VLAPLAN

VLA OBSERVING STRATEGY PLANNER

Version 1.3
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PREFACE

This document is a User's Guide for VLAPLAN -- PC software to assist continuum and line observers with the preparation of VLA observing proposals and observing strategies. VLAPLAN carries out the main calculations that are required to design a VLA observation to produce a given image quality and sensitivity, within the restrictions imposed by the VLA correlator and by computer limitations. The program is a spreadsheet that lets the user adjust the imaging parameters interactively, while reviewing the consequences for VLA configuration choices, total integration times and other critical parameters. The program warns the user about conflicts between the imaging parameters and the VLA hardware capabilities, and suggests strategies for removing such conflicts. It also contains menu-based documentation that can guide the choice of parameters and help the user to learn the program's capabilities.

The software is contained in worksheets that can be run under Lotus *1-2-3*, Borland *Quattro*, or any other spreadsheet programs that will read and execute files in .WK1 or .WKQ format. Little or no user familiarity with the host spreadsheet program is required. The worksheets provide their own menus to lead the user through the basic calculations, and to provide on-screen documentation about the required input parameters. Special key definitions are used to display graphs that are automatically scaled to the context of the user's input parameters.

My aim has been to consolidate into one PC-based package most of the algorithms and graphs that are useful when designing VLA observations but which were previously scattered through many different NRAO documents. These documents include my own lecture "VLA Observing Strategies" from the NRAO Summer Schools on *Synthesis Imaging*, numerous VLA Scientific and Test Memoranda, the *NRAO Newsletter*, the *VLA Observational Status Report* and the *Introduction to the NRAO VLA* (the "Green Book"). Many VLA users have asked for an "expert system" to design VLA observations. This is not such a system. The user must still decide how to make the fundamental tradeoffs between image quality, observing time and data volume that are central to the design of a VLA observing strategy. But I hope that VLAPLAN will make it easier for users to assess these tradeoffs, both by quickly showing the global result of any change in the imaging parameters, and by consolidating the most important calculations (and advice about their consequences) into one place.

Copies of the software are available on 5-1/4 inch diskettes upon request to Sandra Montoya at NRAO, P.O. Box O, Socorro, NM 87801, U.S.A.

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THE NRAO DISTRIBUTION DISKETTE

The distribution diskette that you have received from the NRAO should contain the following files:

In the root (\) directory:

LOTUS.DIR	Lotus *1-2-3* sub-directory
QUATTRO.DIR	*Quattro* sub-directory
README	This text
README.COM	Utility for viewing README
PKXARC.COM	Utility for extracting files
MKLOTUS.BAT	Batch instal for *1-2-3* users
MKQUATTRO.BAT	Batch instal for *Quattro* users

In the \LOTUS sub-directory:

WK1.ARC   Archived *1-2-3* worksheets

In the \QUATTRO sub-directory:

WKQ.ARC   Archived *Quattro* worksheets

To run this software, you will need an IBM PC or clone with at least 320k of RAM, a graphics board, and a spreadsheet program that can read worksheets in either Lotus *1-2-3* Version 2 (.WK1) format or Borland *Quattro* (.WKQ) format. If you do not have either Lotus *1-2-3* Version 2, or Borland *Quattro*, I cannot guarantee that all parts of this package will run correctly. Version 1.2 of this software has, however, been translated to Excel successfully; contact Al Braun at the VLA (505-835-7335) for details.

The two worksheets, VLAPLAN3 and VLAUVPL3, are stored on the distribution disk in a compressed (archived) format.

To extract them in .WK1 format, insert the distribution disk in the drive of your choice and make that the default drive (e.g., put the diskette in drive B and then type B: <CR> where <CR> is a carriage return). Then type:
          MKLOTUS <pathname> <CR>
where *<pathname>* is the full path name *(disk, directory, sub-directory)* in which you wish to store the un-archived .WK1 files. Examples might be:
          MKLOTUS C:\LOTUS\WKS <CR> for a hard disk C:
          MKLOTUS A:\ <CR>   for a diskette A:

At least 210k of disk space must be available in the selected path.

