THE SCHED USER MANUAL

R.C. Walker

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SCHED is a program for planning and scheduling VLBA, Global VLBI, and some VLA observations. This manual describes how to use the program, provides extensive information on all possible inputs, and gives considerable information and advice on many aspects of scheduling VLBI observations. It is meant to be read with an HTML browser although a postscript version is available as part of the SCHED release.

For comments and questions, contact Craig Walker at cwalker@nrao.edu or, for Mark IV and VEX format issues, Huib van Langevelde at huib@jive.nfra.nl.

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1 INTRODUCTION

SCHED is a program for scheduling Very Long Baseline Interferometer (VLBI) Observations. Currently, it can be used to schedule VLBA and Mark III observations on antennas that use the VLBA real time control software. Support for Mark IV observations on any stations that can read VEX format schedules is being added. It can be used to schedule any Mark II observations, although most stations no longer have such equipment. It can also be used for scheduling many types of VLA observations and for scheduling single antenna VLBA observations. Through the use of dummy schedules and the plotting capabilities of the program, SCHED can be used for observation planning. SCHED is the program used to schedule most VLBA projects and is being adopted by the EVN (European VLBI Network) the VSOP orbiting VLBI satellite project as the standard scheduling program for those systems.

While SCHED can be run interactively, it is much better to create an input file using your favorite editor, and then run SCHED on that file. A number of catalogs will also be needed, but the standard ones distributed with SCHED should serve in most cases. When developing a schedule, it is likely that SCHED will be run many times on it before everything is to the scheduler's satisfaction. It is recommended, however, that plotting (see Section 5) be controlled interactively.

SCHED gets its information from a number of files and catalogs which can be imbedded in the main input file or can be left as external files. It also writes several different types of files, some of which are useful for the scheduler and some of which are meant for the computers at the antennas. An outline of the files used by SCHED can be found in Section 3.

and hyperrefthe Getting Started sectionSection on Getting StartedSEC:GETSTART for some good example input files. Any these examples can be used as a template for the user's first try to run the program.

The beginning SCHED user is recommended to check

The beginning user should read the section on KEYIN Free Format Input (Section 2) in order to understand the capabilities and limitations of the parser used to read all input files. He/she should then read the section on Input and Output files (Section 3) for an overview of the information that SCHED requires. Then read the Section 19 for instructions on how to start the program. Finally, read the Section 4on Getting Started which contains 3 examples of SCHED input files. At that point, it would probably be a good to use one of the examples in as a template to make a simple file and try to run the program. It is not strictly necessary to read the rest of the manual. It can be treated as a reference to help answer questions.

There is a lot of information about SCHED and about the process of scheduling VLBI observations in the descriptions of the input parameters (Section 12) and of the parameters for the setup files (Section 17.3). There are detailed discussions of some specific areas of concern in the Scheduling Tips Section (7). This is a section that will be expanded significantly in the future. All of these sections are worth reading through on some slow day for those serious about scheduling.

SCHED is not the same program as PC-SCHED. That program, which was written at Haystack, is the primary program for scheduling of Mark III observations. The VLBA staff (or any user) can convert the DRUDG file from PC-SCHED (or SKED) into a SCHED input file using SKEDCONV. This is the standard way in which VLBA and VLA control files are produced for Mark III programs. VLBI projects can also be produced using the NASA Goddard program SKED and VLBA control files can be produced using DRUDG. That is the standard path used by the geodesy community, but is rare among astronomers.

SCHED may be obtained by anonymous ftp to *ftp.aoc.nrao.edu* under directory *pub/sched.* For more information, see the section on Installing SCHED(Section 18)

A note on notation: the names of computer programs will be given in SMALL CAPS font, the names of files will appear in *slant* font, and the names of SCHED and setup file parameters will appear in `typewriter` font. Some parameters may be abbreviated; where both compulsory and optional characters are displayed, the compulsory ones will be shown in `UPPER-CASE TYPEWRITER` font and the optional ones shown in `lower-case typewriter` font.

2 KEYIN FREE-FORMAT INPUT

All input parameters to SCHED are in the keyin free format, named after Tim Pearson's subroutine that is used to read it. The important features of that format for SCHED are described here. This description is not complete and users of the Caltech package should refer to other documentation for useful capabilities of keyin input that are not normally used for SCHED.

Input via keyin format is of the form `keyword = value`. Different sets of `keywords and values` are separated by spaces or line breaks. The equal sign is optional as long as its absence does not lead to ambiguity. The input `keywords` are not case sensitive. Most of the `values` required by SCHED, except for file names in case sensitive systems like unix, are also not case sensitive. `keywords` are, in all cases, limited to 8 characters in length. Character string `values` can be much longer.

A few SCHED `keywords` may be abbreviated. In the parameter descriptions in this manual, the required characters will be shown in upper case while the optional ones will be shown in lower case. Any characters beyond the required ones must match the optional ones. As an example, the `keyword DURation` can be typed as "`DUR, dur, DURATION, duration, durat, Dur .....`

A `value` can be an array, with elements of the array separated by commas. If the last character on a line is a comma, the input array is assumed to continue on the next line.

The `value` can be a number or a character string. Quotation marks are required for a character string if it can be mistaken for a number or if it contains blanks or commas. Also, because of possible ambiguity with other `keywords`, character string `values` must be in quotes if the equal sign is left out.

If the `value` is a number, the decimal point and fractional part are optional. The parser converts all numbers to double precision real so the program will not know if you specify "5" or "5.0" etc.

If `value` is a time or angle, it can be written in `hh:mm:ss.ss` or `dd:mm:ss.ss` format. Each colon causes all values to the left to be multiplied by 60, giving a result to the program that is in seconds. Values less than an hour or degree can be written `mm:ss.ss` or just `ss.ss`. The decimal and fractional seconds are optional. However, even hours or degrees require the colons; for example, 2 degrees is written as 2:0:0. Numbers larger then 60 are allowed for the minutes and seconds; for example, 2:40 and 160 are equivalent. No imbedded blanks or signs are allowed. A negative or positive sign is allowed in front and applies to the final total number of seconds (ie. -1:20 is returned as -80).

A `keyword` can be specified without a value. This is equivalent, as far as the program knows, to specifying a value of zero. Some `keywords` are used in this way as logical switches to cause something to happen. `LST`, `PEAK`, and `TAPE` are examples from SCHED. Usually the effect of such a switch can be reversed by specifying a non-zero value. For several such switches, SCHED has a corresponding variable `keyword` that has the opposite effect (for example: `RECord` and `NORECord`).

An exclamation mark ("!") causes all items on the rest of the line to be ignored. This is useful for adding comments.

The parser collects all input, regardless of how many lines it is on, up to the line on which it finds the "Endmark", which in the case of SCHED and most other programs is a "/" . For SCHED, these groups correspond to scans in the main input, or a station or a source in the main catalogs.

Some examples of valid, if not very consistent, SCHED input are:

```
SOURCE='0235+164'  YEar = 1988  day 67  Stat = 'OVRO',NRAO,
 vla,vlba_pt  stop 03:35:00  dur = 15:00
comment 'Quotes are needed for more than one word.'  /
```

When a program that uses keyin is run interactively, the user can obtain a list of inputs by typing "`HELP /`" and can obtain a list of the current values of all input variables by typing "`SHOW /`". The input of SCHED is rarely, if ever, given interactively. However `SHOW` can be useful while controlling plots, which is normally interactive.

Keyin values can be mathematical statements in parenthesis; for example,

```
dur = 15
rep = (4*5)
```

This example shows the most likely way in which this capability might be used in SCHED input files. These two commands mean that the scan, which is 15 seconds long, should be repeated 20 times. By using the `(4*5)`, it makes it clear that the repetition lasts for 5 minutes since there are 4 scans per minute.

3 SCHED INPUT and OUTPUT FILES

SCHED takes input from several types of files in addition to any interactive input. All of these files can be separate, as long as SCHED can find them, or most of them can be imbedded in the main input file. The former is more convenient while the latter is safer, when using non-standard files, when the input file is to be sent somewhere else to be run again, as is common in schedule distribution. All input to SCHED is in the keyin free format (see Section 2). This is the same format as is used by all Caltech VLBI package programs. The input file types are:

Main Schedule Input File: This is the file that contains the details of the particular project. It can have the most of the other files imbedded in it. This file must be created by the user. This file should be given a name like *bv016.key* for project BV016.

Source Catalog: This file contains the information about the sources, especially names and positions. There are standard source catalogs, although the user may need to add non-standard sources.

Station Catalog: This file contains information about the antennas including names, positions, slew limits, horizons etc. There is a standard station catalog that should suffice for nearly all users.

Setup Files: These files contain the details required to configure the hardware at the stations. Different projects using the same hardware configuration can use the same setup files. There are many standard setup files. Setup file names conventionally end in *.set*.

Frequency Catalog: This file contains information about valid frequency setups at the stations. The RF ranges that can be covered and the local oscillator and polarization of each IF are given. SCHED can use this information to provide good defaults for many parameters in the setup files. The standard file should be used. Any non-standard information can be in the setup files. This file cannot be imbedded in the main input file.

Tape Initialization File: This file tells SCHED the properties of the tape systems at the stations and where to start on each tape. For many experiments, the default tape initialization parameters will be adequate and this file need not be provided.

SCHED processes the input files and creates several output files. Most follow a naming convention where that starts with the project code (BV016 will be used in the examples here) followed by a file type indicator, then a period, then a two letter station code (pt for Pie Town in the examples below). The experiment code is read by SCHED in the `EXPCODE` parameter in the main schedule input. The station code comes from the station catalog and a list if given in Appendix C. The output files are:

Summary File: This file gives a rather extensive summary of the setups and observations. This is the most useful output file for the user as it shows how SCHED has interpreted the input commands. The file will be called, for example, *bv016.sum*. The items displayed for each scan can be controlled with the parameter `SUMITEM`.

Operator Schedule Files: These files, of which there is one per antenna, give much information the schedule than can be included in the summary file and are useful when that level of detail is needed. They were originally meant for the use of operators of manually controlled antennas, but now most antennas are computer controlled and these files are more useful for the scheduler. The files are named, for example, *bv016sch.pt*.

VLBA type Antenna Control Files: These files provide the on-line control systems of the type found at VLBA antennas with the information they need to control the observations. There is one file per antenna that uses a VLBA control computer for either full control of the station or for control of just the data aquisition system (tape drives, baseband converters etc.). The files are named, for example, *bv016crd.pt*.

Other Antenna Control Files: These files are antenna control files in VLA observe deck format, Green Band Card format, or SNAP (Mark III style, but SCHED can make them for Mark II only). Some antennas, such as the VLA, require both crd. and obs. files. The files are named, for example, *bv016obs.y* for the VLA file.

Mark IV .skd Files in VEX format: These are the files needed for Mark IV stations. Writing of such files is available in special versions of SCHED and will be in the standard version, probably by the end of 1996. Reading of such files, in order to make control files for the VLBA, will be added later. They will be named, for example, *bv016.skd*. A single such file describes the observations for all antennas.

Plots: Sched can make plots of u-v coverage and of various combinations of azimuth, elevation, paralactic angle, hour angle, UT, and GST against each other.

Optimized Schedule: When one of SCHED's optimization modes is turned on, the program writes out a file, such as *bv016.sch* containing the basic scan inputs for a new main schedule file. If desired, the user can use this to construct, and perhaps modify, a new optimized main schedule input. This used to be the way all optimized schedules were constructed, but now that SCHED fully processes an optimized schedule, it is rarely used or needed.

frequencies.list: If the user specifies the parameter `FREQLIST`, SCHED will read the frequency catalog and make a table of all known setups which can be used to make observations in the specified frequency range. Then SCHED will quit without doing further processing. This is useful for planning and for information while making setup files.

4 GETTING STARTED — THREE EXAMPLES

See the section of this manual on installation (Section 18) if SCHED is not yet installed on your computer and if your login is not set up to run SCHED. Also see Section 19 for instructions on how to start the program.

There are several example SCHED input files distributed with the program. They are in the *examples* subdirectory (*$SCHED/examples* if the environment variable is set on unix systems). Any can be consulted for information on how to run SCHED or for use as templates from which to create your own schedule. All should produce valid schedules if run as is. In fact, all are used in the *Verify* script that is used to check new installations and new versions of SCHED. Three of these examples are shown below and all are described here.

manual_2.key This file is shown below as the first example. It is a fairly typical SCHED input file for a VLBA plus single VLA antenna observation. It uses defaults where it can and is relatively simple. This example is a good file to use as a template for making new schedules.

manual_1.key This file is shown below as the second example. It will produce the same schedule as the first example. However, for demonstration purposes, far more parameters are actually specified in the input file. This includes having at least parts of all auxiliary input files (catalogs etc) imbedded. It is fairly complicated and contains a lot of comments in an attempt to show many SCHED features and give some advice on scheduling strategy.

manual_simp.key is the third example below. It is a very simple file that can be used to make plots for experiment planning purposes. Because of the lack of cover information, it cannot be used to produce telesope control files.

egOH.key is a sample spectral line file for VLBA observations of several OH masers transitions.

egglobal.key is a sample file for observations involving the VLBA plus other stations that use the VLBA control files (VLA, Green Bank, and Effelsberg). I know - the "global" is a bit of a misnomer. See *egmkiv.key* and *egvsop.key* for more truely global observations.

egiii.key is a sample schedule for Mark III format observations on the VLBA only. Note that, if other stations are needed, it is necessary to use another program such as SKED or PC-SCHED to make a .drg file. That file can be converted by the VLBA analysts into a SCHED input file from which to make the control files for the VLBA. This example is not output from the conversion program.

egiv.key is a sample schedule for Mark IV/VLBA observations. It will generate a VEX format file for stations controlled by the field system and VLBA type control files for the VLBA and other stations that need them.

egplan.key , much like [*manual_simp.key*], is a simple schedule to assist in experiment planning. It is a bit more complete than *manual_simp.key*.

egvlba.key is a sample schedule for simple VLBA observations.

egvsop.key is a sample schedule for Mark IV / VLBA observations specifically using modes appropriate for observations with the Japanese VLBI satellite, VSOP. It will produce VEX format schedules for stations that use the field system and VLBA format files for those stations that need them.

manual_line.key is the example that is included in the spectral line section of this manual. It is for VLBA and VLA observations of 7mm SiO lines.

vla_vlbi.key is an example of VLBI observations that include the VLA and show some of the complications that can be involved in phasing that instrument.

uptime.key is an example of input for the Caltech Package program *uptime* which is distributed with SCHED. It is used for experiment planning purposes. The functions of *uptime* are partially duplicated by the plotting and dummy schedule making capabilities of SCHED, but *uptime* is still often easier to use. Eventually, as these aspects of SCHED are enhanced, *uptime* will be dropped.

