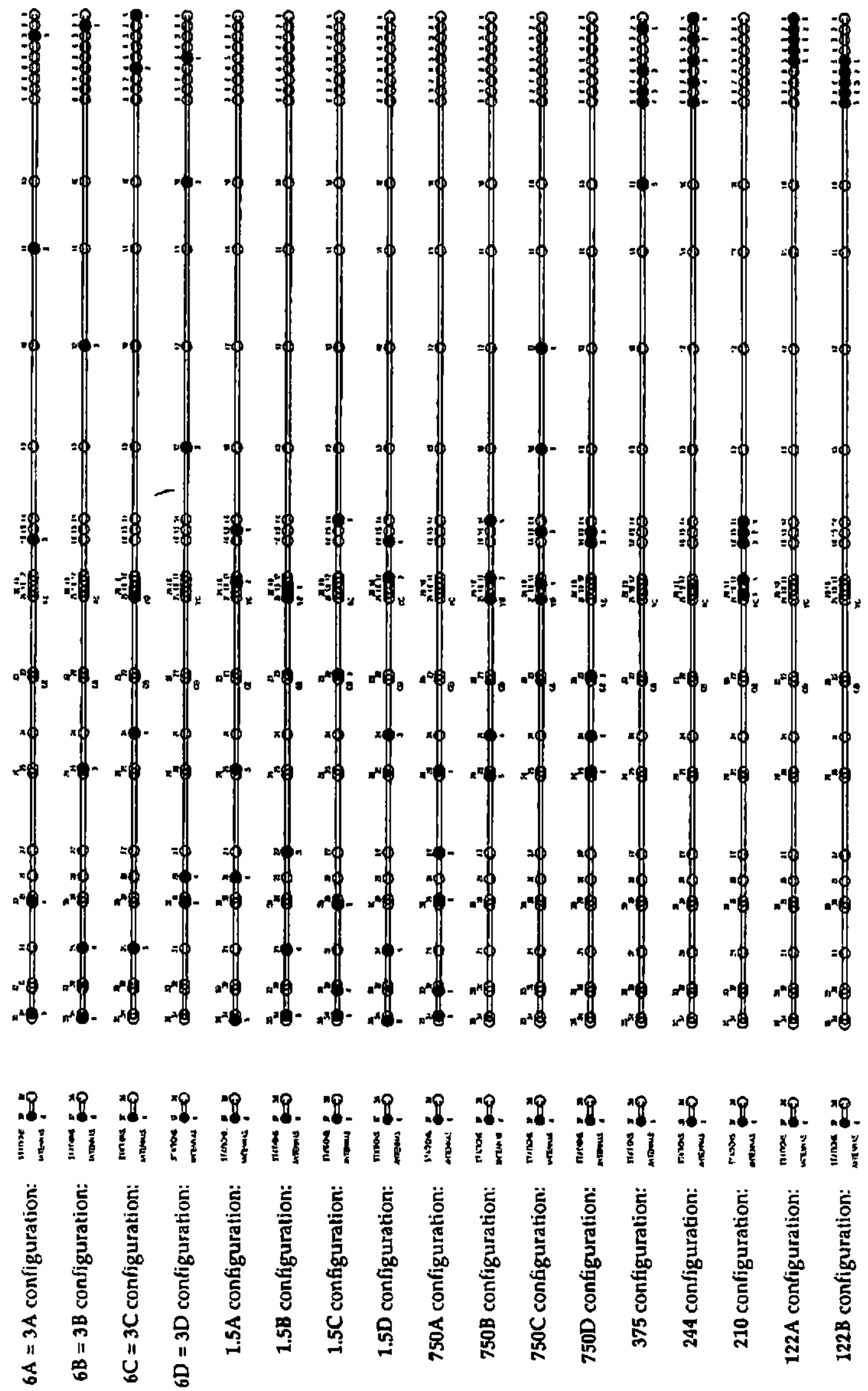

Figure 1: Stations for ATCA configurations.