To extract them in .WKQ format, follow the above instructions but substitute MKQUATTR for MKLOTUS, e.g.
          MKQUATTR C:\QUATTRO\WKQ <CR> or
          MKQUATTR A: <CR>

HOW TO INSTALL THE WORKSHEETS AND CHECK SETTINGS

Lotus *1-2-3* Users

The main program is contained in the Lotus *1-2-3* Version 2 worksheet file VLAPLAN3.WK1.   If you have received WK1.ARC, you must first extract VLAPLAN3.WK1 from this archived format (see previous page).   The second worksheet, VLAUVPL3.WK1, in the .ARC file is an optional extra.

VLAPLAN3.WK1 and VLAUVPL3.WK1 must be run under Lotus *1-2-3* Version 2. Copy VLAPLAN3.WK1 to the disk and directory where you normally keep your Lotus worksheets, then start *1-2-3*.   When you use the *1-2-3* **File Retrieve** command (**/FR VLAPLAN3**) to load the worksheet, the VLAPLAN title screen should appear automatically as soon as the file has loaded.

Press **HOME** to view the *Continuum Summary* screen.   Some cells should be highlighted (unprotected) if you have a color monitor or a Compaq computer. If you have full color capability and no cells are highlighted, you may have received a copy of the worksheet from which the global protection was removed by another user.   In this case, use **Worksheet Global Protect Enable** (**/WGPE**) to protect it, and **File Save** (**/FS VLAPLAN3**) to save the protected version, before proceeding.

If you see the top few lines of the *Line Summary* screen when you press **HOME**, re-adjust your screen set-up to give a standard 25-line display.   All the calculation screens and help files in VLAPLAN are 20 lines deep, so they will be confusing to read if you display more than 20 lines of the spreadsheet at once.

Press **ALT-T** to view the *Time Average Smearing* Graph.   Check that axis labeling is legible and sensible.   The settings stored in the worksheet work reasonably well on IBM CGA, Hercules and VGA graphics boards that I have used. But if those you have received are inappropriate, use the *1-2-3* **/G** *(Graph)* menu to define new setups for the named graphs AVTIME, BANDWID, GAUSSVIS, PBCOR and RFILBAND, save your settings with **/GNC AVTIME**, etc., and then save the worksheet to disk with **File Save** (**/FS VLAPLAN3**).

Lotus *1-2-3* Version 1A Users

Translating VLAPLAN3.WK1 to VLAPLAN3.WKS with a Version 2 Translate utility will not work fully.   VLAPLAN uses @VLOOKUP to grab strings (labels) from tables, and uses a few formula constructions that Version 1A does not accept.

Borland *Quattro* Users

    The NRAO distribution diskette contains WKQ.ARC, from which you can
extract the files VLAPLAN3.WKQ and VLAUVPL3.WKQ as described under "The NRAO
Distribution Diskette". These .WKQ worksheets contain graphics setup commands
that have been customized for *Quattro*. Their macros are identical to those
in the *1-2-3* version, however, so the .WKQ worksheets should be used with
Quattro in its *1-2-3* command mode. To use this mode, you must have run
123MENU.BAT from your *Quattro* distribution disk once to create a Q123.DEF
file. You then start up *Quattro* with the command Q123.

    If you have somehow acquired only VLAPLAN3.WK1 and VLAUVPL3.WK1, these can
also be run under *Quattro* in its Lotus *1-2-3* command mode, but they do not
contain the *Quattro* setup commands for the graphics displays. You should
therefore load VLAPLAN3.WK1 "as is" under *Quattro*, then set colors, grid and
axis defaults for each of the named graphs: AVTIME, BANDWID, GAUSSVIS, PBCOR
and RFILBAND. To do this, type /GNU followed by the graph name, and use the
Quattro Graph Menu to adjust the graph displays to your satisfaction (you
should, for example, reset *Quattro*'s Y-axis scaling of PBCOR to *Manual*, with
a lower limit of 1). After adjusting each graph, store its settings with /GNC
followed by the graph name. Finally, save the modified spreadsheet in .WKQ
format with **File Save (/FS VLAPLAN3.WKQ)**.