4.1 Example 1: Basic Schedule.

The following example gives a fairly typical schedule that relies on SCHED's defaulting schemes and standard catalogs to get most of the required information. The cover and correlator information cannot be reduced nor can the individual scan information. All of those inputs are unique to the observation. This example is probably the most useful one for users to use as a template for making their own schedules. It produces the same schedule as the second example but that example actually shows how many items, that are defaulted or taken from standard catalogs here, can be specified in the schedule file.

```
!  BE001 example of 3C84 observations at 6 and 4 cm.
!
!    This example produces the same schedule as manual_1.key
!    but uses many SCHED defaults and is missing most comments.
!    It shows approximately the sort of file a users would
!    normally make.  Note that all catalogs are defaulted.
!
!
overwrit
! ==========================================================
! ================= Cover Information ====================
! ==========================================================

version  = 1
expt     = 'Example: 3C84 6, and 4 cm'
expcode  = BE002
obstype  = VLBA

piname   = 'Craig Walker'
address1 = 'National Radio Astronomy Observatory'
address2 = 'P. O. Box O'
address3 = 'Socorro, New Mexico, 87801'
address4 = ' U.S.A. '
phone    = '505 835 7247 '
obsphone = '505 835 7247 '
email    = 'cwalker@nrao.edu'
fax      = '505 835 7027 '
obsmode  = 'Continuum'
correl   = 'Socorro'
note1    = ' '
```

```
! ============================================================
! ==============  Correlator Information  ==================
! ============================================================

correl   = 'Socorro'
coravg   = 4
corchan  = 16
cornant  = 10
corpol   = 'on'
corwtfn  = 'uniform'
corsrcs  = 'VLBA Data Base'
cortape  = DAT
corship1 = 'Craig Walker'
corship2 = 'P. O. Box O'
corship3 = 'Socorro NM 87801'
cornote1 = ' '
!

! ============================================================
! =================== Setup Information ===================
! ============================================================
!  These are bare minimum setup "files" that use defaults from
!  the frequency catalog.
!  The first even defaults the BBC numbers and sidebands.
!  This still requires getting the frequencies right for the
!  scheme that SCHED chooses and is not really recommended.

setinit = v6cm.set /
   station  = vlba, vla1
   nchan    = 4
   freqref  = 4991.49
   freqoff  = -4, -4, 4, 4
   bbfilter = 8.0
   bits     = 1
   pol      = dual
   format   = VLBA
   /
endset /

!  The second setup sets BBC's and NETSIDE.  This is the
!  best template for most users.

setinit = v4cm.set /
   station  = vlba, vla1
```

```
   nchan    = 4
   freqref  = 8416.99
   freqoff  = -3.5, -3.5, 4.5, 4.5
   bbfilter = 8.0
   bits     = 1
   bbc      = 1,    2,    3,   4
   netside  = U,    U,    U,   U
   pol      = RCP,  LCP,  RCP, LCP
   format   = VLBA1:4
   /
endset /

! ============================================================
! ========================  The Scans  =====================
! ============================================================
year  = 1995
month = 10
day   = 22
start = 01:30:00
vlamode = vs

!  Note use of station codes.
stations = SC, HN, NL, FD, LA, PT, KP, OV, BR, MK, VLA1

Source = 3C454.3   Dur   = 5:30   Setup = v6cm.set    /
Source = 3C454.3   Dwell = 5:30   Setup = v4cm.set /

stations = SC, HN, NL, FD, LA, PT, KP, OV, BR, VLA1

group 4 rep 14  !   About 3 hours in 12 repeats of the next 4 scans.
Source = 3C84      Dur   = 3:00  gap = 2:00  Setup = v6cm.set /
Source = 3C84      Dwell = 3:00  gap = 0     Setup = v4cm.set /
Source = 0309+411  Dwell = 2:00  /
Source = 3C84      Dwell = 3:00  /

!  Add MK
stations = SC, HN, NL, FD, LA, PT, KP, OV, BR, MK, VLA1

group 4 rep 14  !   About 3 hours.
Source = 3C84      Dur   = 3:00  gap = 2:00  Setup = v6cm.set /
Source = 3C84      Dwell = 3:00  gap = 0     Setup = v4cm.set /
Source = 0309+411  Dwell = 2:00  /
Source = 3C84      Dwell = 3:00  /

group 8 rep 15  !  6.5 hours
```

```
Source = 3C84      Dur   = 3:00  gap = 2:00  Setup = v6cm.set /
Source = 0552+398  Dwell = 3:00  gap = 0     /
Source = 0552+398  Dwell = 2:00  gap = 0     Setup = v4cm.set /
Source = 3C84      Dwell = 3:00  gap = 0     /

Source = 3C84      Dur   = 3:00  gap = 2:00  Setup = v6cm.set /
Source = 3C84      Dwell = 3:00  gap = 0     Setup = v4cm.set /
Source = 0309+411  Dwell = 2:00  /
Source = 3C84      Dwell = 3:00  /

Source = 3C273     Dur   = 5:30  gap = 3:00  Setup = v6cm.set /
Source = 3C273     Dwell = 5:30  gap = 0:00  Setup = v4cm.set /

! ============================================================
! ========================  End of example  ================
! ============================================================
```

4.2 Example 2: Showing Many SCHED Features.

This file demonstrates many of the possible SCHED inputs that users might want to give. It is also heavily annotated with to provide hints and advice to the user. The first example gives the same output files with a lot simpler input. Users will probably want to use it as a template, rather than this one. If you have any questions about any of the input parameters, go back to the contents and find the sections that describe them.

```
!  BE001 example of 3C84 observations at 6 and 4 cm.
!
!    This example shows many things in gory detail and has
!    many comments.  The example manual_2.key is the exact
!    same schedule, but takes advantage of SCHED defaults
!    and is missing most comments.  It looks much less
!    intimidating and is closer to what users will make.
!
! ============================================================
! =================  Cover Information  ====================
! ============================================================

version  = 1
expt     = 'Example: 3C84 6, and 4 cm'
expcode  = BE001
obstype  = VLBA

piname   = 'Craig Walker'
address1 = 'National Radio Astronomy Observatory'
address2 = 'P. O. Box O'
address3 = 'Socorro, New Mexico, 87801'
```

```
address4 = ' U.S.A. '
phone    = '505 835 7247 '
obsphone = '505 835 7247 '
email    = 'cwalker@nrao.edu'
fax      = '505 835 7027 '
obsmode  = 'Continuum'
correl   = 'Socorro'
note1    = ' '

! ==========================================================
! ==============  Correlator Information  ==================
! ==========================================================

correl   = 'Socorro'
coravg   = 4
corchan  = 16
cornant  = 10
corpol   = 'on'
corwtfn  = 'uniform'
corsrcs  = 'VLBA Data Base'
cortape  = DAT
corship1 = 'Craig Walker'
corship2 = 'P. O. Box O'
corship3 = 'Socorro NM 87801'
cornote1 = ' '
!
! ==========================================================
! ==================  Program control  =====================
! ==========================================================
!  Allow SCHED to overwrite existing files:
overwrit

!  To process only VLBA and VLA stations, uncomment:
! dosta 'vl'

! ==========================================================
! =================== Tape initialization  ================
! ==========================================================

tapeini /
tpsta    = vlba,  vla,    eb_vlba, gb_vlba, default
tplength = 17600,  17600,   8800,  8800,  8800
nheadpos = 14,     14,      14,    14,    14
density  = H,      H,       H,     H,     L
   /
```

```
! ============================================================
! ==================== Station Catalog  ====================
! ============================================================
!  For this example, to show the format, get 2 stations from the
!  internal station catalog.  Get the rest from the standard catalog.

stacat /

 STATION=VLBA_PT   STCODE=Pt      CONTROL=VLBA
    ELEV=2371.00  LONG=108:07:07.24    LAT=34:18:03.61
    MOUNT=ALTAZ  AX1LIM=-90,450 AX2LIM=2.25,90 AX1RATE=90 AX2RATE=30
    TSETTLE=2  DAR=VLBA  RECORDER=VLBA  NDRIVES=2  NHEADS=1 NBBC=8
    ! PT    From 150 K Ts line by Beasley and Medcalf  Aug 1992.
    HOR_AZ =   0,  5, 60, 65, 70, 75, 80, 85,165,170,180,185,190,195,
             200,240,245,250,255,265,270,275,280,285,360
    HOR_EL =   2,  2,  2,  3,  3,  2,  3,  2,  2,  3,  3,  4,  4,  3,
               4,  4,  3,  4,  3,  3,  4,  3,  3,  2,  2
  /
  STATION=VLA1      STCODE=Y   CONTROL=VLA
     MOUNT=ALTAZ  AX1LIM=-85,445 AX2LIM=8,90 AX1RATE=40 AX2RATE=20
    TSETTLE=15  DAR=VLBA  RECORDER=VLBA  NDRIVES=2  NHEADS=1 NBBC=8
     TSETTLE = 15
     ELEV=    2100.00  LONG= 107:37:04.79    LAT= 34:04:44.40
   /
endcat /

!  Get most stations from the catalog.
stafile = $SCHED/catalogs/stations.dat

! ============================================================
! ==================== Source Catalog  =====================
! ============================================================
! Get the sources from the imbedded catalog.

srccat /
       epoch='J2000'
   source='J2253+1608','3C454.3'  calcode = 'V'
      ra=22:53:57.74790 dec=16:08:53.5630 /
   source='0309+411'              calcode = 'N'
      ra=03:13:01.96212 dec=41:20:01.1841 /
   source='0316+413','3C84'       calcode = 'V'
      ra=03:19:48.16010 dec=41:30:42.1060 /
   source='0552+398','DA193'      calcode = 'N'
      ra=05:55:30.80561 dec=39:48:49.1656 /
   source='J1229+0203','3C273'    calcode = 'V'
```

```
      ra=12:29:06.69970 dec=02:03:08.5980 /
endcat /
srcfile   = none

! ==========================================================
! =================== Setup Information ==================
! ==========================================================
!  Now specify the setup information.  These are nearly copies of
!  two of the standard setups.  Both set up 4 channel recordings in
!  vlba mode with 1:4 fan out and 64 Mbits per second.  The channel
!  bandwidths are 8 MHz and the sampling is with 1 bit per sample.
!  The first is for frequencies in the 6 cm band.  The second is 4 cm.

!  Note, here is where VLA1 and VLA27 are different - they have
!  different rchan and lchan.  To avoid errors, do not use a
!  generic "VLA"

setinit = v6cm.set /
   nchan    = 4  samprate = 16.0  bits = 1  bbfilter = 8.0  !  64 Mbps
   tpmode   = 2  format = VLBA1:4
   netside  = U, U, U, U
   bbc      = 1, 2, 3, 4
   ifchan   = R, L, R, L
   freqref  = 4990.99  freqoff = -3.5, -3.5, 4.5, 4.5
   fe(1)    = '6cm'    fe(3) = '6cm'   synth(2) = 4.1
   firstlo  = 4100.00
   station  = VLBA     rchan = A  lchan = C   /
   firstlo  = 4360.10
   vlaband  = VC       vlabw = '0000'
   station  = VLA1     rchan = B  lchan = D   /
endset /

setinit = v4cm.set /
   nchan    = 4  samprate = 16.0  bits = 1  bbfilter = 8.0  !  64 Mbps
   tpmode   = 2  format = VLBA1:4
   netside  = U, U, U, U
   bbc      = 1, 2, 3, 4
   ifchan   = R, L, R, L  freqoff = -3.5, -3.5, 4.5, 4.5
   freqref  = 8416.99
   synth(1) = 7.6
   firstlo  = 7600.00  fe(2) = '4cm'   fe(4) = '4cm'
   station  = 'VLBA'   rchan = B  lchan = D   /
   firstlo  = 9039.90
   vlaband  = VX       vlabw = '0000'
   station  = 'VLA1'   rchan = B  lchan = D   /
```

```
endset /

! ============================================================
! =================  Initial Scan Information  =============
! ============================================================
!    Scheduled project time is 1995 Oct 22 from 01:30 to 16 UT.
!    Set the start time.  The day is for the scan stop time.

year  = 1995
month = 10
day   = 22
start = 01:30:00

! ============================================================
! ========================  The Scans  =====================
! ============================================================
 !  Note that this is a moderately complex schedule, but
 !  serves to show a number of points about scheduling style.

 !  The scans will be blocked in groups with 11 minutes of record
 !  time which is 1/4 of a pass on a thin tape at high density.

 !  Start with a fringe finder on all antennas at both frequencies.
 !  The dwell time on the second scan tells SCHED to insert enough
 !  of a gap between the scans for the antennas to get to the source.
 !  The VLA will be in single dish mode 'VS' for the whole project.

stations = VLBA_SC, VLBA_HN, VLBA_NL, VLBA_FD, VLBA_LA,
           VLBA_PT, VLBA_KP, VLBA_OV, VLBA_BR, VLBA_MK, VLA1
vlamode = vs
Source = 3C454.3   Dur   = 5:30   Setup = v6cm.set    /
Source = 3C454.3   Dwell = 5:30   Setup = v4cm.set /

 !  Now observe the target source, 3C84, along with a short scan on a
 !  nearby source for use as a position reference at 4 cm.
 !  Each 13+ minute group includes 13 minutes recording, 2 minute gap,
 !  and a few tens of seconds for slews.
 !  The 2 minute gap at the start allows time for readback tests.
 !  Leave out VLBA_MK for 3 hours because the source is not up.

stations = VLBA_SC, VLBA_HN, VLBA_NL, VLBA_FD, VLBA_LA,
           VLBA_PT, VLBA_KP, VLBA_OV, VLBA_BR, VLA1

group 4 rep 14  !   About 3 hours in 14 repeats of the next 4 scans.
Source = 3C84      Dur   = 3:00  gap = 2:00  Setup = v6cm.set /
```

```
Source = 3C84      Dwell = 3:00  gap = 0     Setup = v4cm.set /
Source = 0309+411  Dwell = 2:00  /
Source = 3C84      Dwell = 3:00  /

 !  Add in VLBA_MK (It would have been ok to leave it in.)

stations = VLBA_SC, VLBA_HN, VLBA_NL, VLBA_FD, VLBA_LA,
           VLBA_PT, VLBA_KP, VLBA_OV, VLBA_BR, VLBA_MK, VLA1

group 4 rep 14  !   About 3 hours.
Source = 3C84      Dur   = 3:00  gap = 2:00  Setup = v6cm.set /
Source = 3C84      Dwell = 3:00  gap = 0     Setup = v4cm.set /
Source = 0309+411  Dwell = 2:00  /
Source = 3C84      Dwell = 3:00  /

 !  Now a good calibrator is available.  Get some scans on it along
 !  with the 3C84 stuff.  Combine two 15 minute blocks into a loop.

group 8 rep 15  !  About 6.5 hours
Source = 3C84      Dur   = 3:00  gap = 2:00  Setup = v6cm.set /
Source = 0552+398  Dwell = 3:00  gap = 0     /
Source = 0552+398  Dwell = 2:00  gap = 0     Setup = v4cm.set /
Source = 3C84      Dwell = 3:00  gap = 0     /

Source = 3C84      Dur   = 3:00  gap = 2:00  Setup = v6cm.set /
Source = 3C84      Dwell = 3:00  gap = 0     Setup = v4cm.set /
Source = 0309+411  Dwell = 2:00  /
Source = 3C84      Dwell = 3:00  /

 !  Finish with another strong fringe finder.

Source = 3C273     Dur   = 5:30  gap = 3:00  Setup = v6cm.set /
Source = 3C273     Dwell = 5:30  gap = 0:00  Setup = v4cm.set /

! ============================================================
! ========================  End of example  ================
! ============================================================
```

