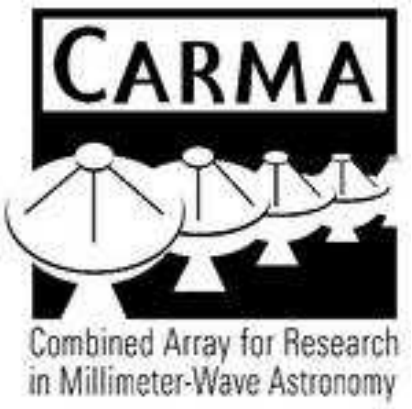


CARMA Memorandum Series #xx

# Antenna Configuration Evaluation

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## ABSTRACT

In this memo we show that the array performance is improved by eliminating two stations, reducing the costs of stations, power and fiber connections and roads, and time spent in antenna reconfigurations. The modified C configuration uses station 57 instead of station 33 which was only used in CARMA C configuration. The modified A configuration uses station 20 from the B configuration instead of station 8 which was only used in the A configuration. For each configuration we simulated observations from -2 to +2 hours sampled at 36 sec intervals. In practice, observations will be interrupted by calibrations and not sampled symmetrically about transit. The effects of the proposed changes are smaller than the effect of the heterogeneous antenna sizes, different weighting, and non optimum sampling of the data. We eliminate a NS station and a section of the loop road and power and fiber distribution. The modified A configuration has a shorter minimum uv spacing and more overlap with the B configuration, allowing better calibration between A and B configurations and more reliable estimates of decorrelation from atmospheric turbulence.

*Change Record*

| Revision | Date | Author | Sections/Pages Affected |
|---|---|---|---|
| | Remarks | | |
| 1.0 | 2004-Mar-24 | MCHW | 1-10 |
| | Original email text mailed to CARMA working group | | |
| 1.1 | 2004-Apr-07 | MCHW | 1-10 |
| | Added tables for heterogeneous arrays | | |
| 1.2 | 2004-Apr-28 | MCHW | 1-1 |
| | improved abstract | | |
| 1.3 | 2004-Apr-29 | MCHW | 1-10 |
| | submitted as CARMA memo | | |

## 1. Introduction

The current CARMA A configuration for 15 antennas uses 4 stations to the east of highway 168 to provide large east-west baselines. These four stations need long fiber runs and separate roadway and power infrastructure. In this memo we explore alternative antenna configurations using stations on the west side of highway 168.

Antenna configurations for Cedar Flat are based on studies of the uv-coverage and synthesised beam characteristics obtained with 15 antennas (CARMA memos 19, 20) Changes to the antenna configuration were required to accommodate the boundaries and topography of the chosen site, and a revised center location for the CARMA C/D/E arrays was chosen (CARMA memo 23) In memo 25 we showed that the array performance was not significantly changed by eliminating two stations.

## 2. Results

alternatve$_A$.$beams.results.20mar06comparesbeamwidths, sensitivities, sidelobes, shadowinganduvrangefor$

A.ant CARMA-15 A-configuration with station 20 instead of 8 B.ant CARMA-15 B-configuration using station 16-30 B+18.ant CARMA A+B configuration. 18-antenna without stations 1-5 B+.ant CARMA-15 A-configuration without stations 1-4 B+30-5.ant CARMA-15 A-configuration without stations 1-5

A and B are "standard".

B+18 is an 18-antenna configuration without stations 1-5. This shows what might be done with a few more antennas on A and B stations rather than clustered as in the EZ, DZ and CZ that I looked at before in memo 25 and 27.

B+ is an A-configuration without stations 1-4 B+30-5 is an A-configuration without stations 1-5 (B+ 30, omit 5)

These last two were the contenders as an alternative A configuration.

B+30-5.ant has better sidelobes and brightness sensitivity. Bes an analysis of alternative A array configuarions without stations 1-4.

. Main conclusion is that better beams are obtained by also omitting station 5. Better sidelobes and brightness sensitivity.

. Station 5 was located to fill the gap between 1-4 and 6-15. and is logically part of this A configuration.

. Defer building station 5 until stations 1-4 are built.

. If stations 1-4 are not built, we should re-evaluate the best location for additional stations (if any)

in the light of experience using the 15-antenna array and possibility of using 3.5 m antennas in 23-antenna configurations. 30-5 has more complete uv sampling which makes it more robust to missing data. Table 5 compares the beam widths and brightness sensitivity using different weightings of the uvdata. The resolution is enhanced using robust weighting. Table 5 shows the loss in brightness sensitivity which also favors the B+30-5 configuation.