    If you wish to use either VLAPLAN3.WKQ or VLAPLAN3.WK1 with *Quattro* in its
default mode, you must modify macros to handle differences between the graph
and print menu commands in *1-2-3* and default *Quattro*.   For example, the
macros invoked by **ALT-B, ALT-P, ALT-Q, ALT-T** and **ALT-V** in VLAPLAN3.WK1 use the
Lotus *1-2-3* command **Graph Name Use (/GNU)** to load named graphs. You must
remove cell protection in *Quattro* with **/DPD (Default Protection Disable)** and
change these macros (at locations AB13, AD13, AF13, AH13 and AJ13) to the
Quattro equivalent: **Graph Name Display (/GND)**. Then set colors and axis
defaults for *Quattro* as described above. If you also wish to use the **ALT-Y**
feature of VLAPLAN to print out parts of the spreadsheet, you must convert the
macros in AB79-81, AC79-83, AD79-82 and AE79-82 to their default *Quattro*
equivalents (see the *Quattro* Reference Manual, Table 4.3, for the syntax).
This is a tedious job, so I strongly recommend running in *1-2-3* command mode
as an alternative! But if you do it, do not forget to protect the worksheet
with **/DPE (Default Protection Enable)** and save it as VLAPLAN3.WKQ before
executing further commands under *Quattro*! Do not save it in .WK1 format, in
case you mistakenly load it into *1-2-3* later; for example, *1-2-3* interprets
/GND as **Graph Name DELETE!**

    To run VLAUVPL3.WKQ or VLAUVPL3.WK1 under default *Quattro*, you should
change /GNU to /GND at locations B114, B119, B124 and D124, then re-save this
worksheet, for similar reasons.

    (I may find the time to improve portability by using menu-equivalent
macro commands some time in the future, but this is not a high priority at the
moment).

HOW TO USE THIS PROGRAM

This program makes various calculations to assist the planning of VLA observing strategies. It is intended for use when writing VLA proposals and/or when beginning to design a VLA observing program in detail. It will help you choose observing parameters to minimize image distortions, observing time and total data volume in ways that meet the restrictions imposed by the VLA hardware. It also reflects some computing policies that are in effect at the VLA at the time of writing the program.

The *Continuum Summary* and *Line Summary* screens prompt you for the basic VLA observing parameters, and compute various important quantities from them. Changing any input parameter recalculates all related quantities. Input parameters should, in general, be changed by making use of the ALT-keys, as indicated on the screens that display these parameters. Use the *Summary* screens to explore options and to get a feel for how the project strategy depends on your input choices. Watch for warning messages about your parameters (press ALT-W for a summary of warnings).

Other screens give details of subsidiary calculations. Press ALT-M for a menu of such calculations. Other ALT-keys are used to change input values or to plot useful graphs while reviewing these subsidiary calculations. ALT-K lists the special keys and menus.

Unless you are familiar with Lotus *1-2-3* or *Quattro*, it may take a while to become used to the menu system. First-time users should watch the "indicator light" (top right in *1-2-3*, bottom right in *Quattro*) carefully. It shows important program status information, including:

READY -- Program is ready for the next data entry or command

MENU -- A command menu is being displayed; you must make a selection or press ESC to leave a menu level

VALUE -- You are entering a number; use **backspace** to edit, <CR> to enter, **CTRL-BREAK** to abort.

ERROR -- An error has occurred; press ESC or <CR> to clear it

Beginners should select menu items by using the arrow keypad to point at (highlight) items, then hitting <CR>. A one-line explanation appears immediately above the spreadsheet as each item is highlighted. "Power users" can select items faster by typing their initial letters.

The *Help* menu (ALT-H) can be used to access various levels of text that should make the program self-documenting. As well as the text you are now reading, there are explanatory pages for each input parameter (ALT-H,I), and for each major element of observing strategy (ALT-H,S). (ALT-H,N) tells you how to get information from NRAO about VLA proposals, hardware and software.

<u>ORDER OF ATTACK</u>

A. Overview

1. Enter parameters in the order in which they are listed on the *Continuum Summary* and *Line Summary* screens (key HOME and PgDn to see these screens). Watch for warning messages as you enter values, and by using **ALT-W**.

2. Use **ALT-M** to see further details of critical calculations, **ALT-H** to get advice about inputs. Watch for warning messages while iterating parameters.

3. Review your final parameter choices on the *Summary* screens and check again for warning messages with **ALT-W**.

The next five sections outline the main calculations, each of which corresponds to a screen in the **ALT-M menu**. The program's **ALT-H** menu gives much more detailed advice than is given here.

B. Choose VLA configuration(s)

Three main parameters are needed:

1. Observing Frequency
   For continuum work, choose this from astrophysical considerations, e.g. for polarimetry, *or* choose it for optimum sensitivity or phase stability. For line work, choose it from the rest frequency and systemic velocity.