4.3 Example 3: Simple Schedule for Planning.

The above file was a complete file for a moderately complicated observation. SCHED input files are not always so complicated. The following file is about as simple as a SCHED file can get. It is set up for exploring the u-v and sky coverage of a source using the plotting abilities of SCHED. Note that the external file names would have to be changed to use it at a non-Socorro site.

```
!-------------------------------------------------------------------
!  Example of very simple SCHED file - for making uv etc plots.
!----------------------------------------------------------------------
overwrit                 !  Allow writing over old output files.
expcode  = UVCOV         !  Needed for name of summary file.
obstype  = NONE          !  No tape recording.
opminant = 4             !  Minimum number of antennas that must be up.
opminel  = 15            !  Don't include scans below this elevation.
setup    = $SCHED/setups/pt4cm.set ! Needs a setup.
stations = SC, HN, NL, FD, LA, PT, KP, OV, BR, MK
year     = 1996    day = 1  start = 00:00:00
dur      = 10:00                  ! (6*24) scans covers 24 hours.
source   = DA193  rep = (6*24)     ! Insert your favorite source here.
/
!----------------------------------------------------------------------
! End of example.
!----------------------------------------------------------------------
```

If the above file were named *uvcov.key*, it could be run with the commands:

```
sched
plot sch=uvcov.key /
```

When the plot section is reached, it requires interactive inputs. However there should be adequate prompting for the user to be able to able to figure out what to do. Just returning a "/" will give a self-scaled u-v plot of all the data.

5 PLOTTING

SCHED has the ability to plot the u-v coverage of sources in a schedule and to plot azimuth, elevation, hour angle, or paralactic angle against any of those quatities or against UT or GST for one to all stations in a schedule. It can also plot the positions of the sources in a schedule in RA and DEC. These plots are useful for assessing the quality of the schedule. They also can be very useful for planning observations, both at the proposal stage and as the schedule is prepared. For this use, see the section on planning (Section 6) and for a very simple example schedule for obtaining plots of hypothetical schedules, see the third example in the Getting Started Section (Section4).

5.1 Making Plots

To cause SCHED to make plots, specify `PLOT` somewhere in the input. Since it is unlikely that this will be desired in the final run of the program, it is best to start a plotting session interactively and then specify `PLOT` and use `SCHedule` to specify the input file. Thus, you would type (on a unix box, anyway):

```
sched
plot  schedule=bv016d.key /
```

(substituting your file for the `bv016d.key`.

If `PLOT` has been invoked, SCHED will proceed to read all of the input files, check the schedule, and do any requested optimization normally. It will write the summary file, but will not write the antenna specific files, at least until later. The summary file will be closed and can be examined while in the plotting session. This may be useful in studying details of what is being plotted.

When the plotting session begins, SCHED writes a description of the possible input parameters, which are also described below, and then prompts for KEYIN style input. The user should specify any desired quantities and then type a "/". The plot will then be made. The plotting utilizes the PGPLOT subroutine library written by Tim Pearson used by the other Caltech Package programs and in wide use in astronomy. If the user, is on a machine with X windows graphics, simply taking all the defaults will cause a u-v plot of all sources and scans in the project to appear on the screen. It is expected that future releases will allow some inputs to be available directly by clicking on buttons on the screen. However, for the first release of SCHED with plotting, all controls are to the window in which SCHED is running.

The inputs can be used to choose between u-v plots, xy, and Ra-Dec plots. For u-v plots, the scale can be specified and a station can be selected for which, on color displays, the baselines to that station will be highlighted (displayed in red). Also the source to be plot can be specified. XY plots are a bit more complicated because they are more flexible. The quantity to plot on each axis can be selected, the scales specified and the station and source chosen to be one or all. See the details of the input parameters below. In addition, the plot can be restricted to scans that use one of the setup files. This can be useful for assessing band switching observations. Note that, if elevation is plotted against azimuth, the horizon as specified in the stations catalog will be plotted in addition to the tracks followed by the sources. Ra-Dec plots simply show the location of each source in the schedule on the sky. The plot scales can be set as in XY plots to show a restricted region. This should be useful for determination of sky coverage or for finding calibrators. At some point, an option to plot all sources in the catalog will be added.

The plot is made, of whatever quantities are specified, but drawing a line from the values at the beginning of each scan to the values at the end of the scan. Thus, if you have very long scans, the individual line segments may become apparent and the plot will not be an exact representation of the data that will be collected.

From the plot input, it is also possible to get SCHED to exit the plot section and do one of 3 things. One is to `FINISH`, which means to continue through the rest of the program and write all the antenna specific files. The second is to `EXIT`, which simply means to quit the program. The third option is especially interesting for experiment planning. It is to `RESTART`, which means to return to the beginning of the program, read and process the input file again, and return to the plot section, remembering the current plot inputs. If the input file has been changed in any way, those changes will be reflected in the new plots. Thus scan times can be changed, new sources specified etc. This is useful, for example, in exploring the u-v coverage for various sources (much like the Caltech program *HAZI*) or determining the times that various sources are visible (like the Caltech program *UPTIME*). It is more flexible than the other programs because you have full control of the schedule so, for example, the u-v coverage from multiple snapshots can be explored. Because it is possible, by deleting some parameters from the input file, to cause SCHED to get confused about the value of some of the parameter for which only one value per project is accepted, the `FINISH` option is locked out after a `RESTART`. If a `RESTART` option has been used, it will be necessary to rerun the program from scratch to get final output schedules. Since you have been modifying the input file on each restart, this should not be a problem.

The input parameters are not reset between runs of the plotting. Thus the user need only specify those items that he/she wishes to change. Some of the built in KEYIN capabilities can be useful here. If you type `SHOW` (and "/"????, KEYIN will list the input variables and their current values. `HELP` generates a list of the variables. Also you can type `SAVE filename` and KEYIN will write a file with name `filename` in the default area containing the current parameter settings. Later, perhaps in another run of SCHED, you can type `@filename` to recover those parameters. The parameter file can be edited — it is a normal KEYIN input file (actually any file can be read with the tt @filename construct, although only up to the first "/").

5.2 Plotting Input Parameters

The KEYIN inputs to the plotting section of SCHED are:

5.2.1 PLotfile

`PLOTfile` gives the output specification for the plot. As with any PGPLOT programs, it is in the form `filename/device`. For interactive devices, the filename need not be specified. The default device is `/xs` which is a good choice for X windows systems. Other devices most likely to be of interest are `/ps` for a postscript file and `/cps` for a color postscript file. See PGPLOT documentationPGPLOT documentation for other options (more will be listed here in the future). The device can be changed at any time. If it is changed, the old one will be closed and the new one opened. This allows the plot to be set up interactively, and then put out in postscript for printing.

5.2.2 SEtnum

When the plotting section is entered the first time, information is written to the screen about possible input options. Among the information presented is a numbered list of the setup files encountered in the input. With `SEtnum`, one of those setup files can be selected by number (avoids lots of typing since setup file names often include full paths and can be quite long). Then the plot will only show scans which use that setup file.

5.2.3 TYpe

`TYpe` is used to specify the type of plot. The option are `UV`, which is the default, `XY`, and `RD`. `UV` causes a plot of the spatial frequency coverage to be plotted. For now, the scale on the plot is km. An expected enhancement eventually is for this to optionally be in wavelengths. For `XY` plots, there are a variety of options which are specified with

XAxis and YAxis, which independently specify the quatantity plotted on each axis. RD requests that the locations of the sources in the schedule be plotted in Ra and Dec.

5.2.4 XAxis

XAxis specifies the quatity to be plotted on the horizontal axis in a TYPE=XY plot. The options are el for elevation, az for azimuth, pa for paralactic angle (for polarization), ha for hour angle, ut for universal time, and tt gst for Greenwich Sidereal time.

5.2.5 YAxis

YAxis specifies the quantitiy to be plotted on the vertical axis in a TYPE=XY plot. The options are el for elevation, az for azimuth, pa for paralactic angle, and ha for hour angle. If xaxis=az and yaxis=el, the antenna horizons will be plotted along with the source tracks.

5.2.6 XLeft and XRight

XLeft and XRight specify the minimum and maximum for the X axis plot scale. If they are not set, or are set to -9999., the axis will be autoscaled. For u-v plots, it is only necessary to specify one value, say XMax, and it will be used for all 4 limits. If more than one are specified, they are used which allows off center plots. For XY plots, the limits should be specified in the units of the plots. For the time axis, the limits should be in the form hh:mm:ss where this is the time offset since the beginning of the first day of the experiment for UT or is the GST. Note for u-v plots, traditionaly, the plot has positive to the left so XLeft will be greater than XRight. For Ra-Dec plots, XLeft and XRight specify the RA range and should be in the form hh:mm:ss (eg. XL = 5:30:00).

5.2.7 YBottom and YTop

YBottom and YTop specify the minimum and maximum for the Y axis plot scale. If they are not set, or are set to -9999., the axis will be autoscaled. For Ra-Dec plots, YBottom and YTop specify the declination limits and should be in the form dd:mm:ss (eg. YB = -12:15:00).

5.2.8 SOurce

SOurce can be used to restrict the plots to a single source. The default, which can be specified at any time is ALL, which will cause all sources to be plotted.

5.2.9 STation

STation can be used to restrict TYPE=XY plots to one station. For TYPE=UV plots, all stations will be plotted, but all baselines to the specified station will be plotted in a contrasting color. The default, which may be specified at any time, is ALL, which will cause all stations to be plotted or not highlighted.

5.2.10 REstart

See the discussion above for details of the effect of `REstart`. In short, it causes the program to return to the beginning and reread the input, which may have changed.

5.2.11 FInish

`FInish` tells SCHED to close the plot files and produce the station specific output files. `FInish` is locked out after a `REstart` to make absolutely sure that the output files really correspond to what is in the schedule file. If `REstart` has been used, it will be necessary to `EXit` and rerun SCHED from scratch to get the station output files.

5.2.12 EXit

`EXIT` tells SCHED to close the plot files and exit. Antenna specific files will not be produced.

6 USING SCHED FOR PROJECT PLANNING

The plotting and summary capabilities of SCHED make it useful for experiment planning. When writing a proposal, it can be used to determine the appropriate GST ranges for a source and to explore the u-v coverage available. While designing a schedule, it can be used to for the same purposes and to experiment with various detailed schedules. It is also possible to use the `RD` option to see the distribution on the sky of sources. This might be useful for selecting calibrators.

The most effective use of SCHED for planning involves using 4 windows on a windowing system. The first is the one in which SCHED was started and to which plotting commands are being given. The second is the plot window. The third is your favorite editor in which changes to the main SCHED input are being made between `REstart`s. The fourth has some sort of listing tool, such as MORE or LESS in unix, which can be used to examine the summary file.

The schedule to use for planning can be very simple. In fact the simple example at the end of the getting started section is designed exactly for this purpose. Multiple sources can be specified, or a `REstart` can be done after editing in each source that is to be examined.

The current plotting capabilities allow the user to perform the functions normally provided by the Caltech package programs UPTIME and HAZI, although UPTIME is perhaps still a bit more convenient. The planning capabilities is an area where enhancements to SCHED are expected in the future. In particular, something in plot form of a nature similar to the UPTIME printer graphics displays of when sources are up is on the wish list. Any suggestions would be welcome.

7 SCHEDULING TIPS

CONSTRUCTION ZONE

This section will contain subsections with detailed discussions and advice on various aspects of scheduling. This should be considered a **construction zone**. A few basic discussions are here, but many more will be added.

7.1 Observing Strategy

A tremendous amount could be said about observing strategy. See the article by Joan Wrobel in the book "Very Long Baseline Interferometry and the VLBA" (1995: ASP) for a good discussion. That book also contains a lot of information about VLBI and is a good reference for all observers to have. Other important sources of information are the "VLBA Observational Status Summary" (see the NRAO home page) and the "before.if" document sent to scheduled users. This section will be limited to a few important concepts to keep in mind while scheduling. It is assumed that the observer already has a reasonable idea of how much time is needed per source, what frequencies to observe, etc. The suggestions here are more oriented toward smooth observing, processing, and calibration.

Fringe finders: In order for the staff at a VLBI correlator to tell if the correlation has gone well, it is necessary to have occasional scans on sources that will provide strong fringes. A minimum of one such scan per tape should be provided and it is a good idea to have one every couple of hours. The "VLBA Observational Status Summary" (see the NRAO home page) and the "before.if" document sent to scheduled users list appropriate sources.

The fringe finders can also be used for "manual phase cal". This is the process of aligning the phases and delays on all individual IFs. This is simply done by running the fringe fitting program on the calibrator and applying the results to all data.

Setting the flux scale: Setting the flux scale of VLBI images is not trivial. Idealy, one would have a compact source of known flux density that could be used, as 3C286 and 3C48 are on the VLA, to calibrate the flux densities. However, by their nature, sources that are compact to VLBI (essentially none are unresolved) are variable and, therefore, do not make good flux calibrators. There are two ways to deal with this.

One is to try to obtain the flux density of a compact calibrator at a close enough time to the VLBI observations that variations will not be significant. At the time of the VLBI observations, some of the larger antennas can be asked to measure flux densities of sources being observed (see the `TANT` command. Better yet, if you have the phased array at the VLA or can get an hour or so of VLA test time, accurate flux densities of your VLBI calibrators can be measured. In order to do this, be sure to include a VLA flux calibrator (usually 3C286 or 3C48) in the VLA schedule. You don't need to record VLBI tape on it.

It is also possible to rely on the apriori calibration of the VLBI antennas. For this, it is best to look carefully at your data and determine which subset of antennas is giving consistent calibration. With the VLBA at intermediate frequencies, it is possible to get the flux scale right to within a few percent at intermediate frequencies this way. You just have to be sure not to let any antennas with bad weather or other problems contribute (don't just use gain normalization in the self-calibration routines, for example). If you are going to rely on apriori calibration, be sure to obtain some data at close to the frequencies at which antenna gains have been measured. These frequencies are given in the *vlba_gains.key* available by anonymous ftp to ftp.aoc.nrao.edu. This is the file that you will need for VLBA calibration.