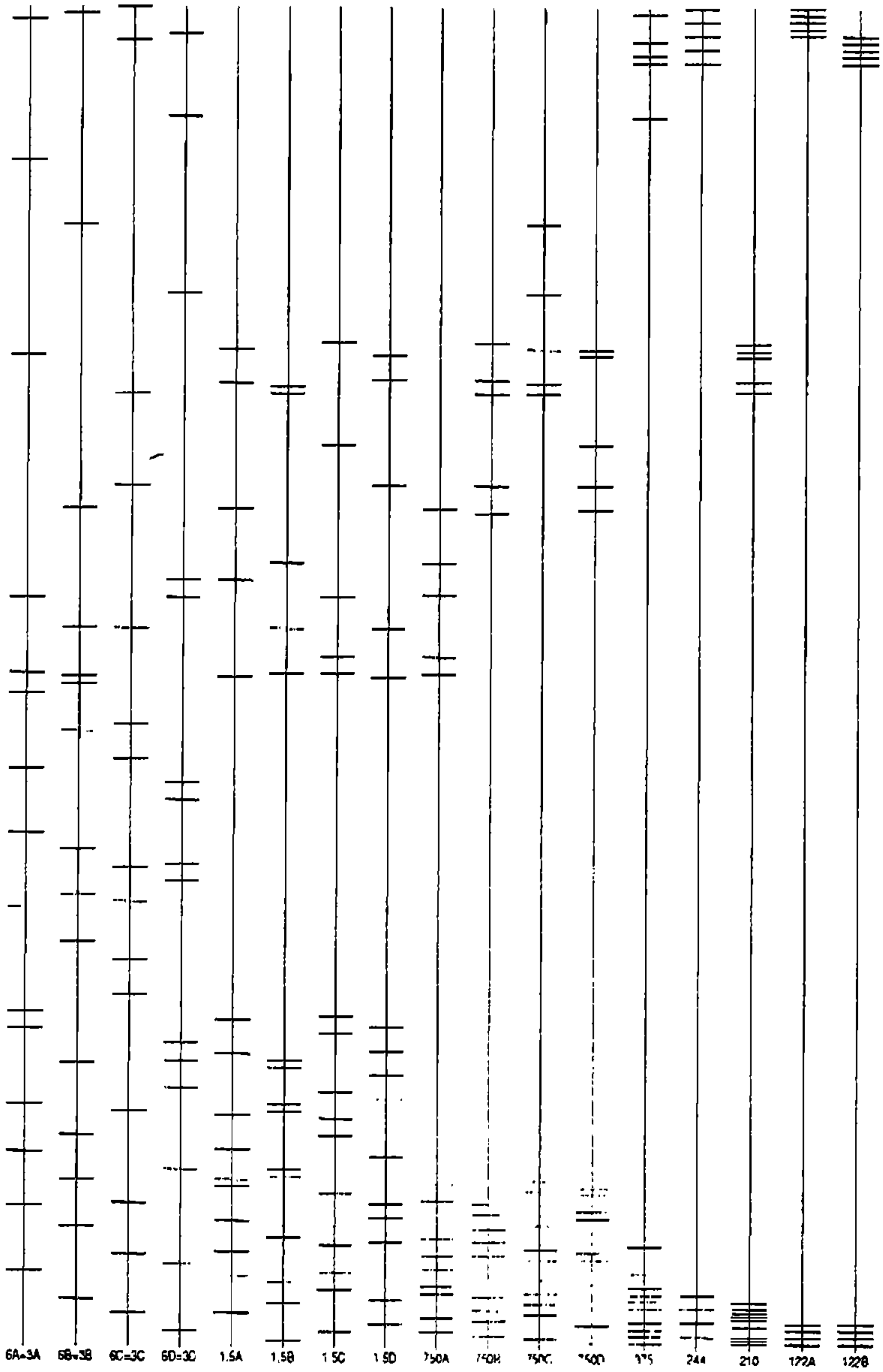

Figure 2: Baseline lengths resulting from ATCA configurations.