2. HPBW of Synthesized Beam
   Choose this to balance the resolution of fine detail against the detection of extended emission. The HPBW sets the *longest* baseline you must use at a given frequency, and hence the *widest* VLA configuration in which you must take data.

3. Largest Angular Structure to be Imaged
   This sets the *shortest* baseline you must use, and thus the most compact VLA configuration in which you must take data. The baseline used by the program to recommend the configuration(s) is that by which a Gaussian with *FWHM=LAS* falls to half its peak amplitude in the u,v plane. Use **ALT-M,R** to see details of the *Resolution and Configuration* calculation and/or **ALT-V** to see the visibility of the Gaussian as a function of baseline length. The declination dependence of the VLA's shortest baseline is conservatively accounted for by assuming that the baseline is that of a meridian snapshot. To explore baseline foreshortening at large Hour Angles, use the VLAUVPL worksheet.

C. Balance Field of View Restrictions

Point sources away from the delay tracking center are attenuated and

smeared by finite IF bandwidth (chromatic aberration). Both effects increase with bandwidth and with angle from the delay tracking center. You specify an acceptable loss of point source amplitude at a maximum field radius (*MAX*); the program recommends a maximum bandwidth. Time averaging also smears and attenuates remote point sources by amounts depending on baseline, Hour Angle, and Declination. The program estimates (a) the averaging time that will, on average, distort the image at *MAX* radius as much as your chosen IF bandwidth, and (b) the averaging time that meets your "acceptable distortion" parameters. Estimate (a) is usually reasonable for continuum work; (b) is usually better for line work. Use **ALT-M,F** to review details.

D. Specify Sensitivity and Find Total Integration Time

Once bandwidth and averaging time are set, the target rms noise level sets the total on-source integration time, and thus the size of the data base. Use **ALT-M,S,C** to review details.

E. Spectral Line Observing

There are three screens specific to spectral line observing.

1. *Line Summary*
This screen can be invoked with **ALT-M,L** or with **PgDn** from the *Continuum Summary*. It shows the primary observing parameters and displays the restrictions on the numbers of channels and on averaging time, given the values of parameters already specified. It is possible to specify all line observing parameters from this screen alone, but also useful are the screens for:

2. *Spectral Line Channels*
This screen explicitly lists the options for spectral line channelization, given a choice of total bandwidth. It calculates the total velocity span and channel velocity resolution for your input parameters. It also warns of VLA computer rules that restrict the choice of averaging time. It is invoked with **ALT-M,N,L**.

3. *Spectral Line Sensitivity*
This screen examines both the "continuum" (all channels combined) and individual channel sensitivities and integration times, including surface brightness sensitivity. It is invoked with **ALT-M,S,L**.

F. Bandwidth Synthesis (optional)

ALT-M,N,B invokes a screen to assist design of continuum experiments that use the spectral line correlator to image wide fields of view at high total IF bandwidth with minimal distortion. It lists the hardware restrictions on the number of channels; it also gives data on bandwidth smearing per channel, on the averaging time equivalent to the per-channel smearing, and on the total integration time needed to reach the target rms with the full bandwidth

SPECIAL KEYS AND MENUS

The following can be used at any *READY* prompt:

1. Data entry keys (use CTRL-BREAK to abort data entry)

Key   Parameter name (units)

ALT-A prompts for   Vis. averaging time (sec)
ALT-C calls a menu for   Number of line channels
ALT-D prompts for   Distortion limit (%)
ALT-E prompts for   Source declination (degrees)
ALT-F prompts for   Observing frequency (GHz)
ALT-G prompts for   Largest Gaussian FWHM (")
ALT-I calls a menu for   IF Bandwidth (MHz)
ALT-J prompts for   Self-cal flux density (mJy)
ALT-L prompts for   Rms (line channel, mJy)
ALT-R prompts for   Rms (continuum, mJy)
ALT-S prompts for   Self-cal averaging time (sec)
ALT-X prompts for   Maximum field radius (")
ALT-Z prompts for   Synthesized HPBW (")

2. Menu Keys (use ESC to abort menu selection)

ALT-H calls a menu to select HELP text
ALT-M calls a menu to select CALCULATION screens
ALT-Y calls a menu to select PRINTOUTS

3. Direct Screen Selection Keys

HOME   shows *Continuum Summary*; then PgDn/PgUp --> *Line/Cont Summary*
ALT-K displays first page of two-page KEY listing
ALT-W displays a summary of WARNING messages about your parameters