The array configurations and results are all in http://astron.berkeley.edu/ wright/carma/config

I suppose I should put these results into another memo.

We compare the performance of the original and modified CARMA configurations.

The fitting procedures are simple **unix csh** scripts which control **MIRIAD** tasks. (CARMA memo 5). These scripts are similar to those used for ALMA and ATA simulations, but are slightly more complex because of the different antenna sizes used in the heterogeneous CARMA telescope. The script generates uv-data for a point source with thermal and atmospheric phase noise, does a phase calibration, and makes an image and beam. A Gaussian fit is made to the synthesised beam, and the results written into a table. The brightness sensitivity, beam FWHM, and residual sidelobe level after the fit are calculated. In addition the script plots the uvcoverage and beam where one can inspect the 2D uvcoverage and sidelobe distribution.

Table 1 lists the synthesized beam FWHM, brightness sensitivity, Tb rms, synthesized beam sidelobe levels, fraction of unshadowed data used in synthesized beam, Nvis, and *uv* range for declinations 30, 0 and -30 for the current configurations.

Table 2 compares the current and modified CARMA C configuration using station 57 instead of station 33 which was only used in CARMA C configuration. The beam characteristics are listed for the original and modified (Cp) configuration for declinations 45, 30, 15, 0, -15, and -30 degrees.

The original and modified beam FWHM are the same within 0.01 arcsec, the uvrange is the same, and the sidelobe levels are better for 4 of the 6 sampled declinations.

Table 3 compares the current and modified CARMA (Ap) configuration which uses station 20 from the B configuration instead of station 8 which was only used in the A configuration. Here, the goal was to eliminate a NS station and a section of the loop road and power and fiber distribution.

The change in the beam shape and sidelobe levels is again very small. The modified A configuration has a shorter minimum uv spacing and more overlap with the B configuration. Both these features have proved desirable from experience with the BIMA long baselines. The beam is rounder at all declinations, and the brightness sensitivity 10% better at high declination.

Table 4 and 5 list the beam characteristics for the CARMA configurations when the stations are populated with 6 and 10m antennas in two different ways. In Table 4 the first 6 antennas are 10m and the last 9 are 6m. In Table 5 the last 6 antennas are 10m and the first 9 are 6m.

For each configuration we simulated observations from -2 to +2 hours sampled at 36 sec intervals.

In practice, observations will be interrupted by calibrations and not sampled symmetrically about transit.

The effects of the proposed changes are smaller than the effect of the heterogeneous antenna sizes, different weighting, and non optimum sampling of the data.

## 3. Conclusion

In this memo we show that the beam characteristics are not significantly changed by eliminating two stations. The modified C configuration uses station 57 instead of station 33 which was only used in CARMA C configuration. The modified A configuration uses station 20 from the B configuration instead of station 8 which was only used in the A configuration. We eliminate a NS station and a section of the loop road and power and fiber distribution. The modified A configuration has a shorter minimum uv spacing and more overlap with the B configuration, allowing better calibration between A and B configurations and more reliable estimates of decorrelation from atmospheric turbulence.

Overall the array performance is improved by reducing the costs of stations, power and fiber connections and roads, and time spent in antenna reconfigurations.

## REFERENCES

CARMA memo 5, Compact Configuration Evaluation for CARMA, Melvyn Wright, Sep 2002

CARMA memo 19, Version 1 CARMA Configurations for Cedar Flat, Tamera Helfer and Melvyn Wright, February 2004.

CARMA memo 20, Version 2 CARMA Configurations for Cedar Flat, Tamera Helfer, February 2004.

CARMA memo 23, Lots in Translation: A Revised Center Location for the CARMA C/D/E Arrays, Glen Petitpas, March 2004.

