AIPS DDT History

Glen Langston, Pat Murphy and Dean Schlemmer
91 May 16

This document is intended for *AIPS* system managers who are installing a new version of *AIPS* . After installation, the accuracy and speed of the primary *AIPS* tasks can be measured with a set of *AIPS* DDTs. The results of the DDTs should be compared with results tabulated in this document.

1 Summary of *AIPS* DDTs

The *AIPS* DDTs are a selection of tasks designed to find *bugs* which are to be *exterminated* before software is released to the public. To ensure the quality of basic image processing software, these DDT tasks measure quantitatively the reliability of a few key tasks. This document records the results of *AIPS* tasks and compares them with those of earlier versions. The tasks tested with the DDTs are UVSRT, UVMAP, APCLN, ASCAL, MX and VTESS. Additional *AIPS* tasks run are UVDIF, COMB, and SUBIM. These tasks start with a standard set of *uv*-data and manipulate it to produce images which are compared with reference images.

Three types of tests are run; SMALL, MEDIUM and LARGE, producing 256, 512 and 1024 square pixel images from *uv*-data sets with 8000, 13000 and 77000 visibilities, respectively. The quality of these tests is determined by subtraction of the resulting images from previously determined standard images.

Appendix A of this document is a listing of an execution of the *AIPS* RUNFILE DDTLOAD , which produces procedures necessary for executing the DDT. Appendix B is a listing of an execution of the *AIPS* RUNFILE DDTEXEC .

For a comparison of execution speeds of the Convex C1 and the IBM 6000 series computers, see *AIPS* memo 71. This memo supersedes *AIPS* memo 63.

2 DDT History

The *uv*-data and resulting images have changed periodically, the latest change occurred in January 1989 and the previous change occurred in October 1987. The changes in January 1989 have been termed the 15APR89 copy of the DDT.

The dates of major events in $\mathcal{AIPS}$ coding which effect the DDTs are described below.

84 Apr Method for validating new CPU running $\mathcal{AIPS}$ needed for new computer procurement.

84 Dec First DDT set of routines defined by Don Wells, Eric Greisen and Bill Cotton

85 Nov DDT modified to allow one of three sizes of DDT, Small, Medium, and Large.

87 Oct A new DDT tape created with high dynamic range LARGE DDT from Alan Bridles data. Tape created by Eric Greisen and Kerry Hilldrup.

89 Jan Code overhaul begins, numerous (All) routines are modified.

89 Mar Clean components are merged before ASCAL to speed execution. New maps created for MEDIUM and LARGE tests of MX tasks. Modification by Chris Flatters.

89 Sep Overhaul bug found in AP routines used by UVMAP.

89 Oct MX bug found by Patrick Leahy which caused strips to be inserted into *some* images at the 0.1 % level. Bug traced to ALGSUB, which had incorrectly performed complex conjugation. This bug was released in several versions of AIPS.

90 Jan Anomalously small number of bits found on CONVEX and SUN for UVMAP and UVBEAM tests. Fixed by replacing single precision with double precision arithmetic.

90 Jan Minor bugs fixed in DDT procedure and printout shortened by Glen Langston.

90 Apr DDTs detect error in MX task just before distribution, showing DDTs are still required.

90 May DDTs show MEDIUM and LARGE reference images for MX contain ALGSUB errors which produce stripes at 1000 to 1 dynamic range. Current MX results are believed correct and a new DDT tape release is planned.

91 Apr Additional changes to MX and its subroutines improve accuracy of output images. In the Pseudo-Array Processor code, fourier transforms are performed with double precision accuracy. The Convex version of these routines are single precision and the results have a small but measurable difference in the output image.

91 May A new HUGE DDT is under development. This DDT produces 4096×4096 pixel images of the supernova remnant Cassiopeia A.

a) *b)*

Figure 1: UV Plots of small DDT data. Radio source is 3C161. *a)* Plot of Amplitude versus Baseline length. *b)* Location of visibilities in the UV plane.

Figure 2: Cleaned Image of 3C161 produced by DDT task MX.

Figure 3: Image of 3C161 produced by DDT task VTESS using Maximum Entropy Deconvolution.

3 How to Run the DDT

Running the DDT consists of three major steps; *a)* creating the DDT procedures, *b)* loading the DDT master images, and *c)* running the DDT procedures which start tasks and compares output. Parts of a sample *AIPS* session is listed below for reading the master images from tape. The *AIPS* RUNFILE DDTLOAD is used to create the required AIPS procedures. The *AIPS* RUNFILE DDTEXEC runs the *AIPS* tasks and produces the test results. Note that DDTEXEC must be run twice, once to read the master images and once to test the *AIPS* tasks. Also note, after setting the DDT inputs, the DDT inputs MUST be TPUT for the inputs to have effect (ie. TPUT DDT). The text the user must type is in lower case.

```
>input mount
AIPS 1: MOUNT:    Verb to software mount a tape
AIPS 1: Adverbs         Values            Comments
AIPS 1: ----------------------------------------------------------------
AIPS 1: INTAPE        1                    Tape unit # (0=> 1)
AIPS 1: DENSITY    1600                    Density to set on mount.
>density=6250                      $ ddt data is on a 6250 bpi tape
>mount                             $ mount the master tape
>run ddtload                       $ create the DDT procedures
   ...  much printout ...
>input ddt
AIPS 3: DDT   :  Verification/timing test; see DDTLOAD.001, DDTEXEC.001
AIPS 3: Adverbs         Values            Comments
AIPS 3: ----------------------------------------------------------------
AIPS 3: TCODE      'TEST'                  INIT,TEST,READ, or WRIT
AIPS 3: TMODE      'M'                     T or M; Test or Master input
AIPS 3: TMASK        32                    test selection bit mask
AIPS 3: DDTSIZE    'SMALL   '              'SMALL','MEDIUM','LARGE' test
AIPS 3: DDISK         5                    Disk drive #: master UVDATA
AIPS 3: MDISK         5                    Disk drive #: other masters
AIPS 3: TDISK         1                    Disk drive #: test images
AIPS 3: IOTAPE        3                    Input/Output tape drive #.
AIPS 3: EDGSKP        4                    Pixels to skip at edges
AIPS 3: TERSE         1                    > 0 => reduced output
AIPS 3: OUTPRINT   '                                               '
AIPS 3:                                    Printer disk file to save
AIPS 3: BADDISK    *all 0                  Disks to avoid
AIPS 3: VERSION    '                                               '
>tcode='read'                      $ prepare to read master files
>tmask=127                         $ read in all ddt master files
>ddtsize='large'                   $ do the big test
>edgskp=16                         $ ignore a few pixels around edge
```

```
>iotape=1                          $ use the tape you mounted for read
>baddisk=2,3,4,5,6,0               $ only use disk 1
>input ddt                         $ check ddt inputs one more time
>tput ddt                          $ save ddt adverbs for DDTEXEC !!!
>run ddtexec                       $ load the master files
  ... much printout and many executions of IMLOD and UVLOD ...
>dismount                          $ go put away the tape
```