4. Graph Selection Keys (hit any key to resume once graph displayed)

ALT-B graphs the BANDWIDTH smearing effect with current parameters
ALT-P graphs the PRIMARY beam correction out to *2*MAX* radius
ALT-Q graphs known L-Band RFI signals and the chosen Observing Band
ALT-T graphs the TIME-average smearing effect with current parameters
ALT-V graphs the VISIBILITY of a Gaussian (FWHM=LAS) vs baseline (km)

DETAILS ABOUT INPUTS

The following sections repeat *Help* screens from the spreadsheet.

Observing Frequency (GHz)   (ALT-F)

The frequency bands for which the VLA is (almost) fully instrumented are
tabulated below, with their VLA "band designations" and S, a measure of
the relative noise performance at these bands. (S is the rms noise per
correlator in 10 seconds, referred to a nominal 50 MHz bandwidth).

Frequency Range	Band	S
0.298 to 0.345 GHz	P Band	87 <--- N.B. only 3 MHz usable band
1.25 to 1.80 GHz	L Band	28
4.25 to 5.1 GHz	C Band	21
7.56 to 9.05 GHz	X Band	14.5
14.25 to 15.7 GHz	U Band	53
21.7 to 24.5 GHz	K Band	112 <--- for new (1988) receivers

The "frequency range" is for 3db loss of sensitivity. P and L Bands may
be affected by strong interfering signals, especially in the more compact
VLA configurations. Consult the VLA Frequency Coordinator before
making final frequency choices in these bands. Interference is rarely
detected or suspected at the higher frequencies.

Synthesized Half-Power Beamwidth - HPBW (arc seconds)   (ALT-Z)

Enter the HPBW that you will use at the MAXIMUM resolution for which
you need to collect data. Lower HPBW's may be obtained by tapering the
data.   UNIFORM weighting in the u,v plane and dense u,v coverage is
assumed. Snapshot observations may have beamwidths that are 20% or more
larger than those of full coverage. The HPBW also depends on
declination, but this can be ignored to first order when planning an
observing strategy.

Note that you will separately enter *LAS*, the largest angular size of
structure that you wish to image. If HPBW and *LAS* are very different,
the program may suggest the use of more than one VLA configuration.
You may wish to adjust parameters so that the project can be done in
one configuration (and thus in one observation). Consult the *Resolution
and Configuration* screen (ALT-M,R) for assistance.

The program will claim that you need VLBI if you input a smaller HPBW
than the VLA can provide at your frequency. Check the *Resolution and
Configuration* screen if this occurs; your HPBW may not be far off!

Largest Angular Scale to be Imaged - *LAS* (arcsec)   (ALT-G)

Enter the full width to half maximum of the largest circular Gaussian
emission region that you need to image. The program calculates the
baseline length (km) at which the visibility function of such a region
falls to half its maximum value at your observing frequency, and uses
this to estimate the shortest baseline that should be present in your
data. If you prefer another criterion, press ALT-V to plot visibility
against baseline length in km, then adjust criterion accordingly.

The program estimates the most compact configuration quite conservatively
from the shortest baseline at H.A. 0 at the next-lowest 10-degree
Dec. to your source; it does not account for baseline foreshortening
off the meridian. To do this, examine VLA u,v plots for your H.A. range
and Dec. (e.g. via VLAUVPL). Then ask if foreshortened baselines in the
next widest configuration provide the "Shortest Baseline" estimated (a)
by the *Resolution* screen (ALT-M,R), or (b) by you from an ALT-V plot.

Note: *LAS* is the diameter of the largest structural *scale* to be imaged,
not the field over which you wish to image point sources correctly.

Maximum Radius of Field with Minimal Distortion   (ALT-X)

Enter the radius in arcsec from the delay tracking center to which
you will need to image point sources with minimal distortion by
bandwidth smearing (chromatic aberration) or time-average smearing.

This parameter, together with the "acceptable distortion" parameter,
will determine the maximum IF bandwidth and data averaging time for
many continuum observations. You may wish to consider displacing
the delay tracking center away from your prime target toward other
interesting sources in order to minimize the value of *MAX*.