For any of these methods to work, it is best to include a strong, compact calibrator and to observe it several times to check consistency.

Setting the relative gains of antennas: Another invaluable use of a strong, compact calibrator is to help ensure that all antennas and all IFs have consistent calibration. After apriori calibration and setting of the flux scale has been done, a model of the calibrator can be used to derive whatever additional gain adjustments are needed. These can be applied to the whole observation to obtain the best possible calibration, short of self-cal.

Readback tests: If there is a gap of 2 minutes or more in your schedule, the VLBA on-line system will do a readback test to check the quality of the recording. Without this, the operations staff has no way to tell if the recordings are being made ok. It is a good idea to include such gaps every hour or two.

Phased VLA: The phased VLA has special calibration needs. If the target source is either too weak or too resolved to be used for phasing up the array, special scans on a calibrator must be inserted for this purpose. This can be done with SCHED or VLA OBSERVE (see Section 10.1 for details. It can be done by the VLA data analysts, but the schedule must contain gaps of adequate length.

Also, the effective beam of the phased VLA (or any other phased interferomenter such as Westerbork) is the synthesized beam. This can be less than an arcsecond in the worst cases. This places far greater demands on source positions required for observing than is typical at single antennas. Be sure to provide positions of sufficient accuracy, which can mean 0.1 arcsecond.

Anyone using the VLA for VLBI should consult the VLBI at the VLA guide.

Calibrator scans: Except for phase or fringe reference calibrators, there will typically be only 2 or a few more scans on each calibrator of the types discussed above. It is tempting to put these scans at the beginning and end of the scheduled observing time. However this is quite risky as those are the time periods most likely to experience problems. The beginning is especially risky because, if there are any problems at a site, they may not have been fixed yet. The end is ok, except at sites where the main target source has been down for a while and the antenna has been idle. It may not wake up again cleanly for the calibration scans. It is best to take time (a few minutes on each calibrator) out of the middle of the schedule a couple of times to get the calibration data.

7.2 Scan Times

There are a variety of way to set the time of a scan. The most obvious are to set the START time and the STOP time. However, this is rarely done. It is far more common when using one of these two, usually the START time, to use a DURation with it. One of these schemes has to be used for the first scan of a project since SCHED has to know when to start.

For any scans other than the first, it is usually more convenient to specify some sort of duration rather than a specific start of stop time. There are a few ways to do this. To understand them most easily, it is best to separate the concept of the scan times from the times that the tape is actually moving. The parameters START, STOP, DURation, DWELL, and GAP are all used to establish the scan times. The time that the tape stops is the same as the scan stop time. However the time that the tape starts can be offset from the scan start time using PRESCAN. The start and stop times that are reported in the summary and .sch files are the tape start and stop times.

If either of START or STOP, are specified, they lock down the scan time. However it is more common that just duration parameters are specified. In that case, the length of the scan is set by the value of either DURation or DWELL. Only one of those two can be specified. The interval between the start of the scan and the end of the previous scan is influenced by both DWELL and GAP. GAP sets the minimum interval. If the duration was specified with DWELL, the scan will start at the earliest at the time allowed by GAP, but will start later if necessary to allow all antennas to get to the source. This is "dwell time scheduling". Note that, if START is specified, GAP will be ignored.

After the scan time has been established, SCHED sets the tape start time by offsetting from the scan start time by the value of PRESCAN. PRESCAN can be of either sign so the tape can be prestarted (perhaps to allow sync time at the correlator), or it can be delayed. It is most likely that PRESCAN will be used for prestarting tapes in dwell time scheduled projects. In older versions of SCHED GAP was not available and PRESCAN was used to set intervals between scans. This still works as before, but is not the recommended proceedure — GAP is much preferred. It is expected that PRESCAN will become a rarely used parameter. When PRESCAN is negative and larger in absolute value than GAP or the slew time, it is possible that the requested tape start time will be before the end of the previous scan. If this happens, SCHED does not change the "scan" times, but rather simply leaves the tape running, setting the tape start time to equal the stop time of the previous scan.

The date specification for a scan is for the scan stop time, regardless of how the scan times are specified. If there is a scan that crosses midnight, this can cause some confusion. However, it is always a bad idea to schedule scans that cross midnight. The VLBA systems don't mind, but it is likely that somewhere in the data processing, a program will be encountered that gets confused. If a schedule crosses a day boundary and START or STOP times are being specified, the new day should be specified. However, if midnight is crossed during any form of duration scheduling, the day will be incremented automatically.

All scans for a given station must be specified in time order. However, it is not necessary for scans for different stations to be in time order. This allows, for example, for the scans for one antenna to be specified separately from the scans for another antenna. While this works, it is not recommended bacause SCHED does not try to identify scans that can be correlated together. Anything that depends on knowing what the whole array is doing is likely to fail. Dwell time scheduling is one such item because SCHED must know how long the slews are for all antennas in a scan. Plotting of u-v coverage is another because SCHED only plots u-v points for baselines between antennas in the same scan. The estimates of data volumes and rates from the correlator, given in the summary file, are yet another because they depend on counts of baselines. Finally, any VEX file produced in such a way is likely to cause problems at a correlator that depends on it (not the VLBA correlator).

SCHED allows sidereal time scheduling by means of the `LST`. For VLBI, the concept of LST needs a bit more specification since it is different for each element of the array. `LST` can take an argument which is the station whose LST is to be used. If there is no argument, that station is assumed to be the VLA since LST scheduling will most commonly be used for VLA schedules. If `LST` is specified, the year and month are ignored and the day is assumed to be the (modified?) julian sidereal day number. One way to determine what this number is would be to find a VLA schedule and read it off the side. Another is to make a dummy run of SCHED with the VLA as a station and look at the fifth line in the *exptobs.y* file where the day is specified as the "Observation day". For comparison, LST day 56789 was 1995 Dec. 12. Of course the LST day increments at a slightly different rate that the UT day.

If sidereal time scheduling is requested, all times and durations are assumed to be in sidereal units.

The trickiest part of setting scan times is probably getting the tape management right, at least until such time as full automatic tape handling is available. Please see the section on tape management (Section 7.3) for details on how to deal with this.

7.3 Tape Management

A fact of life with VLBI is that the data are recorded on tapes and tapes have various limitations. Tapes are not infinitely long and, at least so far, they cannot be stopped and started instantaneously. The time lost, especially when the direction of a tape has to be reversed, can be tens of seconds. Therefore, it is wise for the scheduler to worry about what the tapes are doing. Also tapes have finite bandwidth and capacity. The instantaneous bandwidth cannot be exceeded. A given project will be allotted a specific amount of tape — currently specified as a fixed number of tapes per site, but eventually this will be fractional tapes, or passes, or some equivalent. Therefore, the scheduler has to worry about not using too much tape.

The schedules sent to the antennas will also have to specify such details as track assignments, head positions etc unless automatic tape allocation is used. The user, however, should not need to worry about these details since SCHED has defaults that work fine in all but odd test observations. For the masochistic, the details of the SCHED defaults are given in Appendix B.

WARNING — it is now considered necessary to postpass VLBA/MarkIV thin tapes after recording. This means winding the tape all the way to the end and back to the beginning without stopping. This avoids irregularities in the tape pack that could otherwise lead to tape damage in handling and shipping. These irregularities are caused by starts and stops. Since tapes cost over $1000 each, this is a serious issue. SCHED will issue the necessary commands to request postpasses be done at stations that use VLBA control files.

Unfortunately, a postpass can take up to 33 minutes (22 after a speed change expected in early 1997). For two tape stations, this is not a problem. For single tape stations, it is can be serious since it adds this much to the tape change time. Also, if there is an inadequate gap in the schedule, the next tape can be out of the expected position on the first pass which can cause additional losses when the first reverse pass runs out of tape early. SCHED provides a way to avoid postpasses by keeping track of tape motions. If the last pass went from the far end of the tape to the beginning without stopping, a postpass is not required and is not requested by SCHED at single tape stations. *Therefore, users with single tape stations (all except the VLBA and VLA) who are using more than 1 thin tape per station are advised to not stop the tape on the last pass before each tape change.*

7.3.1 TAPE LENGTHS and PASS TIMES

Tapes for the Mark III and VLBA systems come in two nominal lengths, 9600 ft and 18000 ft. The lengths vary plus the usable length is shortened by the amount of leader needed at each reel. Experience has shown that it is best not to count on more than 17600 feet for the long "thin" tapes. Most short "thick" tapes are over 9000 feet, but there are a significant number as short as 8500. It is probably reasonable to assume that the short tapes will be 8800 ft, half the length of the long tapes, for scheduling purposes.

There are three basic recording speeds to consider. These are the speeds at which 4 million data bits per second are recorded on each track. Mark III and Mark IV format data at low density are recorded at 135 ips (inches per second). VLBA format data at low density are recorded at 133.33 ips. All formats at high density are recorded at 80 ips. Recording rates of half and twice these values are used when the number of bits per second per track is half or twice the 4 Mbps. High density recordings can only be made on "thin" tapes. The following table gives the recording times per pass to expect with these tape speeds and recording rates:

```
-----------------------------------------------------------------
   RECORDING TIMES for 1 pass on VLBA and Mark III tapes.
-----------------------------------------------------------------
   Tape length   Format /        Bit rate per track
      (feet)      density     (2 Mbps)   (4 Mbps)   (8 Mbps)
-----------------------------------------------------------------
      17600      All/High      1:28:00      44:00      22:00
      17600      VLBA/Low        52:48      26:24      13:12
      17600      Mark III/IV     52:08      26:04      13:02
       8800      VLBA/Low        26:24      13:12       6:36
       8800      Mark III/IV     26:04      13:02       6:31
-----------------------------------------------------------------
```

Unless full automatic tape handling is being used (see end of this section), scans should be scheduled so that they are in blocks that constitute a pass. This is not absolutely necessary, because, regardless of the scan times, SCHED will make sure that the scan will fit on the tape and, if not, will reverse the tape. If a scan cannot fit, SCHED will complain and die. Because of these actions, no data will be lost if the schedule is not in blocks of a tape pass, but some amount of tape will be wasted — it is better to be aware of the pass lengths. It is typical to round down the pass times to, for example, 13 minutes for those cases where the full number is 13:02 or 13:13.

Scheduling in blocks of tape passes is more complicated if there is a mixture of thin, high density tape at some sites and thick, low density tapes at other sites, such as might occur in a global observation. For Mark III, the longer tapes will hold 3.37 times as much data per pass as the shorter tapes. Probably the best way to deal with this is to schedule in blocks such that the 2 blocks fit per pass on the thick tapes and 7 blocks fit on the high density, thin tapes. The appropriate time for this for Mark III or VLBA formats is 6:17. Be careful with scans less than 30 seconds in such a schedule because the passes could get out of sync.

Note that, if there is a problem at a station and a tape does not start on time, or a scan is missed, the tape position will be behind that expected by SCHED. At the end of the pass, the tape will reverse when the schedule tells it to, which in this case will be some distance from the end. For this reason, the next pass is likely to run out of tape before it is finished and some data will be lost. The pass after that will begin at the expected place and there will be no further problems.

7.3.2 NUMBER of PASSES

The amount of data that can fit on a tape depends on the length of the tape, the tape speed, and on the number of passes. The Mark III and VLBA systems make longitudinal recordings using many heads, all mounted on a head stack. The width of each head is 38 microns and the "head pitch", or spacing between heads, is 698.5 microns. This difference allows many passes to be recorded with each head simply by shifting the whole head stack over by something more than 38 microns between passes (48 microns is used on the VLBA). The Mark III systems typically use 12 passes while the VLBA uses 14.

Many recording modes do not use all of the heads at once. Mark III systems uses 28 heads while VLBA and Mark IV systems use 32 (they all actually use the same 36 head headstack so the head pitch etc is the same). Mark III Mode A uses all heads in a pass. Modes B and C use half the heads while Mode E uses a quarter. There are many VLBA modes, but they typically use a quarter, half, or all heads, although lesser options are available. If not all the heads are used in a pass, more passes can be made at the same head position, increasing the total time over which data can be recorded on tape. The setup file parameter `TPMODE` gives the number of passes that can be recorded at each head position.

If multiple setups are used in a project, SCHED will figure out which uses the minimum number passes per head position (most tracks per pass) and will use that number of passes per head position for all setups. This wastes tape because some tracks never get recorded, but the alternative is a bookkeeping mess. Therefore, it is strongly recommended that all setups used in a project use the same number of heads per pass (have the same `TPMODE`).

It is perfectly possible to use setups that record at different speeds in the same schedule. As long as they all use the same number of heads, the tape will be used efficiently. However, a change of recording speed causes the VLBA correlator to need a new job. This is not a fundamental problem, but there is overhead for each job which causes work for the correlator staff. Current guidelines on how often changes of this sort can be made can be found in the guidelines for scheduling document found by going to the VLBA home page from the NRAO home page on the WWW. As of late 1996, changes more often than every 2 hours are discouraged. Note that using different tape speeds in different subarrays at the same time will preclude simultaneous correlation and will present the current job script making program with bookkeeping problems it is not equipped to handle. Don't do it!

The total time that can be recorded on a tape is the time per pass times the number of passes per head position times the number of head positions. The following table gives the total time per tape, and also the total bit rate, for various combinations of these parameters.

TOTAL RECORDING TIMES per TAPE (14 Head positions, 32 Heads) *

Tape length (feet)	Format/den	Bit rate per track (2 Mbps)	(4 Mbps)	(8 Mbps)
1 Pass/head pos.	Bit rate:	64 Mbps	128 Mbps	256 Mbps
17600	All/High	20:32:00	10:16:00	5:08:00
17600	VLBA/Low	12:19:12	6:09:36	3:04:48
17600	Mark III/IV/Low	12:09:52	6:04:56	3:02:28
8800	VLBA/Low	6:09:36	3:04:48	1:32:24
8800	Mark III/IV/Low	6:04:56	3:02:28	1:31:14
2 Pass/head pos.	Bit rate:	32 Mbps	64 Mbps	128 Mbps
17600	All/High	41:04:00	20:32:00	10:16:00
17600	VLBA/Low	24:38:24	12:19:12	6:09:36
17600	Mark III/IV/Low	24:19:44	12:09:52	6:04:56
8800	VLBA/Low	12:19:12	6:09:36	3:04:48
8800	Mark III/IV/Low	12:09:52	6:04:56	3:02:28
4 Pass/head pos.	Bit rate:	16 Mbps	64 Mbps	128 Mbps
17600	All/High	82:08:00	41:04:00	20:32:00
17600	VLBA/Low	49:16:48	24:38:24	12:19:12
17600	Mark III/IV/Low	48:39:28	24:19:44	12:09:52
8800	VLBA/Low	24:38:24	12:19:12	6:09:36
8800	Mark III/IV/Low	24:19:44	12:09:52	6:04:56

```
-------------------------------------------------------------------
*  Systems with Mark III hardware use 28 heads and 12 head positions
   so the recording times are lower.
```

If the tape allocated is insufficient to record for the whole allocated time at the desired bit rate, there are several options. The most common is to use a duty factor of less than one — to stop the tape for some of the time. Otherwise, it is necessary to cut down the bit rate or to request more tapes (good luck). Some periods of stopped tapes are desirable for readback tests.