PPLOAD derives its values from a set of files: AT$ANTENNA:CAO#_POINTING.DAT, which contains one line for each station that the antenna has been to before. These lines will have unique AX and AY parameters, but the others will be the same for every station. The file format is given in Appendix B.

- Reset the baseline errors — done by prepending a zeroed solution to the file AT$ANTENNA:STATION.ERRORS. Only antennas which have moved need to be reset. The reset is done by STN_ERR_UPD[3]. The file format is given in Appendix C.
- Close and transfer the file AT$LOG:OBSERVATION.FILE. This file contains a scan history as recorded by CAOBS. It is used in the maintenance of the AT Observations Archive. The file is copied to a file named according to the starting date of the data (e.g. OBS930913.RAW) and is then compressed using the SUMMARY3 program to create a compressed file (e.g. OBS930913.CMPRSS which is e-mailed to the ATNF facility at Marsfield.
- The remaining item is the prepending of the reconfiguration data to the configuration history, AT$LOG:CONFIG_HIST.LOG, which is used by some ATCA programs for the determination of the the date of previous reconfigurations or station locations, etc.. This file is written by the RECONFIG command procedure (which, incidentally, runs the above programs as well). The format is given in Appendix D.

In addition to these changes, the local oscillator monitoring program (LOMON) needs to be restarted, the integration clocks need to be reset (using CAIN) and checks made to ensure that communications to the ACCs are working satisfactorily. CAOBS also requires to be either restarted or initialised, in order to pick up the new data that has been implemented by the above operations.

3.2 Early/normal calibration

The early/normal signals refer to the synchronisation of the integration clocks. More or less quoted from the JEEEA Vol 12, No.2. (Journal of Electrical and Electronics Engineering, Australia) June, 1992 [2], the purpose of the Integration Clock is to produce a signal which defines the start of each integration to an accuracy of a fraction of a sample period. This enables the array control computer (NOEL) to specify precisely the first sample of each integration. The major difficulty with this process arises from the fact that the phase of the sampler clock is continually being rotated. It follows that, with any fixed integration period, inevitably the situation will occur where the start time is close to a 128 MHz sample time. Then the finite delays in the synchronization latching circuit will give rise to an uncertainty in the choice of the first sample of the integration. The circuit may choose the correct sample, as specified by the array control computer, or it may choose a neighbouring sample, approximately 8 ns earlier or later. If the error is made, then this timing error will show up directly in any correlation function involving this input.

As the array control computer can calculate the time difference between the nominal start time and the first sample time in each integration, it can also predict when an error of the type described above is likely to occur. When this is the case, the array control computer sends a request to the integration clock to produce a start signal which is 1 ns earlier than the nominal start time, hence avoiding the region of uncertainty. The chances of error are further reduced by using this early signal whenever the first sample time is within 2 ns of the nominal start time and the normal start signal at other times.

In practice, the normal start signal will not coincide with the nominal start time, but will be offset by some initially unknown value. If the array control computer is to choose correctly between the early and the normal start signals, any such offset must first be calibrated. This is done by observing the sampler phase at which the 8 ns delay error occurs in a correlation function involving the input being calibrated.

[3] Again, an executable with no source code

The calibration of the early/normal discrepancy is done using the EARLY program [7].

3.3 Delay calibration

Delay calibration is done using the CACAL program. CACAL can calibrate the delay, phase and gain of the antennas. Only the delay calibration is essential: bad delays cause decorrelation across the passband, resulting in reduced signal-to-noise [12].

The delays determined at this point are added to the transmission times and geometric delay (calculated from the `TRANSMISSION.TIMES` and `STATION.COORDINATES` files (which are located in `AT$ANTENNA:`). The format of the `STATION.COORDINATES` file is given in Appendix F).

3.4 Modelling the antenna pointing

The bulk pointing error from reconfiguring antennas comes from the slight rotation of the antenna about the vertical axis. The first pointing calibration that is performed is referred to as the "rough pointing" solution and is done by executing a single pointing pattern on a strong calibrator. The pointing error is measured using CATAG and implemented into the pointing file, `AT$ANTENNA:CA0#_POINTING.DAT`, using the PPLOAD program [4]. The program CAIN is used to extract the newly created global solution and put that into the file `AT$ACC:PPARAMS.DAT` (see Appendix E) and load it into the ACCs.