CARMA memo 25, Antenna Configuration Evaluation, Melvyn Wright, Sep 2002

Table 1: current configurations

| Config | DEC | HA | Rms | FWHM | Tb rms | Sidelobe[%] | | | Nvis | uvrange | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | degrees | [hrs] | [mJy] | [arcsec] | [mK] | Rms | Max | Min | [%] | [m] | |
| A | 30 | -2,2,.01 | 0.23 | 0.15 x 0.12 | 295.4 | 1.8 | 9.3 | -7.0 | 100 | 181 | 188 |
| B | 30 | -2,2,.01 | 0.23 | 0.37 x 0.30 | 47.9 | 2.1 | 10.9 | -6.9 | 100 | 82 | 94 |
| C | 30 | -2,2,.01 | 0.23 | 0.91 x 0.75 | 7.8 | 2.0 | 10.0 | -6.0 | 100 | 25 | 37 |
| D | 30 | -2,2,.01 | 0.23 | 2.22 x 1.91 | 1.3 | 2.0 | 10.0 | -6.2 | 100 | 10 | 14 |
| E | 30 | -2,2,.01 | 0.23 | 4.49 x 3.95 | 0.3 | 1.9 | 8.8 | -6.7 | 100 | 8 | 66 |
| A | 0 | -2,2,.01 | 0.27 | 0.16 x 0.15 | 260.1 | 2.5 | 29.3 | -7.1 | 100 | 144 | 183 |
| B | 0 | -2,2,.01 | 0.27 | 0.38 x 0.37 | 44.4 | 2.6 | 27.1 | -11.6 | 100 | 65 | 89 |
| C | 0 | -2,2,.01 | 0.27 | 0.94 x 0.91 | 7.3 | 2.6 | 34.5 | -8.0 | 100 | 18 | 32 |
| D | 0 | -2,2,.01 | 0.27 | 2.39 x 2.22 | 1.2 | 2.6 | 29.5 | -9.6 | 100 | 8 | 12 |
| E | 0 | -2,2,.01 | 0.27 | 5.00 x 4.44 | 0.3 | 2.6 | 47.0 | -9.5 | 100 | 6 | 65 |
| A | -30 | -2,2,.01 | 0.56 | 0.32 x 0.15 | 269.7 | 1.8 | 9.0 | -6.7 | 100 | 62 | 169 |
| B | -30 | -2,2,.01 | 0.56 | 0.76 x 0.38 | 44.8 | 1.7 | 9.1 | -6.6 | 100 | 31 | 80 |
| C | -30 | -2,2,.01 | 0.56 | 1.89 x 0.93 | 7.4 | 1.7 | 8.8 | -6.3 | 100 | 10 | 28 |
| D | -30 | -2,2,.01 | 0.57 | 4.73 x 2.25 | 1.2 | 1.7 | 8.4 | -6.5 | 96 | 5 | 11 |
| E | -30 | -2,2,.01 | 0.80 | 8.53 x 3.87 | 0.6 | 2.3 | 14.5 | -9.0 | 49 | 3 | 56 |

Table 2: Modified CARMA (Cp) configuration using station 57 instead of station 33

| Config | DEC | HA | Rms | FWHM | Tb rms | Sidelobe[%] | | | Nvis | uvrange | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | degrees | [hrs] | [mJy] | [arcsec] | [mK] | Rms | Max | Min | [%] | [m] | |
| C | 45 | -2,2,.01 | 0.23 | 0.91 x 0.75 | 7.8 | 1.8 | 11.7 | -5.9 | 100 | 24 | 369 |
| Cp | 45 | -2,2,.01 | 0.23 | 0.90 x 0.75 | 7.9 | 1.8 | 11.1 | -5.9 | 100 | 24 | 369 |
| C | 30 | -2,2,.01 | 0.23 | 0.91 x 0.75 | 7.8 | 2.0 | 10.0 | -6.0 | 100 | 25 | 373 |
| Cp | 30 | -2,2,.01 | 0.23 | 0.90 x 0.75 | 7.9 | 2.0 | 9.1 | -6.3 | 100 | 25 | 373 |
| C | 15 | -2,2,.01 | 0.24 | 0.91 x 0.81 | 7.5 | 2.2 | 12.1 | -6.8 | 100 | 22 | 359 |
| Cp | 15 | -2,2,.01 | 0.24 | 0.90 x 0.80 | 7.7 | 2.2 | 13.1 | -7.1 | 100 | 22 | 359 |
| C | 0 | -2,2,.01 | 0.27 | 0.94 x 0.91 | 7.3 | 2.6 | 34.5 | -8.0 | 100 | 18 | 324 |
| Cp | 0 | -2,2,.01 | 0.27 | 0.94 x 0.90 | 7.4 | 2.6 | 30.6 | -8.3 | 100 | 18 | 324 |
| C | -15 | -2,2,.01 | 0.34 | 1.22 x 0.91 | 7.1 | 2.0 | 9.8 | -6.2 | 100 | 14 | 305 |
| Cp | -15 | -2,2,.01 | 0.34 | 1.21 x 0.91 | 7.1 | 2.0 | 12.0 | -6.4 | 100 | 14 | 305 |
| C | -30 | -2,2,.01 | 0.56 | 1.89 x 0.93 | 7.4 | 1.7 | 8.8 | -6.3 | 100 | 10 | 284 |
| Cp | -30 | -2,2,.01 | 0.56 | 1.88 x 0.93 | 7.4 | 1.7 | 7.5 | -6.1 | 100 | 10 | 284 |