Each DDT (small, medium, or large) requires 11 files from the tape. Three of these files contain *uv*-data and the remaining eight are master images, which will be used to test the DDT results. The files loaded for the small test are listed below.

```
>inname='*S'; inty=''; ins=0; incl=''
>catalog
AIPS      Catalog on disk  5
AIPS       Cat Usid Mapname      Class   Seq  Pt      Last access      Stat
AIPS         1    1 DDDTS       .UVDATA.    1 UV 01-MAY-1991 00:18:23
AIPS         2    1 MDDTS       .UVSRT .    1 UV 01-MAY-1991 00:18:33
AIPS         3    1 MDDTS       .UVMAP .    1 MA 01-MAY-1991 00:18:44
AIPS         4    1 MDDTS       .UVBEAM.    1 MA 01-MAY-1991 00:18:51
AIPS         5    1 MDDTS       .APCLN .    1 MA 01-MAY-1991 00:18:59
AIPS         6    1 MDDTS       .APRES .    1 MA 01-MAY-1991 00:19:06
AIPS         7    1 MDDTS       .ASCAL .    1 UV 01-MAY-1991 00:19:14
AIPS         8    1 MDDTS       .MXMAP .    1 MA 01-MAY-1991 00:19:25
AIPS         9    1 MDDTS       .MXBEAM.    1 MA 01-MAY-1991 00:19:33
AIPS        10    1 MDDTS       .MXCLN .    1 MA 01-MAY-1991 00:19:40
AIPS        11    1 MDDTS       .VTESS .    1 MA 01-MAY-1991 00:19:48
```

The original *uv*-data file is named DDDTS.UVDATA.1, and all the other files were created from this *uv*-data . The other two *uv*-data sets are MDDTS.UVSRT.1, an XY sorted version of DDDTS.UVDATA.1, and MDDTS.ASCAL.1, a self-calibrated version of DDDTS.UVDATA.1.

Now that the *uv*-data and master images are loaded, the test can be started. The tests will create 1 file for each of the original master files. These files will be named TDDTS.?????.1 (ie. the UVSRT test will create TDDTS.UVSRT.1).

The inputs are set and the test output is summarized below. (After setting the inputs to DDT, do NOT forget to TPUT the DDT inputs or they will have no effect!)

```
>tget ddt                           $ get ddt adverbs
>tcode='test'                       $ indicate test should be run
>input ddt                          $ always check the inputs
>tput ddt                           $ save ddt adverbs for DDTEXEC !!!
>clrmsg                             $ clean up the message file
>run ddtexec                        $ actually run the DDTs
  ... much more printout and several tasks run ...
...
 Mapping tasks should have about 10 BITS of accuracy
 A section of the output is listed below
...
          task             Peak Bits   RMS Bits
AIPS      UVMAP            13.6202     19.2307
AIPS      UVBEAM           10.2618     16.4874
AIPS      APCLN            18.798      24.0944
AIPS      APRES            16.8828     22.2016
AIPS      MXMAP            12.5708     19.0115
AIPS      MXBEAM           14.125      19.4482
AIPS      MXCLN            14.4533     17.5482
AIPS      VTESS            18.6827     25.9653
AIPS      THAT"S ALL, FOLKS!
```

4 Record of the BITS

The DDT results are presented in 4 groups:

a) Sorting and Mapping

b) AP Clean and Self Calibration

c) MX Map and Cleaning

d) Maximum Entropy and DDT Notes

The results of the tests are dependent on the software version, CPU, and the level of debugging of the code. The level of debugging is specified by whether the version is OLD, NEW or TST. The TST version of code is compiled with the DEBUG option and is generally slower than code in the OLD or the NEW versions. Systems with Array Processors also have the option of running with Pseudo-Array Processors by appending PSAP to the version name. (i.e. to run TST with the pseudo array processor code set VERSION='TSTPSAP') Normally, the default VERSION is used by setting VERSION=''.

The results of the tests are quantified by the number of BITS of accuracy. The number of BITS are determined by subtracting the *reference* image from *test result* image. The BITS of accuracy are defined in two ways; *1)* by the MAX difference of the Master image and the Test image and *2)* by the RMS differences between the images. The BITS calculated from the base 2 logarithm of the ratio of PEAK of the reference image and DIFFERENCE of the images.

The maximum and the RMS differences as described by equation (1) below.

$$BITS = \log_2 \frac{DIFF}{PEAK} = \frac{1}{log_{10} 2} \log_{10} \frac{DIFF}{PEAK} = -3.3219 \times \log_{10} \frac{DIFF}{PEAK} \qquad (1)$$

(log_{10} is the Base 10 Logarithm) The reference images are stored on tape in a 32 BIT floating point format, but eight of the Bits are used for the sign and exponent of the number. The maximum accuracy possible is roughly 24 bits. (When the two images are produced by the same machine, the BITS result can be higher. In this case there are few, if any differences between the images, giving a deceptively large number of bits of accuracy.)