Once the bulk correction is removed, the pointing model needs to be recalculated for antennas that have moved, and possibly updated for those that didn't. A global pointing solution, sometimes referred to as the "fine pointing" solution, is done by doing pointing patterns on a number of sources on the sky (typically 20) and then fitting them with an 11-parameter model (the POINT_PROCESS program does this). The errors are determined using CATAG, which runs during the observations. Source selection is done from the catalogue `AT$CAT:POINT.CAT`, and schedules can be made using the SRCPAC program [5]. Once calculated, the new pointing parameters are loaded into the system using CAIN and PPLOAD [4].

3.5 Solving for baseline errors

The errors in antenna position need to be calibrated as well. This procedure, called the "baseline" solution, measures the phase errors from a number (typically 30) of point sources on the sky. Sources can be found in the catalogue `AT$CAT:POINT.CAT` and, again, they can be scheduled using the SRCPAC program [5]. The calibration is performed using the CABSLN program which generates solutions which are written to files in the `AT$BASELINE` area [6].

The solution needs to be prepended to the `STATION.ERRORS` file (see Appendix C) and CAOBS reinitialised, for the corrections to take affect.

`CAOBS` makes use of the station errors in determining the antenna coordinates. These are later used for phase corrections.

4 Using new antenna-station combinations

The following must be taken into consideration for the use of stations not normally used in the "standard" arrays. To use a case study, on 18 December, 1996, the ATCA is scheduled to go to a new configuration, the 210 m. This configuration makes use of the following stations:

Based on past antenna location history, this will be a routine for Antennas CA01, CA03 and CA06.

Config	Station numbers					
210	14	15	16	17	20	37

Table 3: The 210 m configuration.

However, for CA02 and CA04 it will be the first time they are placed on those particular stations, and it will be the first time[4] that *any* antenna has been on station CS20.

Following the 210 m reconfiguration, the following stations will remain "unused": CS23, CS32 and CS36. The 210 m configuration will make the first use of CS20. Unused here, means that the pointing parameters for these stations are untried, the transmission times are uncertain and the station coordinates themselves may be in error. These are readily adjustable parameters, but are uncalibrated. Of more concern, in a sense, are the hardware considerations such as optical fibre connectivity and station post and connector condition.

5 Ramifications of the new stations

The station locations that were selected for the ATCA reflected a greatly different idea of how the Array would be used [11]. Since the commissioning of the ATCA, astronomers have suggested the benefits of additional stations to the current set. As part of the MNRF upgrade [10], it is proposed that extra antenna stations be provided in order to give configurations which will improve observing speed, sensitivity and fidelity for certain classes of astronomical objects [1].

The introduction of new stations, would emphasise the need for reference to antenna station by naming, e.g. CS13, rather than by index numbers in an array. It would also mean that increment systems would no longer be able to be used, as the new stations must lie within the 6 km array, but there are no "available" integer slots in arrays to take extra station numbers.

Such changes must be propagated through a number of on-line software areas. These include the documentation and archiving of the new station names, the new array configurations and any reconfiguration or observation database entries which take this information. It also will affect scheduling programs (e.g. SRCPAC), observing programs (e.g. CAOBS) and online data monitoring software (e.g. CAGET, VIS, CAMON, etc.).

6 Conclusion

The ATCA has successfully addressed the problem of rapid reconfiguration to make up for its deficiency in antenna numbers. The on-line software reconfiguration that accompanies these changes has been outlined here. The current array configurations and configuration calibration files have been documented. Finally, a brief assessment has been given of the ramifications of using previously unused stations and what may need to be considered from the software aspect, with respect to the addition of new stations under the MNRF upgrade.