7.3.3 READBACK TESTS

One way in which the performance of the recording system is monitored is to read back some data from the tapes and check the playback quality. On the VLBA systems, this is done any time there is a gap of longer than 2 minutes. If a really bad head is found, it is possible to make a copy of the data from that head on one of the system tracks (recall that the headstacks have 36 heads). Some day, the correlator will be able to use this data, although not yet. It is in the interests of both the individual project and of overall system maintenance for occasional gaps to be inserted in all projects for readback tests to be done. These gaps are often inserted at the ends of passes.

SCHED will look for gaps long enough for readback tests. If there are less than one every 2 hours, it will complain, but go ahead and make schedules anyway.

7.3.4 TAPE CHANGES

If a project is being scheduled that uses stations that have only one tape drive, it is necessary to schedule in a gap of about 15 minutes for that tape change to be accomplished. Some stations can do it faster, but it is best not to count on it. The VLBA stations and the VLA all have 2 tape drives each and the project will switch from one to the other when the first runs out. Then the operators can change the full tape at their leisure. For these stations, it is not necessary to schedule tape change times. /sched/ will complain, but not die, if a single tape station is requested to change tapes in less than 15 minutes.

An additional concern is that postpasses are needed for thin tapes. This can consume up to 33 minutes. See the beginning of this section for more details.

Sometimes it is a good idea to synchronize tape changes at at least some of the sites. For example, at least in late 1996, the VLBA correlator will not process the time between tape changes at different sites if they are less than something like 3 minutes apart. For optimized schedules, this can present a bit of a problem, so the input parameter `TAPESYNC` is provided to try to cause all stations that are near the end of their tape to change when the first reaches the end.

7.3.5 AUTOMATIC TAPE ALLOCATION

One eventual goal for the VLBA is to get away from all this worry about tapes, at least for all but the most demanding users. Two levels of automatic tape handling are available on the VLBA, although they are still under test (Nov 1996). These modes are invoked using the parameter `AUTOTAPE`.

The lower level allows the on-line system to decide where on the tape to start the next scan. However if the scan runs out of tape going in the current direction, the recorder will stop and the rest of the scan will be lost. Any scan starting less than 40 seconds from the end of the tape will be started in the opposite direction. It is the author's opinion that, because of the variable length of tapes, projects scheduled with this scheme are very likely to exhibit unexpected behavior with possible considerable loss of data. It should work ok for long scans that intentionally try to drive well beyond the end of the tape, but this is almost worse than worrying about specifying the tape behavior at schedule time.

The higher level of automation will be the method of choice for tape scheduling once there is rapid synchronization on the correlator. With this mode, whenever the tape gets to an end, it stops and reverses. The time lost should not be much greater than the time the correlator takes to reverse times the speed-up factor. For high density tapes, the time to reverse is about 5 seconds. Thus for most experiments the data loss should not be a significant problem. Scans of arbitrary length can be scheduled. The user only need to worry about not exceed his/her total tape allotment. The total amount of tape used in a schedule is reported in the summary file.

The full automatic tape handling is being tested and seems to work reasonably well. The tape reversals take somewhat longer than the theoretical minimum, but in most cases, for speed-up factor 2 (recording at 4 Mbps per track), the data loss is of order 15-20 seconds. This should be acceptable for most observations. Therefore we may soon recommend that users use this mode.

8 RECORDING SYSTEMS.

SCHED was originally written as the scheduling program for global VLBI observations using the Mark II recording system. That was a system capable of recording 4 Mbps on video tape recorders. SCHED can still schedule such observations, although the system is obsolete and no longer available at most observatories.

The wide band recording system in use for VLBI for many years has been the Mark III system. SCHED has never been a general purpose scheduling program for Mark III observations. Programs SKED and PC-SCHED serve that role. However, SCHED is capable of scheduling Mark III observations on systems that use the VLBA control files (VLBA, VLA, and Green Bank). In fact, the output of SKED and PC-SCHED is normally processed through SCHED to produce the telescope control files for these antennas for all except geodetic projects.

The Mark III system is now in the process of being replaced by several other systems with greater capabilities. These include the VLBA, Mark IV, S2, and K4 systems. There are new correlators associated with each system, and there is a considerable amount of cross compatibility, either directly or through the use of translation machines. The Mark III, VLBA, and Mark IV systems all use the same tape transport, although with different electronics. In their native modes, they use different data formats, but the VLBA and Mark IV systems are capable of reading and writing Mark III data. More importantly, the VLBA and Mark IV systems have a wide range of compatible recording modes that can be correlated together on the VLBA and future JIVE correlators.

This profusion of recording systems is further complicated by the the possibility of mixing elements of the different systems. There are three elements of each system that must be specified in order to make proper schedules. These are specified in the SCHED station catalog with the paramters `CONTROL`, `DAR` and `RECORDER`. The first element is the control system — what software (and hardware) is used to control the recording system. The options that SCHED can handle for wide band VLBI observations are VLBA and VEX. Formally, these actually refer to the control file type, although each type currently implies a specific computer and software system. Note that the `CONTROL` variable has other options, but they imply one of the above two, plus some specific other telescope control files.

The VLBA control system runs on VME computers using software mainly written for the VLBA. A few other sites (VLA, Green Bank, and one of the systems at Effelsberg) have such systems to control their VLBI hardware. Systems controlled by the VLBA software always consist of VLBA data aquisition racks (DAR — BBCs, formatter etc) and VLBA tape recorder(s).

The VEX option for `CONTROL` causes SCHED to generate a schedule file in the VEX format, as does the `DOVEX` main schedule input parameter. This is the schedule distribution file format developed mainly for the PC Field System (PCFS) and the Mark IV correlators, although it could be used by other systems. The PCFS, running on Linux PCs, is used to control VLBA, Mark IV, and S2 VLBI hardware at many non-VLBA stations including all of the EVN. It is the descendent of, and replacement for, the control system for Mark III systems. Sometimes this system is refered to as FS9, for "Field System 9", refering the the earliest version that could handle VEX input. As of this writing, the PCFS cannot use VEX input to control Mark III format recordings — a ".drg" file (see later) is required. Because of this, and the inability of SCHED to write ".drg" files (currently — the Japanese may change this), Mark III observations involving stations that do not use VLBA control files cannot be scheduled with SCHED.

Systems controlled by the PCFS can consist of a VLBA or Mark IV DAR connected to a VLBA, Mark IV, or S2 recorder. Each combination has slightly different capabilities and requirements. SCHED understands a considerable amount about what these capabilities and requirements are and attempts to insure that the requested observations are possible. However, when doing a large observation with many diverse telescopes, it is best to stick to standard, well tested, observing modes as embodied in the standard setup files and catalogs. The PCFS is also used to control systems consisting of a Mark III DAR and Mark III recorder. However, as noted earlier, VEX files cannot be used to control such systems and, hence, they cannot be scheduled with SCHED.

To further complicate things, the Japanese systems, both on the ground and for the VSOP satellite, have been designed to use the Mark III ".drg" file as input. Hooks have been provided in SCHED to allow software to be added to produce such files, but such software has not yet been written.

8.1 MARK III OBSERVATIONS

To schedule Mark III projects using non-VLBA control file stations or a Mark III correlator, it is best to use PC-SCHED, written by Alan Rogers and Dave Schultz at Haystack (unrelated to SCHED), or SKED, written by Nancy Vandenberg at Goddard Space Flight Center. PC-SCHED can read a very basic SCHED keyin file to get scan times and generate Mark III schedules. This is mainly useful to help get the files needed by a Mark III correlator to process a Mark III observation on the VLBA that was scheduled with SCHED. PC-SCHED and SKED produce a "Standard Schedule File Format" file, which is also known as the "sked file", ".skd file", ".drg file", or "drudg file". This single file contains a complete description of the experiment for all stations.

There is a program called DRUDG, associated with the Mark III systems, that is used to convert the ".drg file" into snap files to control the antennas and tape systems. DRUDG can produce VLBA control files and is used to do so regularily by the geodetic groups. It is rarely used to make schedules for non-geodetic projects. PC-SCHED also is able to produce VLBA control files, but this capability has not been kept up-to-date and should not be used.

An NRAO program called SKEDCONV exists to convert ".drg files" files into SCHED keyin files. It is recommended that most VLBA Mark III observers send their ".drg files" files to the AOC, where the staff will use SKEDCONV and SCHED, along with current setup files, to make the VLBA control files. Instructions on how to submit schedules are provided to observers when they are allocated observing time.

There are no definite plans to support Mark III observations fully with SCHED because the system will soon be obsolete. It will be replaced by the Mark IV system, which is basically an upgrade that uses the same tape recorders (upgraded) and heads, but a new formatter and wider bandwidths from the video converters. SCHED supports the Mark IV system through the VEX control files. However, as mentioned elsewhere, the Japanese systems related to VSOP have been designed around the ".drg file". Hooks have been provided in SCHED where they can attach routines to write ".drg file" output. If this project is completed, SCHED may acquire at limited Mark III capability.

Mark III observations on stations that use VLBA control files (VLBA, VLA, and Green Bank) can be scheduled directly with SCHED. The only difference between Mark III and VLBA format projects on these antennas is the data format on the tape (see the setup file input `FORMAT`) and various details in the setup files. Mark III observations have a one-to-one correspondence between tracks and channels, use one bit samples, and do not barrel roll. They typically use 7 or 14 channels, although Mark III format can be used on any project with no fan out. Anyone scheduling Mark III observations should either use standard setup files or, if making their own, should start with a standard file as a template. Such observations can be correlated on the VLBA correlator, but require production of a ".drg file" if sent to a Mark III correlator.

The PCFS can control Mark III observations on Mark III, Mark IV, and VLBA hardware. However, it will only do this with a Mark III type ".drg file" for input. Since SCHED does not produce such files, it cannot currently schedule Mark III format observations on systems that do not use the VLBA control files (e.g. the EVN). The ".drg file" is also required to control Mark III correlators, and therefore SCHED cannot be used to control experiments that are destinated for such correlators without causing considerable extra effort to generate such a file later. A possible future upgrade to the PCFS and SCHED would allow the use of VEX files to control observations on Mark III hardware or configure Mark III modes on Mark IV hardware.

The VLBA correlator is capable of correlating VLBA, Mark IV, and Mark III formats against each other as long as the sample rates and recording speeds were the same. Therefore the VLBA and Mark IV stations of a global observation that also involves Mark III stations could be scheduled with SCHED if it were to be processed in Socorro. Of course, the Mark III stations would still have to be scheduled somehow, so one of the other programs would probably be used anyway.

8.2 MARK IV OBSERVATIONS

SCHED supports Mark IV observations on Mark IV antennas equipped with the Field System (PCFS). This is done by creating a `*.skd` file in the VEX format. The VEX file is a global and self-contained description of the experiment that is scheduled. The `*.skd` file can be read by the control system (PCFS) and translated (by a program called DRUDG) into a list of commands for the telescope, data acquisition system and recorder.

SCHED currently (Feb. 1997) supports VEX version 1.5, which is accepted by FS9.3.7 or higher.

In order to cause SCHED to write VEX files, the user must either include in the schedule one telescope for which `CONTROL = VEX` is specified in the station catalog or must specify the input parameter `DOVEX`. Two example schedules that produce VEX files are included with the SCHED distribution and are located in the *$SCHED/examples* subdirectory. They are called *egiv.key* and *egvsop.key*.

Mark IV (MkIV) telescopes are characterized by `DAR = MKIV` and `RECORDER = MKIV` in the station catalog and can only be requested to record in any of the MkIV FORMATs. Most MkIV telescopes only support specific BBC's to be connected to certain IF distribution boxes. Currently SCHED only supports "astronomical patching". This requires odd BBC's to be connected to either `IFCHAN = 1N` (normal input, usually LCP) or `IFCHAN = 1A` (alternate, usually RCP). Even BBC's have to be connected to `IFCHAN = 2N` (usually RCP) or `IFCHAN = 2A` for LCP. This can be controlled by explicitly setting `BBC`.

Several features are not yet available or supported for MkIV, either because of pending hardware or software developments. The most important ones as of January 1997 are:

- Continuous tape motion is not supported. Any source change, or change of recorder characteristics requires a gap in the schedule of at least 40 seconds. Support of continuous tape motion requires a software upgrade in SCHED and the Field System.
- Phase Cal detection at the telescopes is not implemented. This requires (planned) soft– and hardware upgrades at the telescopes, the field system and probably SCHED.
- MkIV telescopes cannot currently use any form of barrel rolling. To enable this, enhancements in the Field System and telescope firmware are required.
- MkIV telescopes currently are only able to record without "data modulation". A fix requires a firmware upgrade at the telescopes and a small change of SCHED.

Eventually it will be required that SCHED read Mark IV VEX format `*.skd` files to serve as the DRUDG for the VLBA and VLA. As of Jan. 97, work on this capability has not yet begun.

8.3 NON–VLBA Telescopes with VLBA Recorders

SCHED supports observations on telescopes that have VLBA recorders but are controlled through PCFS. This is also done by creating a `*.skd` file in the VEX format (see section on `MkIV`).

The telescopes are characterized by `DAR = VLBA` and `RECORDER = VLBA`, but `CONTROL = VEX`. They can have a flexible number of BBCs, and usually have only 2 IF channels: A & C. The telescopes can only be requested to record in any of the VLBA FORMATs.

Several features are not yet available or supported for VLBA recorders controlled by PCFS, because of pending software developments. In addition there are currently some stations that have not completed all VLBA upgrades, which make some features unreliable. The most important ones as of January 1997 are:

Continuous tape motion is not supported. Any source change, or change of recorder characteristics requires a gap in the schedule of at least 40 seconds. This requires a software upgrade in SCHED and the Field System.

Phase Cal detection at the telescopes is not implemented. This requires a software upgrade in the field system and SCHEDand this depends on all stations having the latest VLBA equipment (digital switch board).

Most VLBA recorders in the EVN are not able to record on thin tape. Enhancements to enable this are planned for mid–1997.

Some antennas do not have the digital switch board. In these cases care must be exercized not to assign multiple channels to the same BBC/sideband, or the data will be corrupted.

8.4 S2 OBSERVATIONS

The S2 system has been developed in Canada to support the Orbiting VLBI missions VSOP and Radioastron, in addition to ground based astronomy. It is based on VCR technology and is relatively inexpensive. It is being used in Australia on the AT and at a number of other sites around the world.