The mapping routines perform many multiplications and round off errors accumulate, generally giving images with 14 to 16 bits of accuracy ($2^{14} = 16384, 2^{16} = 65336$). A dynamic range of 100,000 to 1 is marginally repeatable for the different CPUs listed here. ($100,000 = 2^{16.6}$) The RMS BITS of accuracy is always greater than the PEAK BITS of accuracy. The expected BITS of accuracy for the tasks is in the range of 10 to 20 BITS.

Note that slight changes in algorithm change the *measured* accuracy of the task significantly. For instance, changing the gridded weighting of *uv*-data in a mapping task produces a slightly different type of map. The comparison of apples and oranges results in a small number of BITS of accuracy.

A final BITS note; the eye can not see differences between two images if there is less than 7 BITS difference. If two images are subtracted, then small differences become visible. (i.e. view the difference map to determine the type of problems occurring in the test image) At the end of each mapping task, a difference file is created with the task COMB. For the small test, the file named TDDTS.DIFF.1, which contains the test image minus the master image. This file is re-written after each task. If a DDT test has a small number of BITs, re-run the DDT only on that part. Then examine the difference file, which can provide a clue to the type of errors occuring.

Several different types of CPUs are listed in the tables. Below the CPUs are described.

CVAX-PS	A Vax 780 computer using pseudo array processor code.
CVAX	A Vax 780 computer with FPS 120B array processor.
OUTBAX	A Vax computer with FPS array processor.
Nrao1	A Convex C1 computer.
Gorilla	A Sun 3/60 Workstation with MC68881 co-processor.
Kong	A Sun 3/60 Workstation with MC68881 co-processor.
SAIPS	A Sun 3/110 Workstation with MC68881 co-processor.

Mandrill	A Sun 4/110 Workstation.
Trace	A Multi-Flow Trace model 1400/300 mini-super computer.
Lemur	An IBM 6000 (Power Station), model 530.
Polaris	An IBM 6000 (Power Station), model 540.

5 UV Sorting and Mapping

The first group of DDTs tests is Sorting and Mapping of *uv*-data . The Small, Medium and Large test results are presented in tables 1, 2, and 3.

The UVSRT test is evaluated by printing the differences between the output file and the master file using the task UVDIF. There are frequently a few differences because several of the *uv*-data points have almost identical U or V values. The exact order of these points seems to depend very strongly on the internal floating point format of the CPU being tested. Inspection of the UVDIF output quickly shows whether the different points are just in a slightly different sort order.

The UVMAP test quality is determined by subtracting the MASTER image from the TEST images to create a DIFF image. If the differences are positive, the TEST image is brighter than the MASTER image.

The DDT mapping results are sensitive to the number of pixels around the edge of the maps excluded from image comparison. For SMALL DDTs 4 pixels should be excluded, for MEDIUM 8 pixels, and for LARGE exclude 16 pixels. The number of pixels to exclude is set by the EDGSKP adverb. The sensitivity of edge pixels is due to the gridding correction for the Fourier Transform. Near the edge of the maps, very small numbers are divided and round off error becomes important.

6 APCLN and ASCAL

The second group of tests check APCLN and the Self Calibration routine ASCAL. Very few changes have been made to these tasks in recent years. New features for self calibration have been put in the task CALIB. The Small, Medium and Large test results are presented in tables 4, 5, and 6. The ASCAL success is determined by the number of difference between the reference data set and the test data set. There difference listed are frequently due to small differences in U, V and W values resulting in the *uv*-data being sorted differently in the two data sets. If there were more than 99 differences in the *uv*-data , the number of differences was listed as "!". The $\mathcal{AIPS}$ task UVDIF lists three types of differences, *a)* flux, *b)* U-V-W coordinate, and *c)* other differences.

7 Image Deconvolution, MX

The third group of tables display the results of the task MX. This task performs three functions; *a)* producing a Fourier transform of the *uv*-data , *b)* creating the BEAM or point response function, and *c)* deconvolving the *uv*-data to produce a cleaned image. The task MX requires a considerable fraction of the total time spent on image analysis and the REAL time used in the MX Clean step is also listed.

8 Maximum entropy and DDT notes

The task VTESS is presented in the fourth group of tables. The total CPU (not Real) time required to execute the DDT is given with notes concerning the DDTs. The most common note is the number of pixels around the edge of a map which are ignored during comparisons. Typically a band 4 pixels wide around the edge are ignored for the Small DDTs. For Medium DDTs, eight pixel wide strips are ignored and for Large, sixteen pixels. This band is set with the DDT adverb EDGSKP.

9 Future Developments

Further DDT tasks are needed to test the $\mathcal{AIPS}$ calibration package and VLBI fring-fitting routines. Also the task ASCAL is being phased out, to replaced by the task CALIB. These functions did not exist in $\mathcal{AIPS}$ when the first DDTs were developed.

A calibration DDT has been created, which is loaded with the runfile VLACLOAD, and executed with the runfile VLACEXEC. This procedure functions similarly to the DDT tests, and will be described in a future $\mathcal{AIPS}$ memo.

A spectral line DDT is also near completion. The spectral line calibration and mapping tasks are tested with this set of procedures.