Note that *MAX* will normally be greater than about *0.5*LAS*, the radius
of the largest structural scale that you need to image in your target
source. (An exception to this rule occurs when the outer parts of
your target source contain no structure whose scale is smaller than
the broadened response, so are not noticeably distorted by the
additional smearing).

Acceptable Distortion - % reduction in point source response   (ALT-D)

This parameter specifies how much distortion due to bandwidth smearing
(chromatic aberration) or time-average smearing you can accept at
the angular radius from your image center specified by *MAX*. These
two parameters together determine the maximum IF bandwidth and data
averaging time for many continuum observations.

The distortions produced by bandwidth and time-average smearing reduce
and broaden the responses to point sources (preserving the integrated
flux densities so long as the effects remain fairly small). Bandwidth
smearing broadens the point source response radially away from the delay
tracking center. Time average smearing acts azimuthally round the phase
tracking center for a source at the pole.

The program measures the effect by the reduction in amplitude of the
point source response. You specify an acceptable percentage loss, $m\%$,
so that the peak response $I = I\_0*(1-m/100)$ where I_0 would be the peak
response in the absence of bandwidth or time-average smearing. Values
in the range 1-10% are tolerable for many applications.

IF Bandwidth (MHz)   (ALT-I)

You must select a standard VLA bandwidth, in MHz (ALT-I gives a menu).

The choice of bandwidth is a tradeoff between sensitivity needs (which
call for large bandwidths), bandwidth smearing effects (which may call
for small bandwidths in continuum work) and velocity coverage in line
work. You are likely to experiment with balancing your choices of IF
bandwidth, data averaging time, and total integration time against VLA
observing restrictions and overall data set size.

The *Continuum Summary* screen recommends an IF bandwidth based on your
field of view and distortion parameters. Continuum observers should
normally begin by entering this recommended bandwidth.

The *Line Summary* screen does not recommend an IF bandwidth because in
most line projects the effects of chromatic aberration are determined by
the single-channel bandwidth, so are small. The total IF bandwidth
is determined by the need to span line profiles and to include off-line
continuum, balanced against correlator and computing restrictions.

Data Averaging Time (sec)   (ALT-A)

This specifies how long the visibility data are averaged before being
recorded. The choice of averaging time is a tradeoff between minimizing
distortions far from the phase-tracking center, preserving the ability
self-calibrate atmospheric fluctuations, and keeping the total number of
visibility records within reasonable bounds. The first two criteria ask
for short averaging times; the last for long ones. The program will
warn you if you set the averaging time > your expected self-cal time.

For continuum work, the averaging time will usually be set by the need
to minimize distortions. Averaging times longer than 60 sec are rarely
appropriate, as they restrict the ability to edit calibrator scans,
which are often only about a minute long for sensitivity reasons.

For line work, the averaging time must often be longer than desirable
to reduce distortion and to follow atmospheric fluctuations, because of
limits to data set sizes that can be processed at the VLA. The limits
imposed by computer needs are geared to the number of line channels,
and are shown (and checked) in the *Line Summary* and *Warning* screens.

Number of Spectral Line Channels   (ALT-C)

The number of line channels must be a power of two and should be chosen
from the menu invoked by **ALT-C**.   The VLA correlator hardware couples
the options for numbers of line channels to (a) the total IF bandwidth,
(b) the number of separate IF's recorded and (c) whether or not on-line
Hanning smoothing is performed. Use the *Spectral Line Channels* screen
(invoked by **ALT-M,N,L**) to review the range of choices. N.B. the program
tells you the number of channels for a Single-IF experiment. The VLA
correlator also allows this total to be split evenly among 2 or 4 IF's.
The choice of number of line channels interacts with the choice of data
averaging time if data will be reduced at the VLA (Computer Rules).
Your final selection will be a compromise between these practical
restrictions and the astronomical requirements for (a) adequate
resolution per channel, (b) adequate spanning of the line profile, and
(c) adequate sensitivity (consult the screen invoked by **ALT-M,S,L**).

Use the *Line Summary* and *Spectral Line Channels* screens to experiment
with different choices and their consequences. The *Line Summary* screen
will warn of "illegal" choices.

Self-calibration parameters

1. *Self-cal Flux Density* (mJy)   (ALT-J)

Enter the total flux density that you expect to be able to include in
a model when self-calibrating the antenna gains. This will often be
the flux density in the brightest point-like components, but may also
include contributions from bright extended structure.