SCHED supports observations on telescopes that have S2 recorders and are controlled through the Field System (FS9.3.7 or higher). This is also done by creating a `*.skd` file in the VEX format (see section on `MkIV`).

The telescopes are characterized by `RECORDER = S2` and `CONTROL = VEX`. Currently `DAR = VLBA` is completely supported (work on `DAR = MKIV` is in progress). For any other `DAR` SCHED will attempt to schedule the observation with a "standard" S2 mode, not using any knowledge on the content of the "user signal".

The modes supported for `DAR = VLBA` can be derived from a document "Compatibility of S2 and VSOPT recordings at S2 and VSOPT Correlators" by R. Wietfeldt, available at ftp::s2.sgl.ists.ca:pub/s2/svlbi/s2vsop_compat_memo_v*.ps.Z.

Because the S2 recorders work in a way conceptually different from VLBA (or MkIV) recorders, the user should bear the following in mind when scheduling for S2 recorders.

Please note that no operational tests with SCHED and S2 recorders have been completed yet.

The S2 recorder internally works with a number of recorders which each have one head and track. The S2 box uses 1, 2, 4 or 8 recorders depending of the mode. In SCHED this is characterized by setting `TPMODE` to the number of groups will be used by the S2 recorder.
The concept of fan–in or fan–out does not apply to S2 recorders in SCHED.
Tape lengths for S2 tapes are specified as the length for standard *US VCR* recording in seconds. Thus, when the VCR cassette has 120 (minutes) on the label the tape lengths is 7200 (ft) in SCHED. European buyers should be careful; a ST-120 tape presumably is labeled SE-180, but should still be scheduled with TPLENGTH = 7200. The S2 LP is obtained by using low density for which the `TPSPEEDL = 6.3` (ips) and SLP by using `TPSPEEDH = 4.2` (ips). These speeds are chosen in order to simulate that a 120 minute cassette will last for 7200*12/(6.3*60)=229 minutes, consistent with the S2 documentation. For high density the same tape lasts for 343 minutes per group (multiply by `TPMODE` to get the total time).
S2 tape motion is supposed to be "adaptive". The S2 recorders should start 2.5 minutes before a scan, stop only 0.5 minutes after the scan and generally continue to spin if any gaps are shorter than 3 minutes. This is the default and only mode of control for S2 recorders through SCHED.

9 SPECTRAL LINE OBSERVATIONS

SCHED can set observing frequencies for spectral line observations based on local standard of rest (LSR) velocities provided in the source catalog and rest frequencies provided in a separate type of input. This option is invoked by specifying `DOPPLER` and can be turned off with `NODOP` (`DOPCAL` is an obsolete form that was too easy to confuse with "DO PCAL"). If `DOPPLER` is invoked, SCHED calculates the velocity of the center of the Earth with respect to the LSR in the direction of the source at the time of the middle of the project. From this velocity, the source velocity from the source catalog, and the rest frequency, the required observing center frequency is calculated. The antennas need to know the LO settings so SCHED must know the bandwidth. The bandwidth will usually be obtained from the setup file. It may be provided for the scan with the `BW` parameter, although this will not be allowed if VEX files are being written. Otherwise

Note that channels assigned to the same BBC will be given the same frequency as the first channel on that BBC, no matter what velocities etc are given for the other channels. This will be the case when there are upper/lower sideband pairs. Their frequencies cannot be set independently. Because of the different sidebands, they will, however, cover different velocity ranges.

The frequencies derived from the doppler calculations have to be rounded off to a value that can be set on the available synthesizers. For the Mark III/IV and VLBA systems, frequencies can be set to the nearest 10 kHz. However other systems are different — VSOP, for example, can only be set to the nearest 1 MHz. The parameter `DOPINCR` can be used to control the rounding.

The doppler calculations are for the center of the Earth for the middle of the project. This implies that the frequency for each source will be constant for the duration of the project. Experience over the years with spectral line VLBI has shown this to be the preferred observing mode since it minimizes the chances of mistakes at stations that do not have automatic frequency setting. The shifts of the resulting spectra of about a km per second that result from the rotation of the Earth can be removed in post-processing with the CVEL program in the NRAO spectral line software or with a task of the same name and with similar capability in AIPS.

The LO sum used when doppler calculations are requested is the RESTFREQ * (1 - (VLSR+VSUN+VEARTH)/c) - BW/2 where RESTFREQ is the line rest frequency from the line initialization input, VLSR is the LSR velocity of the source from the source catalog, VSUN is the velocity component due to the sun's motion with respect to the LSR, VEARTH is the velocity component due to the Earth's motion around the sun, c is the speed of light, and BW is the bandwidth (appropriately signed according to the sideband). This definition is often refered to as the radio definition of velocity since the ratio of the change of frequency over the frequency is set to the velocity over the speed of light. Perhaps some day other definitions, along with heliocentric velocities will be added.

Internally, if Doppler calculation is requested, SCHED calculates the desired observing frequencies and puts them in the same array that would be used if `FREQ` were used. This will override any `FREQ` specifications in the main schedule and any frequency specifications in the setup files. The frequencies of baseband converters will then be set properly based on the `FIRSTLO` for the station.

The number of channels desired is set with `NCHAN` in the setup file (`NCHAN` in the main schedule is an obsolete parameter and is not used.). To calculate a frequency, SCHED must have, for each channel, a bandwidth, a velocity from the source catalog, and a rest frequency from the line initialization input information. If a value is missing for any channel of any parameter, the value of that parameter for channel 1 will be used. This avoids the need, for example, of specifying lots of bandwidths when they are all the same.

For continuum sources mixed in with line sources, specify `NODOP` for that scan to avoid the Doppler calculations.

Often it is desired to observe a continuum source at the same frequency as a line source for bandpass calibration. This can be done by specifying the line source with `DOPSRC` in the continuum source's scan. The `DOPSRC` will be used for the Doppler calculation.

The important parameters in the SCHED keyin file for Doppler frequency calculation are listed below. Detailed descriptions are given with the descriptions of other SCHED parameters.

`DOPPLER` and `NODOP` turn the Doppler calculations on and off.
`DOPSRC` is used to specify the source, if it is different from the scan source, for which the Doppler calculations should be made. This is useful for bandpass calibration.
`DOPINCR` is used to determine the level of rounding of frequencies that is used.
`LINENAME` specifies which group of rest frequencies to use. It must match one of the sets of lines named with `LINESET` in the `LINEINIT` input.

`BW` sets the bandwidth for the scan and overrides the setup file value. This is useful for switching between wideband observations on calibrators and narrow band observations on line sources. The value in the setup file will be used if it is not specified. This parameter is not allowed if VEX files are being written. In general, it is a good idea to use a new setup file when changing bandwidths because quite a few other parameters also change.

`LINEINIT` indicates that after the next "/", information on the rest frequencies of spectral lines will be given. If invoked, the rest frequencies will be read, and SCHED will return to reading input for the same scan that it was on before the "/".

The rest frequencies are specified in separate keyin inputs in the SCHED keyin file following a "/" if `LINEINIT` was specified. There can be one rest frequency per channel, although any not specified default to the first which is often the desired behavior. There should be one velocity per channel in the source file for each source to be observed (other than continuum calibrators). Each group of lines has a name which is then refered to using `LINENAME` in the scan input. The group can change with each scan, but be careful to change the setup file, too, if necessary. Up to 10 groups of lines are allowed. The parameters in the `LINEINIT` group are:

`LINESET`: Name of the group of lines. `LINENAME` in the scan input will be used to invoke this group.

Argument: Name of up to 8 characters.

Options: Any name.

Default: None

Usage: Defaults to previous value - don't do it!

Example: `LINESET='H2O'`

`RESTFREQ`: Rest frequencies.

Argument: Up to one real number per channel. The first value will be used for any channels for which a value is not given.

Options: Any value.

Default: `0`

Usage: Defaults to previous value.

Example: `RESTFREQ=22235.08`

`ENDLINES`: This parameter, on a separate line with a "/", ends the restfrequency inputs much like the `ENDCAT` parameter ends in-line source and station catalog inputs.

Argument: None.

Options: None.

Default: Not specified.

Usage: Defaults to previous value, but this has no effect since this will be the last line of the rest frequency input to be read.

Example: `ENDLINES /`

A fairly extensive list of possible rest frequencies is given below. These frequencies are not guaranteed. If anyone finds an error, please notify Craig Walker (cwalkernrao.edu).

```
-----------------------------------------------------------------
lineinit /
!   Frequencies from Reid and Moran's Annual Reviews article preprint.
!   Do not keep more than 10 lines in a SCHED input file.
lineset='OH1612'  restfreq=1612.231   /
lineset='OH1665'  restfreq=1665.402   /
lineset='OH1667'  restfreq=1667.359   /
lineset='OH1720'  restfreq=1720.530   /
lineset='OH4660'  restfreq=4660.42    /
lineset='OH4765'  restfreq=4765.562   /
lineset='OH6030'  restfreq=6030.747   /
lineset='OH6035'  restfreq=6035.092   /
lineset='CH3OH'   restfreq=6668.518   /  Menton preprint.
lineset='CH3OH'   restfreq=12178.595  /  A. Kemball
lineset='OH13'    restfreq=13441.417  /
lineset='NH3'     restfreq=18499.393  /  Pratrap Preprint.
lineset='CH3OH'   restfreq=19967.3961 /  Menton preprint.
lineset='H2O'     restfreq=22235.08   /
lineset='CH3OH'   restfreq=23121.0242 /  Menton preprint.
lineset='CH3OH'   restfreq=25124.87   /
lineset='SiO425'  restfreq=42519.3    /
lineset='SiO428'  restfreq=42820.54   /
lineset='SiO431'  restfreq=43122.03   /
lineset='SiO862'  restfreq=86243.35   /
lineset='SiO868'  restfreq=86846.89   /
lineset='CH3OH'   restfreq=44069.43   /  Bachiller preprint (SAO)
lineset='CH3OH'   restfreq=97980.97   /  Plambeck preprint (SAO)
lineset='SiO1293' restfreq=129363.26  /
! some more from VLA OBSERVE
lineset='H'        restfreq=1420.405752   /
lineset='H2CO4830' restfreq=4829.656900   /
lineset='H2CO145'  restfreq=14488.475000  /
lineset='NH3(1,1)' restfreq=23694.495500  /
lineset='NH3(2,2)' restfreq=23722.633600  /
lineset='NH3(3,3)' restfreq=23870.129600  /
lineset='NH3(4,4)' restfreq=24139.416900  /
lineset='NH3(5,5)' restfreq=24532.988700  /
```

```
endlines /
-----------------------------------------------------------------
```