Test Date	AIPS Version	CPU	Old New Tst	UVSRT CPU Time	UVSRT U-V Diffs	UVMAP CPU Time	UVMAP MAP Peak	UVMAP MAP RMS	UVMAP BEAM Peak	UVMAP BEAM RMS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
86-Apr-15	?	Nrao1	?				9.4		9.2	
86-Jul-24	?	CVAX	?			42.7	16.8	17.6	16.8	17.6
86-Jul-24	?	CVAX-PS	N			108.9	13.2	17.5	9.7	16.1
86-Aug-08	?	CVAX	?	24.5	0,0,0	35.3	15.8	22.4	15.8	20.6
86-Jun-18	Jul86	Nrao1	?	11.2	0,0,4	18.5	9.5	14.6	6.5	13.0
86-Aug-14	?	Nrao1	?	11.3	0,0,4	18.5	9.5	14.6	6.5	13.0
87-Mar-01	Jul87	Nrao1	?	10.5	0,0,4	18.4	12.5	17.4	10.5	16.2
88-Mar-06	?	Nrao1	?	5.8	0,0,6	8.5	16.1	21.8	12.7	18.5
88-Aug-29	Jul88	Gorilla	O	14.4		105.6				
89-Jun-17	Apr89	CVAX	O	22.9	0,0,0	32.1	21.2	26.6	17.6	23.2
89-Jul-23	Apr89	Nrao1	O	6.5	0,0,4	12.2	9.6	14.8	7.6	13.9
89-Jul-23	Oct89	Nrao1	T	8.6	0,0,6	12.6	9.6	14.8	7.6	13.9
89-Jul-23	Oct89	Gorilla	T	17.4	0,0,0	209.3	13.3	19.2	10.7	16.8
89-Jul-23	Jul89	Gorilla	N	15.9	2,0,0	182.8	13.3	19.2	10.7	16.8
89-Jul-23	Oct89	CVAX	T	22.1	0,0,0	34.2	21.2	26.6	17.6	23.2
89-Jul-23	Oct89	CVAX-PS	T	21.9	0,0,0	72.5	2.5	7.7	-3.9	2.3
89-Sep-18	Apr89	Kong	O	14.1	0,0,2	102.8	13.7	19.3	11.2	17.2
89-Sep-19	Oct89	Kong	N	15.5	0,0,4	101.8	14.3	19.3	10.8	16.9
89-Oct-01	Oct88	Trace	T	3.7		7.4				
90-Feb-01	Oct89	Nrao1	O	8.6	0,0,6	7.4	9.6	14.8	7.6	13.9
90-Feb-02	Jul90	Nrao1	T	8.7	0,0,6	16.0	13.1	19.0	9.9	16.5
90-Feb-02	Jul90	SAIPS	T			139.4	13.7	19.2	11.2	17.2
90-Feb-05	Jul90	SAIPS	T	25.0	0,0,4	146.1	14.1	19.5	10.8	16.9
90-Apr-06	Apr90	Nrao1	O	9.2	0,0,6	13.5	13.7	19.2	10.3	16.5
90-Apr-06	Apr90	SAIPS	O	21.7	0,0,4	143.7	14.1	19.4	10.8	16.9
90-Apr-09	Apr90	CVAX-PS	O	18.1	0,0,0	99.6	13.7	19.3	11.3	17.1
90-Apr-10	Apr90	OUTBAX	O				21.2	26.6	17.6	23.2
90-May-31	Jul90	CVAX-PS	N	18.4	0,0,0	97.7	13.7	19.3	11.3	17.1
90-Jun-05	Apr90	Nrao1	O	7.9	0,0,6	12.5	13.6	19.2	10.3	16.5
90-Jun-05	Jul90	Nrao1	N	8.0	0,0,6	11.5	13.6	19.2	10.3	16.5
90-Jun-05	Oct90	CVAX-PS	T	23.4	0,0,0	100.1	13.7	19.3	11.3	17.1
91-Jan-16	Jan91	Nrao1	O	6.5	0,0,6	16.5	13.6	19.2	10.3	16.5
91-Feb-15	Jan91	Mandrill	O	9.9	0,0,2	27.3	13.7	19.3	10.6	16.5
91-May-14	Apr91	Nrao1	N	6.5	0,0,6	15.1	13.6	19.2	10.3	16.5

Table 1: Small DDT results for UVSRT and UVMAP

Test	AIPS	CPU	Old	UVSRT		UVMAP				
Date	Version		New	CPU	U-V	CPU	MAP	MAP	BEAM	BEAM
			Tst	Time	Diffs	Time	Peak	RMS	Peak	RMS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
89-Jul-23	Apr89	Nrao1	O	10.9	0,0,2	31.1	7.4	13.4	8.2	13.7
89-Jul-23	Jul89	Nrao1	N	11.6	0,0,2	26.8	8.7	14.8	9.6	15.2
89-Jul-23	Oct89	Nrao1	T	12.3	0,0,2	28.5	7.4	13.4	8.2	13.7
89-Jul-24	Jul89	Gorilla	N	23.9	0,0,2	586.0	13.3	18.2	13.8	18.6
89-Jul-24	Apr89	CVAX	O	38.2	0,0,0	57.9	19.5	25.9	20.1	25.7
89-Jul-24	Oct89	CVAX	T	34.0	0,0,0	55.4	19.5	25.9	20.1	25.7
89-Sep-19	Apr89	Kong	O	23.7	0,0,2	314.0	14.6	18.2	15.0	18.7
89-Sep-20	Oct89	Kong	N	23.5	0,0,2	312.0	14.6	18.2	15.0	18.7
90-May-29	Jul90	Nrao1	N	11.5	0,0,2	24.0	13.5	17.8	13.4	17.8
90-Jun-01	Oct90	Nrao1	T	13.3	0,0,2	39.9	14.6	17.9	14.6	17.9
90-Jun-01	Jul90	SAIPS	N	35.0	0,0,2	561.0	14.4	18.2	14.6	18.7
90-Jun-04	Apr90	SAIPS	O	34.9	0,0,2	429.6	14.8	18.2	15.0	18.7
91-Jan-16	Jan91	Nrao1	O	14.1	0,0,2	26.6	14.6	17.9	14.5	17.9
91-May-14	Apr91	Nrao1	N	16.9	0,0,2	28.0	14.6	17.9	14.5	17.9