Table 3: Modified CARMA (Ap) configuration using station 20 instead of station 8

| Config | DEC | HA | Rms | FWHM | Tb rms | Sidelobe[%] | | | Nvis | uvrange | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | degrees | [hrs] | [mJy] | [arcsec] | [mK] | Rms | Max | Min | [%] | [m] | |
| A | 45 | -2,2,.01 | 0.23 | 0.15 x 0.12 | 295.4 | 1.7 | 8.7 | -7.2 | 100 | 182 | 188 |
| Ap | 45 | -2,2,.01 | 0.23 | 0.15 x 0.13 | 272.7 | 1.7 | 7.4 | -7.2 | 100 | 140 | 188 |
| A | 30 | -2,2,.01 | 0.23 | 0.15 x 0.12 | 295.4 | 1.8 | 9.3 | -7.0 | 100 | 181 | 188 |
| Ap | 30 | -2,2,.01 | 0.23 | 0.15 x 0.13 | 272.7 | 1.8 | 8.2 | -7.0 | 100 | 143 | 188 |
| A | 15 | -2,2,.01 | 0.24 | 0.15 x 0.13 | 284.6 | 1.9 | 13.3 | -6.9 | 100 | 163 | 188 |
| Ap | 15 | -2,2,.01 | 0.24 | 0.15 x 0.13 | 284.6 | 2.0 | 14.1 | -6.9 | 100 | 127 | 188 |
| A | 0 | -2,2,.01 | 0.27 | 0.16 x 0.15 | 260.1 | 2.5 | 29.3 | -7.1 | 100 | 144 | 183 |
| Ap | 0 | -2,2,.01 | 0.27 | 0.16 x 0.15 | 260.1 | 2.5 | 33.4 | -7.1 | 100 | 104 | 183 |
| A | -15 | -2,2,.01 | 0.34 | 0.20 x 0.15 | 262.0 | 1.9 | 10.8 | -6.8 | 100 | 108 | 172 |
| Ap | -15 | -2,2,.01 | 0.34 | 0.20 x 0.15 | 262.0 | 1.9 | 10.8 | -6.6 | 100 | 77 | 172 |
| A | -30 | -2,2,.01 | 0.56 | 0.32 x 0.15 | 269.7 | 1.8 | 9.0 | -6.7 | 100 | 62 | 169 |
| Ap | -30 | -2,2,.01 | 0.56 | 0.33 x 0.15 | 261.6 | 1.7 | 9.2 | -6.6 | 100 | 53 | 169 |

Table 4: Heterogeneous array where the first 6 antennas are 10m and the last 9 are 6m

| Config | DEC | HA | Rms | FWHM | Tb rms | Sidelobe[%] | | | Nvis | uvrange | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | degrees | [hrs] | [mJy] | [arcsec] | [mK] | Rms | Max | Min | [%] | [m] | |
| A | 30 | -2,2,.01 | 0.18 | 0.14 x 0.12 | 247.7 | 2.3 | 13.0 | -9.9 | 100 | 181 | 18 |
| B | 30 | -2,2,.01 | 0.18 | 0.31 x 0.23 | 58.4 | 2.1 | 12.1 | -9.0 | 100 | 81 | 7 |
| C | 30 | -2,2,.01 | 0.18 | 1.21 x 1.02 | 3.4 | 3.4 | 15.7 | -9.7 | 100 | 48 | 2 |
| D | 30 | -2,2,.01 | 0.18 | 3.00 x 2.58 | 0.5 | 3.5 | 19.7 | -10.0 | 100 | 21 | 1 |
| E | 30 | -2,2,.01 | 0.18 | 5.77 x 5.21 | 0.1 | 2.9 | 16.8 | -9.0 | 100 | 10 | 5 |
| A | 0 | -2,2,.01 | 0.21 | 0.16 x 0.13 | 233.4 | 3.1 | 35.6 | -15.7 | 100 | 144 | 18 |
| B | 0 | -2,2,.01 | 0.21 | 0.31 x 0.29 | 54.0 | 2.9 | 39.0 | -14.5 | 100 | 64 | 6 |
| C | 0 | -2,2,.01 | 0.21 | 1.43 x 1.08 | 3.1 | 4.2 | 48.0 | -10.4 | 100 | 38 | 2 |
| D | 0 | -2,2,.01 | 0.21 | 3.60 x 2.70 | 0.5 | 4.3 | 39.7 | -15.3 | 100 | 17 | 1 |
| E | 0 | -2,2,.01 | 0.21 | 7.10 x 5.29 | 0.1 | 4.2 | 42.6 | -15.4 | 100 | 8 | 5 |
| A | -30 | -2,2,.01 | 0.43 | 0.32 x 0.14 | 221.9 | 2.2 | 12.1 | -10.1 | 100 | 110 | 16 |
| B | -30 | -2,2,.01 | 0.43 | 0.60 x 0.31 | 53.5 | 1.9 | 12.3 | -8.0 | 100 | 30 | 6 |
| C | -30 | -2,2,.01 | 0.43 | 2.56 x 1.13 | 3.4 | 3.0 | 14.1 | -7.5 | 100 | 25 | 2 |
| D | -30 | -2,2,.01 | 0.44 | 6.37 x 2.74 | 0.6 | 3.2 | 11.3 | -8.2 | 96 | 10 | 9 |
| E | -30 | -2,2,.01 | 0.73 | 10.70 x 4.24 | 0.4 | 3.6 | 22.7 | -11.7 | 50 | 3 | 5 |