The example below shows the SCHED input for a spectral line It is a modified version of the file used for a project by Phil Diamond in Dec 95. The modifications are to adjust for some of the new features of SCHED that were not available at the time the file was used. Note that the tape initialization stuff probably could be defaulted and that it is not necessary to repeat the DUR and GAP specification every scan. However some users prefer to show these details and it certainly doesn't hurt. Also, the bandwidth specification is the same as the setup file so it is not required (it used to be).

```
! EXAMPLE - spectral line observations.

! ===========================================================
! =================  Cover Information  ====================
! ===========================================================

EXPT = 'BD27 VLBA format 7mm line 1995 DEC 29 18:00 -> DEC 30 18:00 UT'
EXPCODE  = 'BD027'
VERSION  = 1

PINAME   = 'P.J.Diamond'
ADDRESS1 = 'NRAO'
ADDRESS2 = 'P.O. Box O'
ADDRESS3 = 'Socorro, NM 87801, USA'
PHONE    = '1-505-835-7365 (work) or 1-505-835-2095 (home)'
OBSPHONE = '1-505-835-7365 (work) or 1-505-835-2095 (home)'
FAX      = '1-505-835-7027'
EMAIL    = 'pdiamond@nrao.edu (internet)'
OBSMODE  = 'VLBA'
OBSTYPE  = 'VLBA'
NOTE1 = 'At VLA use antenna 27'
NOTE2 = 'its the standard VLBI antenna and has good Q band performance'

! ===========================================================
! ==============  Correlator Information  ==================
! ===========================================================

correl   = 'Socorro'
coravg   = 4
corchan  = 256
cornant  = 10
corpol   = 'off'
corwtfn  = 'uniform'
corsrcs  = 'standard'
```

```
cortape  = DAT
corship1 = 'Athol Kemball'
corship2 = 'P. O. Box O'
corship3 = 'Socorro NM 87801'

! ==========================================================
! ================== Tape initialization  =================
! ==========================================================

tapeini /
  tpsta   = vlba,   vla,    gb_vlba, eb_vlba, default
  tpdrive = 1,      1,      1,       1,       1
  tplength= 17600,  17600,  8800,    8800,    8800
  ndrives = 2,      2,      1,       1,       1
  nheadpos= 14,     14,     14,      14,      14
  density = H,      H,      L,       L,       L
   /

! ==========================================================
! ===================  Source Catalog  ===================
! ==========================================================

SRCCAT /
SOURCE='3C273'    RA=12:26:33.2480 DEC= 02:19:43.290 EPOCH='B1950' /
SOURCE='3C279'    RA=12:53:35.8380 DEC=-05:31:08.040 EPOCH='B1950' /
SOURCE='3C345'    RA=16:41:17.6080 DEC= 39:54:10.820 EPOCH='B1950' /
SOURCE='3C454.3'  RA=22:51:29.52   DEC= 15:52:54.35  EPOCH='B1950' /
SOURCE='OJ287'    RA=08:51:57.2530 DEC= 20:17:58.440 EPOCH='B1950' /
SOURCE='1823+568' RA=18:23:14.9490 DEC= 56:49:18.050 EPOCH='B1950' /
SOURCE='1334-127' RA=13:34:59.8150 DEC=-12:42:09.900 EPOCH='B1950' /
SOURCE='1633+382' RA=16:33:30.6280 DEC= 38:14:10.050 EPOCH='B1950' /
SOURCE='0420-014' RA=04:20:43.5400 DEC=-01:27:28.660 EPOCH='B1950' /
SOURCE='1749+096' RA=17:51:32.8185 DEC= 09:39:00.728 EPOCH='J2000' /
SOURCE='RAQR'     RA=23:41:14.269  DEC=-15:33:42.89   EPOCH='B1950'
                  VEL = -27.0, -27.0 /
SOURCE='RLEO'     RA=09:44:52.2    DEC= 11:39:40.8   EPOCH='B1950'
                  VEL = -2.0,  -2.0 /
SOURCE='VYCMA'    RA=07:20:54.6    DEC=-25:40:12.2   EPOCH='B1950'
                  VEL = 20.0 /
SOURCE='VXSGR'    RA=18:05:02.9    DEC=-22:13:55.6   EPOCH='B1950'
                  VEL = 8.0 /
SOURCE='UHER'     RA=16:23:35.0    DEC= 19:00:18.0   EPOCH='B1950'
                  VEL = -15.0, -15.0 /
SOURCE='IKTAU'    RA=03:50:43.7    DEC= 11:15:31.8   EPOCH='B1950'
                  VEL = 34.0, 34.0  /
```

```
SOURCE='TXCAM'    RA=04:56:41.4    DEC= 56:06:29.9   EPOCH='B1950'
                  VEL = 9.0, 9.0 /
SOURCE='NMLCYG'   RA=20:46:25.59   DEC= 40:06:58.3   EPOCH='J2000'
                  VEL = -5.0, -5.0 /
SOURCE='SPER'     RA=02:19:15.1    DEC=+58:21:34.0   EPOCH='B1950'
                  VEL = -40.0, -40.0 /

ENDCAT /

! ==========================================================
! ====================  Station Catalog  ===================
! ==========================================================

stafile  = '$SCHED/catalogs/stations.dat'

! ==========================================================
! ==============  Spectral line rest frequecies  ===========
! ==========================================================

LINEINIT /
lineset='ccal'  restfreq=43122.027, 43122.027, 43126.027, 43126.027,
                         43130.027, 43130.027, 43134.027, 43134.027 /
lineset='prog'  restfreq=43122.027, 43122.027 /
ENDLINES /

! ==========================================================
! ====================  Observing setup  ===================
! ==========================================================

setinit = bd27.set  /
nchan    = 8  samprate = 8.0  bits = 1  bbfilter = 4.0  !  128 Mbps
tpmode   = 4  format = VLBA1:1
bbc      = 1, 2, 3, 4, 5, 6, 7, 8
netside  = U, U, U, U, U, U, U, U
ifchan   = R, L, R, L, R, L, R, L
!   Radio Astronomy allocation:  42400-43500
pcal     = 'off'
freqref  = 43150.99
firstlo  = 42400.00  fe(1) = '7mm'   fe(3) = '7mm'
synth(2) = 7.6  synth(3)= 11.6   ! LO = Syn(2) + 3*Syn(3)
station  = 'VLBA'   rchan = A  lchan = C   /
firstlo  = 42489.9, 42489.9
vlaband  = VQ
vlabw    = '0000'
vlafeab  = 51.6
```

```
vlafecd  = 13.4
vlasyna  = 3889.9
vlasynb  = 3889.9
flukea   = 100.0
flukeb   = 200.0
pcal     = 'off'    !  Pulse cal tone can mess up spectra.
station  = 'VLA1'   rchan = B  lchan = D   /

endset /

! ==========================================================
! ================  Initial Scan Information  =============
! ==========================================================
!
STATIONS = VLBA_SC, VLBA_HN, VLBA_NL, VLBA_FD, VLBA_LA,
           VLBA_PT, VLBA_KP, VLBA_OV, VLBA_BR, VLBA_MK, VLA1
VLAMODE 'VS'

YEAR   = 1995
MONTH  = 12
DAY    = 29
START  = 18:02:00
!
!
LINENAME = 'ccal'  DOPPLER
SETUP  = 'bd27.set'
BW = 4.0, 4.0, 4.0, 4.0, 4.0, 4.0, 4.0, 4.0

! ==========================================================
! =======================  The Scans  ====================
! ==========================================================

SOURCE = '1749+096'  GAP = 00:02:00 DUR = 00:11:00 DOPSRC 'SPER'/
!
SOURCE = 'SPER'      GAP = 00:02:00 DUR = 00:11:00 /
SOURCE = 'SPER'      GAP = 00:02:00 DUR = 00:11:00 /
SOURCE = 'SPER'      GAP = 00:02:00 DUR = 00:11:00 /
!
SOURCE = '3C454.3'   GAP = 00:02:00 DUR = 00:11:00 DOPSRC 'SPER'/
!
SOURCE = 'SPER'      GAP = 00:02:00 DUR = 00:11:00 /
SOURCE = 'SPER'      GAP = 00:02:00 DUR = 00:11:00 /
SOURCE = 'SPER'      GAP = 00:02:00 DUR = 00:11:00 /
SOURCE = 'SPER'      GAP = 00:02:00 DUR = 00:11:00 /
!
```

```
SOURCE = '3C454.3'   GAP = 00:02:00 DUR = 00:11:00 DOPSRC 'SPER'/
!
SOURCE = 'SPER'      GAP = 00:02:00 DUR = 00:11:00 /
SOURCE = 'SPER'      GAP = 00:02:00 DUR = 00:11:00 /
SOURCE = 'SPER'      GAP = 00:02:00 DUR = 00:11:00 /
!
!     ---------------------------------
!    |                                 |
!    |   Many scans in the same style.  |
!    |_________________________________|
!

SOURCE = '1749+096'   GAP = 00:02:00 DUR = 00:11:00 DOPSRC 'UHER'/
!
SOURCE = 'UHER'       GAP = 00:02:00 DUR = 00:11:00 /
SOURCE = 'UHER'       GAP = 00:02:00 DUR = 00:11:00 /
SOURCE = 'UHER'       GAP = 00:02:00 DUR = 00:11:00 /
SOURCE = 'UHER'       GAP = 00:02:00 DUR = 00:11:00 /
!
SOURCE = '1749+096'   GAP = 00:02:00 DUR = 00:11:00 DOPSRC 'UHER'/
!
SOURCE = 'UHER'       GAP = 00:02:00 DUR = 00:11:00 /
SOURCE = 'UHER'       GAP = 00:02:00 DUR = 00:11:00 /
SOURCE = 'UHER'       GAP = 00:02:00 DUR = 00:11:00 /
!
SOURCE = '1749+096'   GAP = 00:02:00 DUR = 00:11:00  DOPSRC 'UHER'/
! ---------------------------------------------------------------------
```

10 SCHEDULING THE VLA

SCHED can be used to schedule essentially all types of VLBI observations on the VLA. It can also be used instead of OBSERVE to schedule pure VLA observations involving a limited subset of the special cards that can be in VLA schedules. This includes most continuum observations. For more information on the VLA, check out the VLA from the NRAO home page at *http://www.nrao.edu*. For much detailed information on VLBI at the VLA, follow the links to VLBI at the VLA. The latter document is available in postscript form from the VLA home page.

All observations at the VLA need an observe file that is used by the VLA on-line computers to control the antennas and correlator. In addition, all VLBI observations at the VLA also require a VLBA-style control file for the VME that controls the VLBA data aquisition rack and tape recorder. SCHED produces both kinds of files.

The VLBA control file, called *bq001crd.y* by SCHED for an example project with `EXPCODE=bq001`, is similar to those provided for VLBA stations, except that some VLBA specific commands for receivers, etc. are omitted. This file controls BBC settings, when the tape starts and stops, what head positions are in use, and which head groups are activated.

The observe file, called *bq001obs.y* by SCHED in this example, is the file that is normally created by the NRAO program `OBSERVE` (can be found from the NRAO home page) and given to the VLA on-line system. While SCHED is intended for VLBI scheduling and this output is provided mainly for projects that use the VLA for VLBI, there is no reason that it cannot be used for scheduling pure VLA projects. In fact, a few parameters of interest only for non-VLBI projects are provided for VLA observers, including the ability to schedule in LST. However, SCHED has only limited ability to provide the special setup cards, namely those that start with "//".

SCHED can provide "//LO" and "//FI" cards with parameters to set synthesizers to fixed values. The setup file can be used to provide values for the synthesizer settings. If `FREQ` or `DOPPLER` is used, the BBC settings will be adjusted to try to reach the right frequency for the VLBI data. Note that this has no effect on the VLA observing frequency. "//LO" and "//FI" cards are provided if, and only if, the required information is present in the setup file or could be obtained for the setup file by SCHED from the frequency catalog. SCHED also provides the "//PM" cards if proper (or planetary) motion is present for the source in the source catalog. Since the epoch of zero offset is given in IAT, IAT-UTC must be provided with parameter `IATUTC` in the SCHED keyin file. If other "//" cards are needed, or other options are needed on the "//LO" and "//FI' cards, the regular VLA *OBSERVE* must be used or they must be edited in by hand. Beware of the fixed formats: if values are put in the wrong columns, the VLA on-line system will not behave as expected!

10.1 VLBI at the VLA

For much detailed information on VLBI at the VLA, follow the links to the VLBI at the VLA guide.

There are two very different modes in which VLBI can be done at the VLA. These are single dish and phased array observations. For single dish VLBI observations, the IF signals from one antenna of the array are sent to the VLBI recording equipment (VLBA DAR and recorder). Other than having to worry about the VLA's rather complicated LO system, such observations are very similar to observations at other VLBI observatories. The phased array observations, on the other hand, have some very special needs. For such observations, the signals from all VLA antennas are summed in the VLA correlator and the summed signal is sent to the VLBI equipment. This gives a sensitivity for the "antenna" that is increased by about the number of phased antennas, *if* the array is phased properly. Array phasing is accomplished by the on-line control system. Output phases from the correlator are used to derive adjustments to the phase of the LO at each antenna that, when applied, will cause the next correlator phases to go toward zero. The system can phase up on a calibrator and then freeze the phases on a target source when the target source is either too weak, resolved, or confused for successful phasing.

For successful phasing of the array, a source must be greater than about 0.1 Jy (see the guide referenced above for details) and have a position that is good to a fraction of the VLA synthesized beam (enhanced sensitivity is only obtained over this area). It must have small structure phases and not have other sources in the primary beam that might confuse the phasing algorithm. The position accuracy is especially important if a calibrator is being used to phase the array for observations of another source. Adding phasing sources is tricky, because it is desirable to spend a minimum amount of time on them, but if they are missed, the rest of the data will be bad.

There are two ways to deal with VLBI observations that require phasing on a source different from the target source. The best is probably to simply schedule VLBI scans, with the proper `VLAMODE`, on the phasing source. These observations can then also be used to assist the VLBI calibration, assuming an appropriate calibrator has been chosen. The other scheme is to insert calibration scans into the VLA's schedule file (the OBSERVE file), but not the tape control file, for the phasing operation. SCHED provides some tools to simplify this operation. It can also be done using the VLA OBSERVE program. This is done by the VLA analysts for some programs, especially Mark III programs.

For VLBI observations at the VLA, both an OBSERVE file and a VLBA style tape control file are needed and can be created by SCHED. All of the controls provided for managing tapes for the VLBA also work for the VLA. SCHED also has special capabilities for scheduling VLA observations as described below.

Mark III programs that use the VLA are often scheduled using PC-SCHED (the Haystack program). The resulting "Standard Schedule File Format" or drg file is sent to the AOC where staff will convert it to a SCHED keyin file using SKEDCONV. They will then run SCHED to create the required files for both the VLA and the VLBA. For such observations, phasing sources are usually inserted where required after the initial OBSERVE file has been made.

For observations that require phasing on a calibrator, the array must be phased in auto-phasing (`VLAMODE = VA`) mode prior to VLBI observations of the target source in extended-phasing (`VLAMODE = VX`) mode. These calibrator observations constitute additional scans that must be in the VLA observe file, but that no other VLBI observatory or the tape control file for the VLA needs to know about. (Note that Westerbork needs something of the sort, but they have never requested special information in SCHED output files).

If it is desired to add phasing scans on a calibrator on which VLBI data will not be recorded and that will not be observed at the other VLBI observatories, the parameter `VLAPSRC` can be used. If a `VLAPSRC` is given, SCHED will automatically insert phasing observations in the VLA OBSERVE file at appropriate times. Note that `VLAPSRC` must be a source in the same catalogs that are searched for `SOURCE` and `DOPSRC`. SCHED will add a phasing scan to the observe file which will end either 1 minute before the main VLBI scan starts, or 3 minutes after the previous VLBI scan ends, whichever is later. If the latter option is used, SCHED complains if less than 2 minutes of the VLBI scan remains. Also with the latter option, the VLBA-style tape control file will still start the tape when the main VLBI scan was supposed to start. This keeps tape motions at the VLA and other sites synchronized, although it can lead to the need to flag data that won't have VLBI fringes. SCHED will not add a phasing scan if the VLBI scan is in `VLAMODE=VA` or if `VLAPSRC` is the same as `SOURCE`. This avoids the need to keep respecifying `VLAPSRC` whenever a VLBI calibrator is observed in mode `VA` and prevents the addition of unnecessary extra scans when the VLBI schedule calls for observations of the phasing source.

It is highly recommended that the NRAO OBSERVE program be used to check the VLA observe file for slew and dwell times on the phasing sources. The scan stop times may have to be adjusted with OBSERVE to obtain an adequate amount of on-source time for phasing. It is especially critical to be careful about slew times for sources near the zenith where long azimuth slews may be needed to go a short distance on the sky. SCHED only recently acquired to ability to calculate slew times and this has not yet been extended to the VLA phasing scans. This is an area of future construction.

SCHED is also able to deal with reference pointing using the `PEAK` command. Refer to the description of `PEAK` for details. The VLA-only example below uses this capability.

10.1.1 An Example

Below is an example of a file for a VLBI observation that uses the phased VLA. For phasing, a source is used that can also be used as a VLBI phase or fringe fitting reference. All antennas are sent to the reference and VLBI data is taken on it. This is now the prefered style for phasing. Of course the `VLAPSRC` parameter could also have been used if non-recording scans with only the VLA on the calibrator had been desired.