Table 2: Medium DDT results for UVSRT and UVMAP

Test	AIPS	CPU	Old	UVSRT		UVMAP				
Date	Version		New	CPU	U-V	CPU	MAP	MAP	BEAM	BEAM
			Tst	Time	Diffs	Time	Peak	RMS	Peak	RMS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
89-Jul-23	Apr89	Nrao1	O	66.8	52,148	126.6	8.2	13.6	7.9	14.8
89-Jul-23	Oct89	Nrao1	T	71.9		126.1	8.6	13.8	9.5	15.2
89-Jul-23	Oct89	CVAX	T	197.2	0,0,0	160.5	16.3	26.2	25.8	32.0
89-Sep-21	Apr89	Kong	O	152.8	18,!,74	1317.9	12.9	17.3	15.0	17.7
9O-Jun-25	Jul90	Nrao1	N	39.3	52,148	92.8	11.9	15.6	14.0	16.2
91-Feb-17	Jan91	Polaris	O	22.6	,	35.5	12.3	17.3	15.1	17.7
91-May-03	Apr91	Nrao1	N	85.3	52,148	95.1	12.1	15.6	14.2	16.2
91-May-15	Jul91	Lemur	T	27.0	18,78	43.7	13.1	17.4	15.1	17.7

Table 3: Large DDT results for UVSRT and UVMAP

Test	AIPS	CPU	Old	APCLN						ASCAL	
Date	Version		New	CPU	MAP	MAP	CPU	RES	RES	CPU	U-V
			Tst	Time	Peak	RMS	Time	Peak	RMS	Time	Diffs
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
86-Aug-08	?	CVAX	?	52.0	14.9	18.9	30.4	11.5	16.8	49.4	0,0,0
86-Jun-18	Jul86	Nrao1	?	43.4	13.8	16.6	11.3	15.8	17.2	93.0	0,0,4
86-Aug-14	?	Nrao1	?	46.1	13.6	16.2	13.3	15.9	17.2	97.0	0,0,4
87-Mar-01	Jul87	Nrao1	?	42.6	13.6	16.2	11.3	15.9	17.2	85.4	0,0,4
88-Mar-06	?	Nrao1	?	31.1	12.3	15.8	7.3	8.9	12.4	74.8	0,0,6
88-Aug-29	Jul88	Gorilla	O	890.0			85.8			2624.4	
89-Jun-17	Apr89	CVAX	O	46.4	26.6	30.1	26.3	22.2	26.8	51.4	0,0,0
89-Jul-23	Apr89	Nrao1	O	36.6	18.8	24.1	7.9	16.9	22.2	83.2	0,0,6
89-Jul-23	Oct89	Nrao1	T	37.5	18.8	24.1	8.7	16.9	22.2	83.7	0,0,6
89-Jul-23	Oct89	Gorilla	T	1573.5	14.1	20.7	165.8	17.0	22.4		
89-Jul-23	Jul89	Gorilla	N	1424.7	14.1	20.7	139.2	17.0	22.4	5766.9	0,0,4
89-Jul-23	Oct89	CVAX	T	46.1	26.6	30.1	25.5	22.2	26.8	52.6	0,0,4
89-Jul-23	Oct89	CVAX-PS	T	925.8	14.1	20.7	52.1	15.9	21.3	1252.3	0,0,0
89-Sep-18	Apr89	Kong	O	904.2	18.0	23.8	84.0	17.0	22.4	2558.1	0,0,2
89-Sep-19	Oct89	Kong	N	900.4	18.0	23.8	80.6	17.0	22.4	2540.9	0,0,4
89-Oct-01	Oct88	Trace	T	18.3			4.4			34.8	
90-Feb-01	Oct89	Nrao1	O	37.3	18.8	24.1	7.6	16.7	22.2	86.3	0,0,6
90-Feb-02	Jul90	Nrao1	T	40.6	18.8	24.1	8.5	16.7	22.2	24.8	0,0,6
90-Feb-05	Jul90	SAIPS	T	1203.4	18.0	23.8	107.3	17.0	22.4	785.5	0,0,4
90-Apr-06	Apr90	Nrao1	O	37.5	18.8	24.1	6.7	16.7	22.2	21.7	0,0,6
90-Apr-06	Apr90	SAIPS	O	1257.0	18.0	23.8	103.0	17.0	22.4	472.0	0,0,4
90-Apr-09	Apr90	CVAX-PS	O	1005.1	14.1	20.5	55.3	12.5	18.4	288.8	0,0,0
90-Apr-10	Apr90	OUTBAX	O		26.6	30.1		22.2	26.8		
90-May-31	Jul90	CVAX-PS	N	996.9	14.1	20.5	57.3	12.5	18.4	540.2	0,0,0
90-Jun-05	Apr90	Nrao1	O	38.2	18.8	24.1	6.9	16.9	22.2	32.9	0,0,6
90-Jun-05	Jul90	Nrao1	N	36.3	18.8	24.1	7.1	16.9	22.2	29.9	0,0,6
90-Jun-05	Oct90	CVAX-PS	T	993.5	14.1	20.5	56.8	12.5	18.4	544.5	0,0,0
91-Jan-16	Jan91	Nrao1	O	41.7	18.8	24.1	9.4	16.9	22.2	28.3	0,0,6
91-Feb-15	Jan91	Mandrill	O	311.4	14.1	20.7	17.9	16.9	22.3	189.9	0,0,2
91-May-14	Apr91	Nrao1	O	42.3	18.8	24.1	10.6	16.9	22.2	33.9	0,0,6