[4] since at least early 1992 — well before any of these reconfiguration/pointing procedures were in place

A CONNECTION.FILE format

```
CA01    --> CS25
CA02    --> CS27
CA03    --> CS29
CA04    --> CS33
CA05    --> CS34
CA06    --> CS37


baselines

   244.9    373.7    658.2    734.7   3750.0
   128.8    413.3    489.8   3505.1
   284.5    361.0   3376.3
    76.5   3091.8
  3015.3


written 30-OCT-96
```

B CAO#_POINTING.FILE format

The first column is the antenna number. It will only be the antenna number appropriate to the file if the antenna has a history of being on that station. Otherwise, the number will be zero.

```
1   -8.0,    8.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
1   -9.0,    7.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
1  -13.0,    7.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
1  -13.0,   13.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
1   -6.0,    1.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
1   22.0,  -22.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
1   -6.0,   21.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
1    0.0,    4.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
1    3.0,   17.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
1   26.0,  -77.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
0    0.0,    0.0,   0.0,  378.0,  16.0,  -92.0,  -26.0,   0.0,   0.0,  106.0,   0.0,
```

```
0    0.0,    0.0,    0.0,  378.0,   16.0,  -92.0,  -26.0,    0.0,    0.0,  106.0,    0.0,
0    0.0,    0.0,    0.0,  378.0,   16.0,  -92.0,  -26.0,    0.0,    0.0,  106.0,    0.0,
0    0.0,    0.0,    0.0,  378.0,   16.0,  -92.0,  -26.0,    0.0,    0.0,  106.0,    0.0,
!A   ax      ay      ey      fx      fz      ea      ee      ca      ea    ce_dz      sc
!
! Global pointing data for CA01
```

C STATION.ERRORS format

The columns are: X-, Y- & Z-corrections, the rotation parameters and the antenna name. The seventh line contains the clock error and beyond that is ignored by CAOBS (which reads this file).

```
-0.0010 -0.0097 -0.0103  0.0000  0.0000  0.0000        CA01
-0.0109 -0.0067 -0.0072  0.0000  0.0000  0.0000        CA02
-0.0025 -0.0095 -0.0114  0.0000  0.0000  0.0000        CA03
-0.0034 -0.0121  0.0031  0.0000  0.0000  0.0000        CA04
-0.0047 -0.0128  0.0073  0.0000  0.0000  0.0000        CA05
 0.0040 -0.0090 -0.0100  0.0000  0.0000  0.0000        CA06
0.200                                            Clock error
        Solution by CABSLN      31-OCT-96  00:30:50

0.000   0.000   0.000   0.000   0.000   0.000   ca01
0.000   0.000   0.000   0.000   0.000   0.000   ca02
0.000   0.000   0.000   0.000   0.000   0.000   ca03
0.000   0.000   0.000   0.000   0.000   0.000   ca04
0.000   0.000   0.000   0.000   0.000   0.000   ca05
0.004  -0.009  -0.010   0.000   0.000   0.000   ca06
0.200                                           clock error
                      30-OCT-1996 07:33:19.33
```

etc.