Table 5: Heterogeneous array where the last 6 antennas are 10m and the first 9 are 6m

| Config | DEC | HA | Rms | FWHM | Tb rms | Sidelobe[%] | | | Nvis | uvrange | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | degrees | [hrs] | [mJy] | [arcsec] | [mK] | Rms | Max | Min | [%] | [m] | |
| A | 30 | -2,2,.01 | 0.18 | 0.15 x 0.13 | 213.4 | 2.5 | 10.6 | -11.8 | 100 | 181 | 188 |
| B | 30 | -2,2,.01 | 0.18 | 0.39 x 0.30 | 35.6 | 2.9 | 12.5 | -11.5 | 100 | 81 | 70 |
| C | 30 | -2,2,.01 | 0.18 | 1.18 x 0.61 | 5.8 | 2.6 | 14.3 | -19.9 | 100 | 48 | 27 |
| D | 30 | -2,2,.01 | 0.18 | 2.86 x 1.55 | 0.9 | 2.5 | 14.3 | -20.3 | 100 | 21 | 10 |
| E | 30 | -2,2,.01 | 0.18 | 3.90 x 3.52 | 0.3 | 2.2 | 19.2 | -14.5 | 100 | 10 | 5( |
| A | 0 | -2,2,.01 | 0.21 | 0.17 x 0.15 | 190.4 | 3.3 | 38.5 | -13.8 | 100 | 144 | 183 |
| B | 0 | -2,2,.01 | 0.21 | 0.40 x 0.37 | 32.8 | 3.8 | 27.9 | -23.8 | 100 | 64 | 69 |
| C | 0 | -2,2,.01 | 0.21 | 1.17 x 0.76 | 5.5 | 2.8 | 33.8 | -19.8 | 100 | 38 | 26 |
| D | 0 | -2,2,.01 | 0.21 | 2.82 x 1.92 | 0.9 | 2.8 | 37.6 | -21.7 | 100 | 17 | 10 |
| E | 0 | -2,2,.01 | 0.21 | 4.42 x 3.90 | 0.3 | 3.1 | 43.4 | -18.4 | 100 | 8 | 5( |
| A | -30 | -2,2,.01 | 0.43 | 0.35 x 0.16 | 177.5 | 2.4 | 11.6 | -11.4 | 100 | 110 | 169 |
| B | -30 | -2,2,.01 | 0.43 | 0.77 x 0.40 | 32.3 | 2.4 | 12.0 | -8.0 | 100 | 30 | 68 |
| C | -30 | -2,2,.01 | 0.43 | 1.54 x 1.18 | 5.5 | 1.9 | 9.7 | -15.9 | 100 | 25 | 24 |
| D | -30 | -2,2,.01 | 0.44 | 3.85 x 2.85 | 0.9 | 1.9 | 11.3 | -16.7 | 95 | 10 | 96 |
| E | -30 | -2,2,.01 | 0.55 | 7.32 x 3.44 | 0.5 | 2.7 | 16.2 | -14.0 | 43 | 3 | 5( |