Table 4: Small DDT results for APCLN and ASCAL

Test Date	AIPS Version	CPU	Old New Tst	APCLN CPU Time	MAP Peak	MAP RMS	CPU Time	RES Peak	RES RMS	ASCAL CPU Time	U-V Diffs
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
89-Jul-23	Apr89	Nrao1	O	201.6	11.9	14.6	25.3	15.4	21.2	353.1	0,0,2
89-Jul-23	Jul89	Nrao1	N	201.4	11.9	14.6	25.8	15.4	21.2	380.7	0,0,2
89-Jul-23	Oct89	Nrao1	T	206.2	11.9	14.6	27.0	15.4	21.2	373.0	0,0,2
89-Jul-24	Jul89	Gorilla	N	12476.7	11.4	14.2	631.3	15.4	21.3	24036.3	0,0,2
89-Jul-24	Apr89	CVAX	O	194.6	26.3	29.7	58.1	21.2	25.9	88.5	0,0,0
89-Jul-24	Oct89	CVAX	T	189.0	26.3	29.7	52.4	21.2	25.7	90.3	0,0,0
89-Sep-19	Apr89	Kong	O	7735.6	11.8	14.7	361.1	15.4	21.3	10457.7	0,0,2
89-Sep-20	Oct89	Kong	N	7805.7	11.8	14.7	356.9	15.4	21.3	10405.7	0,0,2
90-May-29	Jul90	Nrao1	N	188.9	11.9	14.6	21.3	15.4	21.2	49.6	!,0,2
90-Jun-01	Oct90	Nrao1	T	247.3	11.9	14.6	39.6	15.4	21.2	52.4	45,!,2
90-Jun-01	Jul90	SAIPS	N	13173.7	11.9	14.8	601.8	15.4	21.3	2127.2	45,!,2
90-Jun-04	Apr90	SAIPS	O	11102.0	11.8	14.7	477.4	15.4	21.3	1398.0	45,!,2
91-Jan-16	Jan91	Nrao1	O	183.5	11.9	14.6	23.1	15.4	21.2	124.9	0,0,2
91-May-14	Apr91	Nrao1	N	199.2	11.9	14.6	24.4	15.4	21.2	138.2	0,0,2

Table 5: Medium DDT results for APCLN and ASCAL

Test Date	AIPS Version	CPU	Old New Tst	APCLN CPU Time	MAP Peak	MAP RMS	CPU Time	RES Peak	RES RMS	ASCAL CPU Time	U-V Diffs
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
89-Jul-23	Apr89	Nrao1	O	683.0	13.0	17.3	116.5	14.2	20.7	449.2	52,148
89-Jul-23	Oct89	Nrao1	T	675.1	13.0	17.3	110.2	14.2	20.7	414.8	
89-Jul-23	Oct89	CVAX	T	519.9	13.7	17.4	137.5	8.5	12.3	395.0	0,0,0
89-Sep-21	Apr89	Kong	O	25896.9	13.0	17.0	1915.7	14.1	20.6	15763.5	18,!,74
90-Jun-25	Jul90	Nrao1	N	560.6	13.0	17.3	87.4	14.2	20.7	700.0	52,148
91-Feb-16	Jan91	Polaris	O	1121.8	11.0	16.8	32.5	14.1	20.6	1949.3	,
91-May-03	Apr91	Nrao1	N	538.6	13.0	17.3	84.0	14.2	20.7	2374.0	52,148
91-May-15	Jul91	Lemur	T	706.0	10.8	16.8	37.0	14.2	20.6	2373.6	18,74

Table 6: Large DDT results for APCLN and ASCAL

Test	AIPS	CPU	Old				MX					
Date	Version		New	CPU	MAP	MAP	BEAM	BEAM	CPU	Real	CLN	CLN
			Tst	Time	Peak	RMS	Peak	RMS	Time	Time	Peak	RMS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
86-Apr-15	?	Nrao1	?		12.1		12.3				14.0	
86-Jul-24	?	CVAX	?	57.8	16.8	17.6	16.8	17.6				
86-Jul-24	?	CVAX-PS	N	141.5	12.7	17.4	13.6	17.5				
86-Aug-08	?	CVAX	?	48.2	15.8	19.7	99.0	99.0	163.8	1044.0	14.4	17.0
86-Jun-18	Jul86	Nrao1	?	21.2	11.8	17.4	14.4	17.5	100.0	159.0	16.7	17.8
86-Aug-14	?	Nrao1	?	25.6	11.9	17.4	14.4	17.5	111.5	604.0	16.7	17.8
87-Mar-01	Jul87	Nrao1	?	22.2	12.9	17.4	14.3	17.5	99.6	127.0	15.0	17.3
88-Mar-06	?	Nrao1	?	10.0	15.4	21.2	15.8	21.7	58.7	837.0	17.9	24.4
88-Aug-29	Jul88	Gorilla	O	131.7					1767.9	1845.0		
89-Jun-17	Apr89	CVAX	O	44.6	19.5	25.3	32.0	34.4	150.3	424.0	23.7	28.7
89-Jul-23	Apr89	Nrao1	O	14.8	12.8	18.8	14.5	19.5	79.9	94.0	14.3	17.3
89-Jul-23	Oct89	Nrao1	T	14.8	12.8	18.8	14.5	19.5	79.9	100.0	14.3	17.3
89-Jul-23	Oct89	Gorilla	T	267.8	13.4	19.0	14.5	19.6	3680.0	3780.0	14.1	17.4
89-Jul-23	Jul89	Gorilla	N	239.9	13.4	19.0	14.5	19.6	3370.5	3473.0	14.1	17.4
89-Jul-23	Oct89	CVAX	T	46.9	19.5	25.3	32.0	34.4	148.3	417.0	14.6	17.5
89-Jul-23	Oct89	CVAX-PS	T	92.9	13.6	19.3	14.3	19.6	1293.8	1379.0	14.1	17.4
89-Sep-18	Apr89	Kong	O	127.3	13.6	19.4	14.8	19.7	1732.8	1791.0	18.1	23.9
89-Sep-19	Oct89	Kong	N	126.0	13.6	19.4	14.8	19.7	1727.6	1796.0	14.6	17.5
89-Oct-01	Oct88	Trace	T	7.7					58.7	61.0		
90-Feb-01	Oct89	Nrao1	O	13.8	12.6	18.8	14.5	19.5	78.6	90.0	14.8	17.6
90-Feb-02	Jul90	Nrao1	T	18.8	13.4	18.9	14.6	19.6	103.3	901.0	14.8	17.6
90-Feb-02	Jul90	SAIPS	T						2287.3		14.9	17.6
90-Feb-05	Jul90	SAIPS	T	163.6	12.6	19.0	15.1	19.8	1888.5		14.9	17.6
90-Apr-06	Apr90	Nrao1	O	13.4	12.8	19.1	14.6	19.6	77.1	700.0	14.8	17.6
90-Apr-06	Apr90	SAIPS	O	168.0	12.6	19.0	15.1	19.8	1996.0	2451.0	14.9	17.6
90-Apr-09	Apr90	CVAX-PS	O	107.9	13.5	19.1	14.3	19.5	1395.0	1938.0	14.0	17.4
90-Apr-10	Apr90	OUTBAX	O		19.5	25.3	32.0	34.4			14.4	17.5
90-May-31	Jul90	CVAX-PS	N	108.1	13.7	19.1	14.2	19.6	1595.0	2470.0	13.8	17.5
90-Jun-05	Apr90	Nrao1	O	13.5	13.2	19.0	14.6	19.6	77.4	197.0	14.5	17.6
90-Jun-05	Jul90	Nrao1	N	13.6	12.6	19.0	14.1	19.5	76.8	220.0	14.5	17.5
90-Jun-05	Oct90	CVAX-PS	T	149.0	13.7	19.1	14.2	19.6	1587.0	2387.0	13.8	17.5
91-Jan-16	Jan91	Nrao1	O	20.6	12.6	19.0	14.1	19.5	76.2	133.0	14.5	17.5
91-Feb-15	Jan91	Mandrill	O	44.3	13.2	19.0	14.4	19.6	468.0	493.0	13.8	17.5
91-May-14	Apr91	Nrao1	N	19.1	12.3	18.6	14.1	19.4	87.9	133.0	14.5	17.4