D CONFIG_HIST.LOG format

This file contains the date, stations of antennas CA01 to CA06 and the array name (c.f. Table 2). The entire file (which dates from the October, 1992 to November, 1996) has been recorded here for posterity.

```
30-OCT-1996  25 27 29 33 34 37 750A
15-OCT-1996  15 18 25 28 35 37 1.5A
3-OCT-1996  3 11 16 30 34 37 6A
18-SEP-1996  2 6 8 9 10 37 375
30-AUG-1996  2 12 25 31 35 37 6B
19-AUG-1996  5 6 7 8 9 37 122B
11-JUN-1996  1 6 21 24 31 37 6C
3-JUN-1996  5 10 13 28 30 37 6D
13-MAY-1996  15 16 22 24 25 37 750D
29-APR-1996  16 17 24 31 35 37 1.5D
12-APR-1996  2 6 8 9 10 37 375
12-MAR-1996  3 11 16 30 34 37 6A
04-MAR-1996  5 6 7 8 9 37 122B
29-FEB-1996  19 21 27 31 34 37 1.5B
12-FEB-1996  14 22 30 33 34 37 1.5C
22-JAN-1996  14 17 21 24 26 37 750B
2-JAN-1996  12 13 15 18 21 37 750C
4-DEC-1995  1 6 21 24 31 37 6C
1-NOV-1995  3 11 16 30 34 37 6A
16-OCT-1995  16 17 24 31 35 37 1.5D
3-OCT-1995  12 13 15 18 21 37 750C
19-SEP-1995  15 16 22 24 25 37 750D
21-AUG-1995  5 10 13 28 30 37 6D
1-AUG-1995  2 6 8 9 10 37 375
26-JUN-1995  1 6 21 24 31 37 6C
14-JUN-1995  14 17 21 24 26 37 750B
7-JUN-1995  15 16 22 24 25 37 750D
30-MAY-1995  12 13 15 18 21 37 750C
17-MAY-1995  19 21 27 31 34 37 1.5B
10-MAY-1995  14 22 30 33 34 37 1.5C
4-APR-1995  1 6 21 24 31 37 6C
23-MAR-1995  15 18 25 28 35 37 1.5A
13-MAR-1995  1 3 5 7 9 37 244
21-FEB-1995  25 27 29 33 34 37 750A
24-JAN-1995  3 11 16 30 34 37 6A
10-JAN-1994  2 6 8 9 10 37 375
15-DEC-1994  3 11 16 30 34 37 6A
28-NOV-1994  3 6 8 9 10 37 SPECIAL
23-NOV-1994  2 6 8 9 10 37 375
09-NOV-1994  5 10 13 28 30 37 6D
24-OCT-1994  15 16 22 24 25 37 750D
17-OCT-1994  12 13 15 18 21 37 750C
05-OCT-1994  5 6 7 8 9 37 122B
26-SEP-1994  1 6 21 24 31 37 6C
26-SEP-1994  15 16 22 24 25 37 750D
19-SEP-1994  16 17 24 31 35 37 1.5D
13-SEP-1994  19 21 27 31 34 37 1.5B
30-JUN-1994  3 11 16 30 34 37 6A
21-JUN-1994  1 6 21 24 31 37 6C
14-JUN-1994  14 22 30 33 34 37 1.5C
7-JUN-1994  19 21 27 31 34 37 1.5B
30-MAY-1994  14 17 21 24 26 37 750B
23-MAY-1994  16 17 24 31 35 37 1.5D
12-APR-1994  5 10 13 28 30 37 6D
28-MAR-1994  2 6 8 9 10 37 375
21-MAR-1994  14 22 30 33 34 37 1.5C
16-MAR-1994  15 18 25 28 35 37 1.5A
```

8-MAR-1994	1	6	21	24	31	37	6C
21-FEB-1994	25	27	29	33	34	37	750A
8-FEB-1994	2	12	25	31	35	37	6B
13-OCT-1993	3	11	16	30	34	37	6A
5-OCT-1993	16	17	24	31	35	37	1.5D
30-SEP-1993	2	6	8	9	10	37	375
13-SEP-1993	5	10	13	28	30	37	6D
7-SEP-1993	12	13	15	18	21	37	750C
31-AUG-1993	1	6	21	24	31	37	6C
23-AUG-1993	19	21	27	31	34	37	1.5B
2-AUG-1993	1	6	8	9	11	37	SPECIAL
20-JUL-1993	15	16	22	24	25	37	750D
30-JUN-1993	1	6	21	24	31	37	6C
9-JUN-1993	3	11	16	30	34	37	6A
2-JUN-1993	14	17	21	24	26	37	750B
24-MAY-1993	2	6	8	9	10	37	375
10-MAY-1993	19	21	27	31	34	37	1.5B
23-MAR-1993	15	18	25	28	35	37	1.5A
17-MAR-1993	19	21	27	31	34	37	1.5B
10-MAR-1993	16	17	24	31	35	37	1.5D
25-FEB-1993	5	10	13	28	30	37	6D
31-JAN-1993	1	6	21	24	31	37	6C
25-JAN-1993	25	27	29	33	34	37	750A
17-JAN-1993	12	13	15	18	21	37	750C
13-JAN-1993	14	17	21	24	26	37	750B
30-NOV-1992	3	11	16	30	34	37	6A
16-NOV-1992	5	6	7	8	9	37	122B
2-NOV-1992	3	11	16	30	34	37	6A
26-OCT-1992	19	21	27	31	34	37	1.5B
16-OCT-1992	1	6	21	24	31	37	6C

E PPARAMS.DAT format

The columns are arranged the same as in the CAO#_POINTING.FILE (Appendix B).