2. *Self-cal Averaging Time* (seconds)   (ALT-S)

Enter the time for which you expect to average each solution for the
antenna gains when self-calibrating. This should not exceed the
expected atmospheric phase coherence time, and cannot be less than
the visibility averaging time. A warning appears if you specify a
self-cal averaging time less than the visibility averaging time!

The program will calculate the rms of the gain solutions in amplitude
and phase within each self-cal averaging time. Use these to judge
whether self-calibration can improve your data.

Bandwidth Synthesis parameters   (ALT-M,N,B)

In the present context, "bandwidth synthesis" refers to using the VLA
spectral line correlator to observe continuum sources in a number of
narrow channels simultaneously. In this mode, the distortions produced
by chromatic aberration are governed by the IF bandwidth of the single
channels, whereas the sensitivity of the final image (assuming that it
is made by summing over all the channels) is determined by the total IF
bandwidth. Bandwidth synthesis thus lets you decouple the field of
view and sensitivity constraints for continuum work, *subject to the
same constraints on number of channels and averaging time as in spectral
line work*. It is useful for wide field imaging at high sensitivity.

The *Bandwidth Synthesis Summary* screen, invoked by **ALT-M,N,B**, lists (a)
the distortion due to chromatic aberration at the specified *MAX* radius
on the individual channel images, (b) the constraints on the number of
channels for the selected total bandwidth, (c) the constraints on the
visibility averaging time from image distortion and from VLA computer
rules (given the other selected parameters), and (d) the integration
time and data set size required for your specified final sensitivity.

USEFUL REFERENCES

The following publications give more detail about VLA observing strategy and hardware. Recent updates of #2 and #3 and #5 should be consulted for any changes to the VLA capabilities and observing restrictions. #6 and #7 are general treatments of synthesis imaging problems and radio interferometry.

1.   A.H.Bridle, "VLA Observing Strategies", lecture in the NRAO Summer School on SYNTHESIS IMAGING, last published in 1985 by the NRAO, P.O. Box O, Socorro, NM 87801, USA.

2.   R.C.Bignell, "VLA Observational Status Report", a summary of VLA capabilities, updated roughly annually. Distributed by NRAO Socorro.

3.   "NRAO NEWSLETTER", distributed quarterly by NRAO Charlottesville. Configuration Schedules, Proposal Deadlines, Hardware changes, etc.

4.   R.A.Perley, "The Effect of Bandwidth on the Synthesized Beam", VLA Scientific Memo No. 138 (1981). Distributed by NRAO Socorro.

5.   A.Rots, "Spectral Line Users' Guide", distributed by NRAO Socorro. Users' manual for VLA Spectral Line System.

6.   R.A.Perley, F.R.Schwab and A.H.Bridle (eds.), the NRAO Summer School on SYNTHESIS IMAGING, last published in 1985 by the NRAO, P.O. Box O, Socorro, NM 87801, USA. Treats imaging issues in detail.

7.   A.R.Thompson, J.M.Moran and G.W.Swenson, "Interferometry and Synthesis in Radio Astronomy", general text published by Wiley 1988.

VLAUVPL

This worksheet is loaded in the same way as VLAPLAN. It has only one screen. This asks you to decide whether to plot the u,v tracks of the innermost or outermost three VLA antennas, and to specify a VLA configuration, declination and elevation limits. Once the inputs have been specified, *you must press F9 to recalculate the baselines for your source as a function of Hour Angle*. (Automatic recalculation is turned off in this worksheet because the calculation takes too long in the slower types of PC and would otherwise be done as you entered every new parameter).

ALT-P graphs the tracks in the u,v plane on an absolute (km) scale.

ALT-H graphs u,v distance versus Hour Angle, labeling each point with the arms that contribute the plotted baselines.

ALT-V graphs u,v distance versus Hour Angle, labeling each point with its elevation angle.

ALT-L plots elevation angle versus Hour Angle.

This worksheet is a useful adjunct to VLAPLAN if your project is sensitive to the fine details of the inner or outer u,v coverage at large Hour Angles. Over much of the sky, baseline lengths may be significantly foreshortened by projection at large Hour Angles. You may therefore be able to use a single VLA configuration for a full synthesis observation of an extended source even when the shortest baseline on the meridian is a factor of two or three too long to sample the largest angular scale properly. In such cases, VLAPLAN may recommend multi-configuration observations because it is designed to be conservative, and considers only the baseline lengths that are available on the meridian. Realize, however, that the elevation is low when baselines are heavily foreshortened, and data quality at low elevations may be compromised by atmospheric phase fluctuations and attenuation (especially above 5 GHz).