Table 7: Small DDT results for MX

Test Date (1)	AIPS Version (2)	CPU (3)	Old New Tst (4)	CPU Time (5)	MAP Peak (6)	MAP RMS (7)	BEAM Peak (8)	MX BEAM RMS (9)	CPU Time (10)	Real Time (11)	CLN Peak (12)	CLN RMS (13)
89-Jul-23	Apr89	Nrao1	O	34.9	13.6	17.8	14.1	17.8	301.5	346.0	11.5	14.6
89-Jul-23	Jul89	Nrao1	N	32.6	15.2	18.0	15.4	18.0	284.5	346.0	10.3	14.1
89-Jul-23	Oct89	Nrao1	T	34.3	13.6	17.8	14.1	17.8	300.8	361.0	10.3	14.1
89-Jul-24	Jul89	Gorilla	N	780.8	13.6	18.1	14.5	18.6	16555.9	16839.0	10.3	14.2
89-Jul-24	Apr89	CVAX	O	94.4	18.2	24.8	32.0	34.4	304.1	994.0	20.4	26.3
89-Jul-24	Oct89	CVAX	T	92.8	18.2	24.8	32.0	34.4	283.6	974.0	10.2	14.2
89-Sep-19	Apr89	Kong	O	410.6	14.6	18.2	15.1	18.7	9742.9	9947.0	11.6	14.4
89-Sep-20	Oct89	Kong	N	408.2	14.6	18.2	15.1	18.7	9759.9	9979.0	10.3	14.2
90-May-29	Jul90	Nrao1	N	29.7	13.7	17.8	13.7	17.8	269.9	809.0	10.3	14.2
90-Jun-01	Oct90	Nrao1	T	59.8	14.8	17.9	14.7	17.9	385.3	1143.0	10.3	14.2
90-Jun-01	Jul90	SAIPS	N	702.4	14.6	18.2	14.7	18.7	15955.3	18475.0	10.0	14.2
90-Jun-04	Apr90	SAIPS	O	548.0	14.3	18.2	15.0	18.7	13373.3	14785.0	10.0	14.2
91-Jan-16	Jan91	Nrao1	O	41.1	14.4	17.9	14.7	17.9	293.8	1492.0	10.3	14.2
91-May-14	Apr91	Nrao1	N	35.5	14.2	17.9	14.7	17.9	304.9	1546.0	10.3	14.2

Table 8: Medium DDT results for MX

Test Date (1)	AIPS Version (2)	CPU (3)	Old New Tst (4)	CPU Time (5)	MAP Peak (6)	MAP RMS (7)	BEAM Peak (8)	MX BEAM RMS (9)	CPU Time (10)	Real Time (11)	CLN Peak (12)	CLN RMS (13)
89-Jul-23	Apr89	Nrao1	O	134.3	13.8	18.1	14.9	19.5	1193.8	1551.0	11.2	17.0
89-Jul-23	Oct89	Nrao1	T	122.9	13.9	18.1	15.1	19.5	1137.2	1451.0	11.2	16.9
89-Jul-23	Oct89	CVAX	T	212.8	16.6	22.7	32.0	34.1	794.5	2957.0	21.7	27.8
89-Sep-21	Apr89	Kong	O	1477.3	14.2	19.0	15.4	19.6	32700.0	33414.0	10.7	16.8
90-Jun-25	Jul90	Nrao1	N	140.2	13.8	18.1	14.8	19.4	983.9	4409.0	9.7	15.9
91-Feb-16	Jan91	Polaris	O	53.1	13.8	18.9	13.9	19.6	1245.9	1301.0	9.5	15.9
91-May-03	Apr91	Nrao1	N	100.5	13.9	18.1	15.0	19.5	924.6	1323.0	9.7	15.9
91-May-15	Jul91	Lemur	T	155.7	14.0	19.0	15.2	19.6	1245.9	830.3	9.5	15.9