1	26.0,	-77.0,	0.0,	378.0,	16.0,	-92.0,	-26.0,	0.0,	0.0,	106.0,	0.0,
2	-25.0,	-102.0,	0.0,	-37.0,	3.0,	0.0,	-19.0,	0.0,	0.0,	97.0,	0.0,
3	26.0,	94.0,	0.0,	-1.0,	4.0,	18.0,	-24.0,	0.0,	0.0,	109.0,	0.0,
4	3.0,	-48.0,	0.0,	70.0,	-29.0,	-234.0,	-26.0,	0.0,	0.0,	97.0,	0.0,
5	-20.0,	6.0,	-12.0,	39.0,	-77.0,	45.0,	-30.0,	0.0,	0.0,	93.0,	0.0,
6	-11.0,	28.0,	0.0,	107.0,	-89.0,	53.0,	-29.0,	-5.0,	12.0,	58.0,	0.0,

F STATION.COORDINATES file

-4752438.4590	2790321.2990	-3200483.7470	CS01	29-Mar-1985	0.000000	0.000000
-4752422.9220	2790347.6750	-3200483.7470	CS02	29-Mar-1985	0.000000	0.000000
-4752407.3850	2790374.0520	-3200483.7470	CS03	29-Mar-1985	0.000000	0.000000
-4752391.8480	2790400.4290	-3200483.7470	CS04	29-Mar-1985	0.000000	0.000000
-4752376.3110	2790426.8050	-3200483.7470	CS05	29-Mar-1985	0.000000	0.000000
-4752360.7740	2790453.1810	-3200483.7470	CS06	29-Mar-1985	0.000000	0.000000
-4752345.2370	2790479.5570	-3200483.7470	CS07	29-Mar-1985	0.000000	0.000000
-4752329.7000	2790505.9340	-3200483.7470	CS08	29-Mar-1985	0.000000	0.000000
-4752314.1630	2790532.3100	-3200483.7470	CS09	29-Mar-1985	0.000000	0.000000
-4752189.8670	2790743.3210	-3200483.7470	CS10	29-Mar-1985	0.000000	0.000000
-4752088.8760	2790914.7670	-3200483.7470	CS11	29-Mar-1985	0.000000	0.000000
-4751941.2760	2791165.3420	-3200483.7470	CS12	29-Mar-1985	0.000000	0.000000
-4751785.9060	2791429.1060	-3200483.7470	CS13	29-Mar-1985	0.000000	0.000000
-4751677.1480	2791613.7410	-3200483.7470	CS14	29-Mar-1985	0.000000	0.000000
-4751661.6110	2791640.1170	-3200483.7470	CS15	29-Mar-1985	0.000000	0.000000