To make more complete VLA coverage plots, use *UVSIM* in *AIPS* (or other u,v simulation software). The computations for the full VLA take a bit too long in most PC's!.

<u>APPENDIX A.</u> Known Bugs in This Program

None known yet (but I'm waiting !)

APPENDIX B. How to Reach Me (Alan H.Bridle)
To Report Bugs, Make Comments, Etc.

Write to me at:

National Radio Astronomy Observatory
Edgemont Road
Charlottesville
VA 22903-2475, USA

Call me at:

804-296-0375 (office)
804-296-0211 (to leave message)

Send E-mail to me at:

abridle@nrao (BitNet), or 6654::abridle (SPAN) or
!uunet!nraol!abridle   (UUCP)

Please note that my support of this program does not imply that I will
assume any responsibility for your VLA observing run itself!   I offer this
program without warranty, as an aid only. Use at your own risk! Bug reports
and other comments/suggestions àre most welcome, however.

APPENDIX C. Audit Trail

Version 1.0   (July 1988)

Tested by Charlottesville staff.   Not generally released.

Version 1.1   (September 1988)

Added:

1. Built-in comparison of averaging time and self-cal time, with warnings.
2. Display maximum averaging time for distortion in *Continuum Summary*.
3. Dec-dependent minimum baseline on meridian for configuration selection based on LAS (look-up table derived from VLAUVPL).

Changed:

1. ALT-P does not plot PBCOR when Rots/Napier approximation <1.000.
2. Formulae for time average smearing (to Bridle-Schwab 1988 Synthesis Imaging Summer School formulae from 1985/1982 Summer School formulae).
3. Warning messages for bandwidth, averaging time errors.
4. Look-up tables for illegal bandwidths < 0.195 MHz, so that warning messages, not just ERR codes, appear if bandwidth set too low.
5. Correlator codes in *Spectral Line Channels* screen to the Aug 1988 allowed varieties.
6. Various *Help* and *Inputs* text screens to account for above.
7. Format of *Resolution* screen to improve readability, show minimum baseline lengths.

Version 1.2   (October 1988)

Added:

1. All parameters are now input with ALT-keys.
2. Documentation for self-calibration parameters.
3. ALT-K display for data entry keys also gives current values.
4. ALT-Q display of RFI at L-Band, plus RFI table below Observing Frequency Strategy help text; from VLA Test Memo 139 and the GLONASS satellite frequencies.
5. ALT-H: added *NRAO* menu and sub-menus.

Changed:

1. Format of both *Continuum Summary* and *Line Summary* screens, to improve readability.
2. ALT-K display to two pages.
3. Labeling and location of "hidden" baseline tables.
4. ALT-H *Help* screens to reflect the above.

5. *Line Summary* screen was reading out total integration time for natural weighting, but calling it uniform; it now says and does the uniform weighting case. *Sensitivity* screen has been correct since Version 1.0.

Demonstrated to VLA staff in this version. Detailed comments from Bill Cotton and Rick Perley.

Version 1.3   (December 1988)

Added:

1. **ALT-Y**: printout options for summaries, detailed calculations, keys and menus, and help text on inputs.
2. Calculates bandwidth effect at channel bandwidth in *Field of View* screen, to help plan bandwidth synthesis observing.
3. *Bandwidth Synthesis Summary* screen and related strategy text.
4. Quit_Menu option to all sub-menus (quick return to *READY* mode).

Changed:

1. *Spectral line sensitivity* calculation now uses single IF (was 2 IF's -- as in continuum -- but single IF is more relevant here).
2. Title screen and **ALT-K** display now advertise **CTRL-BREAK** option for escaping from data entry macros.
3. Tidied up *Field of View* screen and bandwidth smearing look-up tables, to improve readability and to allow channel bandwidth smearing calculation for bandwidth synthesis.
4. HELP *Strategy* menu (**ALT-H,S**): *MAX Radius*, *Distortion*, and *Bandwidth Synthesis* help text put under one *Field of View* item.
5. All New Mexico telephone numbers to new AOC numbers.
6. Data set size calculation in B20, B40 to sum widest and closest arrays; also removed 1000-block approximation for line data (D40).