Table 9: Large DDT results for MX

Test Date	AIPS Version	CPU	Old New Tst	VTESS CPU Time	VTESS CLN Peak	VTESS CLN RMS	Total CPU Time	Notes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
86-Apr-15	?	Nrao1	?		99.0		0.0	Edgeskip= 0
86-Jul-24	?	CVAX-PS	N				250.4	Edgeskip= 4
86-Aug-08	?	CVAX	?	283.1	1.9	9.1	656.2	Edgeskip= 0
86-Jun-18	Jul86	Nrao1	?	138.4	17.0	19.3	425.6	Edgeskip= 3
86-Aug-14	?	Nrao1	?	138.4	17.0	19.3	448.4	Edgeskip= 3
87-Mar-01	Jul87	Nrao1	?	100.3	3.7	10.9	378.9	Edgeskip= 3
88-Mar-06	?	Nrao1	?				189.0	Edgeskip= 3
88-Aug-29	Jul88	Gorilla	O	735.0			6269.0	Edgeskip= 3
89-Jun-17	Apr89	CVAX	O	137.2	21.0	27.7	485.0	Edgeskip= 4
89-Jul-23	Apr89	Nrao1	O	42.9	19.2	26.5	276.2	Edgeskip= 4
89-Jul-23	Oct89	Nrao1	T	42.9	19.2	26.5	280.0	Edgeskip= 4
89-Jul-23	Oct89	Gorilla	T	871.2	22.3	29.7	6619.2	Edgeskip= 4
89-Jul-23	Jul89	Gorilla	N	737.6	22.3	29.7	11738.2	Edgeskip= 4
89-Jul-23	Oct89	CVAX	T	153.0	21.0	27.7	503.2	
89-Jul-23	Oct89	CVAX-PS	T	293.7	18.9	25.8	3953.0	Edgeskip= 4
89-Sep-18	Apr89	Kong	O	496.9	3.7	10.2	5936.1	Edgeskip= 4
89-Sep-19	Oct89	Kong	N	433.5	19.4	26.7	5845.7	Edgeskip= 4
89-Oct-01	Oct88	Trace	T	33.6			164.2	Edgeskip= 4
90-Feb-01	Oct89	Nrao1	O	38.7	16.8	21.9	270.7	Edgeskip= 4
90-Feb-02	Jul90	Nrao1	T	45.5	16.8	21.9	257.6	Edgeskip= 4
90-Feb-02	Jul90	SAIPS	T				2426.7	Edgeskip= 4
90-Feb-05	Jul90	SAIPS	T	575.8	16.8	21.9	4787.8	Edgeskip= 4
90-Apr-06	Apr90	Nrao1	O	35.4	16.8	21.9	207.7	Edgeskip= 4
90-Apr-06	Apr90	SAIPS	O	550.4	17.3	21.9	4608.7	Edgeskip= 4
90-Apr-09	Apr90	CVAX-PS	O	297.5	18.9	25.8	3212.1	Edgeskip= 4
90-Apr-10	Apr90	OUTBAX	O		18.9	25.8	0.0	Edgeskip= 4
90-May-31	Jul90	CVAX-PS	N	308.2	18.9	25.8	3664.5	Edgeskip= 4
90-Jun-05	Apr90	Nrao1	O	35.9	18.7	26.0	218.2	Edgeskip= 4
90-Jun-05	Jul90	Nrao1	N	37.6	18.7	26.0	213.6	Edgeskip= 4
90-Jun-05	Oct90	CVAX-PS	T	327.9	18.9	25.8	3725.4	Edgeskip= 4
91-Jan-16	Jan91	Nrao1	O	45.7	18.7	26.0		Edgeskip= 4
91-Feb-15	Jan91	Mandrill	O	93.5	22.3	29.8		Edgeskip= 4
91-May-14	Apr91	Nrao1	N	50.4	18.7	26.0		Edgeskip= 4

Table 10: Small DDT results for VTESS and Total DDT CPU time

Test Date	AIPS Version	CPU	Old New Tst	VTESS CPU Time	VTESS CLN Peak	VTESS CLN RMS	Total CPU Time	Notes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
89-Jul-23	Apr89	Nrao1	O				933.1	Edgeskip=16
89-Jul-23	Jul89	Nrao1	N	92.7	21.5	29.3	1030.3	Edgeskip=16
89-Jul-23	Oct89	Nrao1	T	98.4	23.1	30.9	1053.5	Edgeskip= 4
89-Jul-24	Jul89	Gorilla	N	2241.8	14.5	18.6	56701.4	
89-Jul-24	Apr89	CVAX	O				777.5	Edgeskip= 4
89-Jul-24	Oct89	CVAX	T	295.0	25.1	33.0	1040.0	Edgeskip= 4
89-Sep-19	Apr89	Kong	O	1673.3	3.1	9.9	30357.7	Edgeskip= 8
89-Sep-20	Oct89	Kong	N	1321.8	21.8	29.7	30036.8	Edgeskip= 8
90-May-29	Jul90	Nrao1	N	77.7	21.5	29.4	651.3	Edgeskip= 4
90-Jun-01	Oct90	Nrao1	T	153.0	21.5	29.4	951.0	Edgeskip= 8
90-Jun-01	Jul90	SAIPS	N	2272.2	22.5	30.2	34826.8	Edgeskip= 8
90-Jun-04	Apr90	SAIPS	O	1776.0	21.8	29.9	28661.8	Edgeskip= 8
91-Jan-16	Jan91	Nrao1	O	88.0	21.5	29.3		Edgeskip= 8
91-May-14	Apr91	Nrao1	O	96.5	21.5	29.3		Edgeskip= 8

Table 11: Medium DDT results for VTESS and Total DDT CPU time

Test Date	AIPS Version	CPU	Old New Tst	VTESS CPU Time	VTESS CLN Peak	VTESS CLN RMS	Total CPU Time	Notes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
89-Jul-23	Apr89	Nrao1	O				2653.5	
89-Jul-23	Oct89	Nrao1	T	440.7	20.9	29.0	2988.7	
89-Jul-23	Oct89	CVAX	T	1072.9	22.8	31.1	3352.7	Edgeskip= 12
89-Sep-21	Apr89	Kong	O	7944.8	5.5	11.2	85253.2	Edgeskip= 16
90-Jun-25	Jul90	Nrao1	N	389.1	21.2	20.2		Edgskip= 12
91-Feb-16	Jan91	Polaris	O	172.3	18.7	27.24		Edgskip= 16
91-May-03	Apr91	Nrao1	N	348.7	21.2	29.2		Edgskip= 16
91-May-15	Jul91	Lemur	T	197.3	18.6	27.2		Edgskip= 16, Not all optimized

Table 12: Large DDT results for VTESS and Total DDT CPU time