-4751646.0740	2791666.4930	-3200483.7470	CS16	29-Mar-1985	0.000000	0.000000
-4751591.6950	2791758.8100	-3200483.7470	CS17	29-Mar-1985	0.000000	0.000000
-4751583.9260	2791771.9980	-3200483.7470	CS18	29-Mar-1985	0.000000	0.000000
-4751576.1570	2791785.1870	-3200483.7470	CS19	29-Mar-1985	0.000000	0.000000
-4751568.3890	2791798.3750	-3200483.7470	CS20	29-Mar-1985	0.000000	0.000000
-4751560.6200	2791811.5630	-3200483.7470	CS21	29-Mar-1985	0.000000	0.000000
-4751444.0930	2792009.3860	-3200483.7470	CS22	29-Mar-1985	0.000000	0.000000
-4751436.3240	2792022.5740	-3200483.7470	CS23	29-Mar-1985	0.000000	0.000000
-4751350.8710	2792167.6450	-3200483.7470	CS24	29-Mar-1985	0.000000	0.000000
-4751296.4920	2792259.9620	-3200483.7470	CS25	29-Mar-1985	0.000000	0.000000
-4751288.7240	2792273.1500	-3200483.7470	CS26	29-Mar-1985	0.000000	0.000000
-4751172.1960	2792470.9730	-3200483.7470	CS27	29-Mar-1985	0.000000	0.000000
-4751133.3540	2792536.9140	-3200483.7470	CS28	29-Mar-1985	0.000000	0.000000
-4751102.2800	2792589.6660	-3200483.7470	CS29	29-Mar-1985	0.000000	0.000000
-4751094.5110	2792602.8540	-3200483.7470	CS30	29-Mar-1985	0.000000	0.000000
-4751024.5950	2792721.5480	-3200483.7470	CS31	29-Mar-1985	0.000000	0.000000
-4750970.2160	2792813.8650	-3200483.7470	CS32	29-Mar-1985	0.000000	0.000000
-4750962.4480	2792827.0530	-3200483.7470	CS33	29-Mar-1985	0.000000	0.000000
-4750923.6050	2792892.9940	-3200483.7470	CS34	29-Mar-1985	0.000000	0.000000
-4750915.8370	2792906.1820	-3200483.7470	CS35	29-Mar-1985	0.000000	0.000000
-4749424.2880	2795438.3140	-3200483.7470	CS36	29-Mar-1985	0.000000	0.000000
-4749393.1980	2795491.0500	-3200483.6940	CS37	29-Mar-1985	0.000000	0.000000
-4751576.1570	2791785.1870	-3200483.7470	C	22-Jan-1989	0.000000	0.000000

```
station coordinates - revised after J. Reynolds investigations.
MHW changed CS37 on 21-Feb-1994 from (offset used to be in station.errors)
 -4749393.2150  2795491.0660 -3200483.7470   CS37      29-Mar-1985      0.000000  0.000000

 X,Y,Z (m): name;  date of coordinate determination; tilt (degrees)
''

''      at$antenna:station.coordinates
```

References

[1] Caswell, J. L., Stavely-Smith, L., *Extra stations for the Compact Array*, ATNF technical document, AT/31.6.7/012, 1992.

[2] JEEEA Vol 12, No.2. (Journal of Electrical and Electronics Engineering, Australia) June, 1992.

[3] Kesteven, M. J., Calebretta, M. R., *Calibration Notes, I — Antenna Errors*, ATNF technical document, AT/25.1.1/029, 1986.

[4] McKay, D. J., *ATCA pointing calibration*, `http://wwwnar.atnf.csiro.au/www/operations/pointing.html`, 1996.

[5] McKay, D. J., *SRCPLOT: Source plotting programs* `http://wwwnar.atnf.csiro.au/www/software/utility/user/srcplot/srcplot.html` , 1996.

[6] McKay, D. J., *Baseline solutions*, `http://wwwnar.atnf.csiro.au/www/operations/baseline.html`, 1995.

[7] McKay, D. J., *ATCA: Information on EARLY*, `http://wwwnar.atnf.csiro.au/www/software/on-line/user/early/early.html`, 1995.

[8] Nelson, G. J., *Scheduling Compact Array Configurations*, AT technical document AT/39.2/015, 1993

[9] Nelson, G. J., *Array Configurations and Length of Scheduling Period*, AT technical document AT/39.2/019, 1993.

[10] Norris, R. P., The ATNF MNRF Upgrade,
`http://wwwatnf.csiro.au/mnrf/mnrf.html` , 1996

[11] Poulton, G. T., *Antenna Layout for the Australia Telescope*, IAU Symposium - Indirect Imaging, pp 67–74, 1983.

[12] Wieringa, M. H., *Calibrating the array - CACAL*,
`http://wwwnar.atnf.csiro.au/www/software/on-line/user/cacal/cacal.html`