Note that the main example in the Getting Started section has a single VLA antenna in it and serves as an example of that type of observing.

```
! Start file bw099.key.  Example of a VLBI observation using the
!                        VLA as a phased array.
!                        Original file by J. Wrobel.
!                        Modified for the SCHED manual by C. Walker.
!
expt     = 'bw099 1cm 15jan97 Wrobel'
expcode  = 'bw099'
version  = 1
piname   = 'J.M. Wrobel'
address1 = 'NRAO, P.O. Box O'
address2 = 'Socorro, NM 87801'
address3 = 'USA'
phone    = '+1-505-835-7392'
obsphone = 'VLA'
fax      = '+1-505-835-7027'
email    = 'jwrobel@nrao.edu (internet)'
obsmode  = '128-4-2'
obstype  = 'VLBA'
note1    = 'VLBA target               : J1220+29=NGC4278=UGC07386 ***'
note2    = 'VLBA DR check/VLA phase ref: J1221+28                 ***'
note3    = 'VLBA FF/manual pcal/bpass  : J1229+02=3C273           ***'
note4    = 'VLBA amp check, VLA amp std: J1310+32, J1331+30=3C286  ***'

correl   = 'socorro'
cornant  = 11
corchan  = 16
```

```
coravg   = 2
corpol   = 'on'
corwtfn  = 'uniform'
corsrcs  = 'NGC4278 from schedule, else standard'
cortape  = 'dat'
corship1 = 'jwrobel at aoc'

! tape initialization stuff ******************************************
!        These are defaults so this section is not actually needed.
!        It is included here to show the format in an example.

tapeini /
obscode ='default'
tpsta   ='vlba', 'vla1', 'vla27', 'eb_vlba', 'gb_vlba', 'default'
tpdrive =1,      1,      1,      1,         1,         1
tpindex =1,      1,      1,      1,         1,         1
tplength=17600,  17600,  17600,  17600,     17600,     8800
ndrives =2,      2,      2,      1,         1,         1
nheadpos=14,     14,     14,     14,        14,        14
density =H,      H,      H,      H,         H,         L
        /

! inline source catalog **********************************************

srccat  /
source='J1220+2916','J1220+29','B1217+295','NGC4278','UGC07386'
     ra=12:20:06.8243  dec= 29:16:50.716  epoch='J2000'  calcode='M'
     remarks='From preliminary JVAS paper III' /
endcat /

! standard catalogs **************************************************
!        These are the defaults - included to show format.

srcfile  = $SCHED/catalogs/sources.vlba
stafile  = $SCHED/catalogs/stations.dat

! schedule stuff *****************************************************

year     = 1997
month    = 1
day      = 15
start    = 06:45:00
stations = vlba_sc, vlba_hn, vlba_nl, vlba_fd, vlba_la,
           vla27,
           vlba_pt, vlba_kp, vlba_ov, vlba_br, vlba_mk
```

```
comment = '**** At VLA use 1 thin tape and 4 as reference antenna.'
!      Note - outside users do not need to specify the reference antenna.

! Adopt 14 passes per tape and 44m per thin tape pass using a standard
! one cm setup file.
setup   = '$SCHED/setups/v1cm-128-4-2.set'

! Point vla27 south to make wraps predictable. Assess phasing.
source  = 'J0725-00' gap = 00:00 dur = 12:00 vlamode 'VA' norecord /

! Swing vla27 to ngc4278's phase ref source.
source  = 'J1221+28' gap = 00:00 dur = 05:00 vlamode 'VA' norecord /

! Do passes 1-4.  This is a sequence of calibrator/source pairs.
group 2   repeat 16
 source = 'J1221+28' gap = 00:00 dur = 03:00 vlamode 'VA'   record /
 source = 'NGC4278'  gap = 00:00 dur = 08:00 vlamode 'VX'   record /

! Start pass 5.   Get VLBI fringe finder and VLA flux calibrator.
comment = '**** Start 1st calibration sequence.'
! vla27 mode VA is ok for J1310+32 but not for 3C273.
! vla27 mode VX for 3C286 to hold phases constant.
 source = 'J1224+03' gap = 00:00 dur = 04:00 vlamode 'VA' norecord /
 source = '3C273'    gap = 00:00 dur = 05:30 vlamode 'VX'   record /
 source = 'J1310+32' gap = 01:00 dur = 05:30 vlamode 'VA'   record /
 source = '3C286'    gap = 00:00 dur = 04:00 vlamode 'VX' norecord /
comment = '**** End   1st calibration sequence.'

! Swing vla27 to ngc4278's phase ref source.
source  = 'J1221+28' gap = 00:00 dur = 03:00 vlamode 'VA' norecord /

! Finish pass 5.
group   2 repeat 3
 source = 'J1221+28' gap = 00:00 dur = 03:00 vlamode 'VA'   record /
 source = 'NGC4278'  gap = 00:00 dur = 08:00 vlamode 'VX'   record /

! Do passes 6-9.
group   2 repeat 16
 source = 'J1221+28' gap = 00:00 dur = 03:00 vlamode 'VA'   record /
 source = 'NGC4278'  gap = 00:00 dur = 08:00 vlamode 'VX'   record /

! Start pass 10.
comment = '**** Start 2nd calibration sequence.'
 source = 'J1224+03' gap = 00:00 dur = 04:00 vlamode 'VA' norecord /
```

```
 source = '3C273'    gap = 00:00 dur = 05:30 vlamode 'VX'   record /
 source = 'J1310+32' gap = 01:00 dur = 05:30 vlamode 'VA'   record /
 source = '3C286'    gap = 00:00 dur = 04:00 vlamode 'VX' norecord /
comment = '**** End   2nd calibration sequence.'

! Swing vla27 to ngc4278's phase ref source.
source  = 'J1221+28' gap = 00:00 dur = 03:00 vlamode 'VA' norecord /

! Finish pass 10.
group   2 repeat 3
 source = 'J1221+28' gap = 00:00 dur = 03:00 vlamode 'VA'   record /
 source = 'NGC4278'  gap = 00:00 dur = 08:00 vlamode 'VX'   record /

! Do passes 11-14.
group   2 repeat 16
 source = 'J1221+28' gap = 00:00 dur = 03:00 vlamode 'VA'   record /
 source = 'NGC4278'  gap = 00:00 dur = 08:00 vlamode 'VX'   record /

! end bw099.key
```

10.2 VLA-Only Project Example

This second VLA example demonstrates the use of SCHED to schedule a pure VLA project. The SCHED input for VLA observations is very much like that for VLBI observations. There are some parameters provided, and listed below, to control some of the input information for which the VLBI defaults may not be appropriate. The example is a modified version of an actual schedule used to make the VLA observations described. The modifications were required by changes in the way in which SCHED handles setup files and the paramters `VLABAND` and `VLABW`. These parameters are no read from the setup files, not the main schedule input.

```
! -------------------------------------------------------------------
! EXAMPLE of SCHED file for non-VLBI VLA observations.
! -------------------------------------------------------------------
!  VLA observations to get flux densities of DA193 and 3C84 at VLA.
!  Note that the example setup files are used for cc and qq bands.

! -----  Cover Information

version  = 1
expt     = 'Get flux densities for BV16'
piname   = 'Craig Walker'
address1 = 'National Radio Astronomy Observatory'
address2 = 'P. O. Box O'
address3 = 'Socorro, New Mexico, 87801'
```

```
address4 = ' U.S.A. '
phone    = '505 835 7247 '
obsphone = '505 835 7247 '
email    = 'cwalker@nrao.edu'
fax      = '505 835 7027 '
obsmode  = 'Continuum'
correl   = 'Socorro'

! -----  File names and other details.

stafile   = $SCHED/catalogs/stations.dat
srcfile   = $SCHED/catalogs/sources.vlba
obstype   = vla          ! Tells SCHED that this is VLA only.
expcode   = BV016
stations  = VLA
vlatype   = CONTINUUM
vlausern  = 450
vlamode   = '  '

lst                      ! Schedule in LST.

! -----  A source that is not in the external source list:

srccat /

source='CTA21'   ra=03:16:09.1383   dec= 16:17:40.448
epoch='B1950'   calcode='B' /

endcat /

! -----  Scans.

day = 56719              ! LST day of stop of first scan.
start = 4:00:00          ! LST start time.

source = 'DA193'

 ! Do not do anything with pointing (PEAK command).
 dur = 8:00  setup = $SCHED/examples/manual_vla-cc.set   peak = -1 /
 dur = 3:00  setup = $SCHED/setups/vla-uu.set  /
 dur = 3:00  setup = $SCHED/setups/vla-xx.set  /

 ! Peak up the pointing using X band.
 dur = 5:00  setup = $SCHED/setups/vla-xx.set   peak = 1  / ! Peak up
```

```
 ! Hold the pointing offset on the following scans at Q and K bands.
 dur = 4:00  setup = $SCHED/examples/manual_vla-qq.set   peak = 0  /
             setup = $SCHED/setups/vla-kk.set  /

source = '3C48'
 dur = 8:00  setup = $SCHED/setups/vla-xx.set   peak = 1  /

 dur = 4:00  setup = $SCHED/examples/manual_vla-qq.set   peak = 0  /
             setup = $SCHED/setups/vla-kk.set  /

source = '3C84'
 dur = 6:00  setup = $SCHED/setups/vla-xx.set   peak = 1 /
 dur = 3:00  setup = $SCHED/examples/manual_vla-qq.set   peak = 0 /
             setup = $SCHED/setups/vla-kk.set  /

source = '3C84'
             setup = $SCHED/setups/vla-uu.set   peak = -1 /
             setup = $SCHED/setups/vla-xx.set  /
             setup = $SCHED/examples/manual_vla-cc.set  /
             setup = $SCHED/examples/manual_vla-cc.set  /
             setup = $SCHED/setups/vla-pp.set  /

source = '3C48'
 dur=6:00    setup = $SCHED/setups/vla-uu.set  /
 dur=3:00    setup = $SCHED/setups/vla-xx.set  /
             setup = $SCHED/examples/manual_vla-cc.set  /
             setup = $SCHED/examples/manual_vla-cc.set  /
 dur=4:00    setup = $SCHED/setups/vla-pp.set  /

source = 'DA193'
 dur=9:00    setup = $SCHED/setups/vla-uu.set  /
 dur=4:00    setup = $SCHED/setups/vla-xx.set  /
             setup = $SCHED/examples/manual_vla-cc.set  /

source = 'CTA21'
 dur=10:00   setup = $SCHED/setups/vla-ll.set  /
 dur=4:00    setup = $SCHED/setups/vla-pp.set  /

! ------------------------------------------------------------------
```

The above file used several setup files since it was sampling all bands used at the VLA. Two are shown below. All of the others are like the first — very simple because they use the standard mode. The second specifies the LO settings for the Q (7mm) band observations so it is rather more complicated. Note that, for many frequency settings, SCHED can obtain the required information from entries in the frequency catalog.

```
! ---------------------------------------------------------------------
! EXAMPLE setup file for non-VLBI observations at the VLA at 6cm.
! ---------------------------------------------------------------------
!  vla-cc.set
!  Non-VLBI observations at the VLA at C band
format=none  station=VLA  vlaband=CC  vlabw='0000' /
! ---------------------------------------------------------------------

! ---------------------------------------------------------------------
! EXAMPLE setup file for non-VLBI observations at the VLA at 7mm.
!     (Use as an example of the format, not the detailed numbers)
! ---------------------------------------------------------------------
! firstlo (ifa, qband) = feab-fecd+syna+flukea+900MHz-600MHz
freqref = 43210.99
format = none
vlaband = VQ
vlabw   = '0000'
!
firstlo  = 42589.9
vlafeab = 51.6      vlafecd = 13.0
vlasyna = 3589.9    vlasynb = 3639.9
flukea = 100.0      flukeb = 200.0
station  = 'VLA'  /
! ---------------------------------------------------------------------
```

10.3 Parameters Specific to the VLA

This sections gives a brief description of each of the parameters available to SCHED that are specifically for VLA observations or are especially useful for VLA observations. More general purpose SCHED parameters that are also required for other stations are not mentioned. For details on the parameters, consult the detailed descriptions of each parameter. The first list is of parameters in the main schedule input. The second is of setup parameters.

`VLATYPE`: Specify the type of observations. Should be provided for non-VLBI observations. Valid options are `'VLBI'`, `'CONTINUUM'` or `'LINE'`.
`VLATSYS` and `VLANTSYS` These turn on and off the Tsys corrections made to the correlated VLA data. This used to be required in order to obtain calibration data for the VLBI observations. That is no longer true so most observations can be made with the Tsys corrections turned on which is now the default.
`VLAUSERN`: This gives the VLA user number. The default of 600 is reasonable for VLBI but the actual user number should be provided for other types of projects.
`VLAMODE`: Specify the VLA mode. Common options for VLBI are `' '`, `VA`, `VX`, or `VS`. See VLA documentation on the many others that are available for non-VLBI observations.

`LST`: Schedule is assumed to be in LST. `LST` specified without a value assumes the VLA. A station name can be given as the argument, in which case the `LST` is for that station. When `LST` is specified, the `DAY` must be the modified local sidereal day number as found on VLA monthly schedules.

`DAY`: Must be the modified local sidereal day number as found on VLA monthly schedules if `LST` is specified. In such cases, `YEAR` and `MONTH` are ignored.

`IATUTC`: Difference between IAT and UTC, which is currently about 30 seconds. This is only used for setting the zero offset epoch for the "//PM" (proper motion) card.

`SETUP`: Specifies the setup file from which information for the "//LO" and "//FI" cards are taken.

`FREQ`: and `DOPPLER` Warning — these parameters cannot be used for non-VLBI observations at the VLA since they are only used to adjust the baseband converter frequencies.

`RECord`: and `NORECord` These parameters find one of their main uses in observations that use the VLA, especially the phased array. It is often useful, for both phasing scans and for scans inserted just for calibration of the VLA, to be able to turn the VLBI tape recorders off. `RECord` and `NORECord` can be used to specify which scans should be recorded on the VLBI drives and which should not be.

`VLAPSRC`: Phasing source to use before a VX mode scan.

The parameters in the setup file that apply only to the VLA are below. They are used to set the band and bandwidths of the VLA and for setting up the "//FI" and "//LO" cards. They are:

`FEFILTER`: The front end filters are normally 50 MHz wide. If there is strong RFI near the observing frequency, as is common at L and P bands, it may be desirable to use the 25 MHz or 12.5 MHz front end filters. This parameter is used to request the filters to use. It goes on the "//LO" card.

`FLUKESET`: Which flukeset (1 or 2) to be used. Unfortunately there seems to be no good way to predict this reliably. Usually Flukeset 1 will be used for phased array and normal VLA observations while Flukeset 2 will be used for single antenna VLBI, but this is not always true. The VLA operators should be alerted that Flukeset specified on the "//FI" card might have to be changed. If it is not specified, or is set to 0, a blank will be given and the VLA operators will set it.

`VLABAND`: Specify the frequency band. Must be one of the defaults without the //LO and //FI cards. Some valid options are `VP, VL, VC, VX, VK, PP, LL, CC, XX, UU, KK, HH,` or 18. For complete information on the standard bands, see the following section.

`VLABW`: Specify the back end bandwidth for each of the 4 VLA IFs as a 4 digit number in quotes (SCHED treats it as a character string), with one digit for each IF. The default is `'0000'` for 50 MHz in each IF. The consequent back end bandwidth is `50/(2**n)` MHz, where `n` is the digit specified.

`FLUKEA`: A Fluke synthesizer frequency. It is usually near 100 MHz. See the document "VLBI at the VLA" for details on what it should be. See Section 9 for more information on the frequency settings.

`FLUKEB`: B Fluke synthesizer frequency. Actually this is the value for the "//FI" card which is twice the actual synthesizer setting. To get the same frequency on the AC and BD IFs, `FLUKEB` should be `FLUKEA` plus 100.0.
`VLAFEAB`: 1st LO for the VLA observations for the AB (RCP) IFs. For standard VLBI projects, the value should be -3.2 for L band, 0 for C band, and 17.5 for K band. Again see VLA documentation for details of other alternatives.
`VLAFECD`: Same as `VLAFEAB` but for the VLA's C and D (LCP) IFs.
`VLAIF`: Name of the IF file that contains gain and efficiency data. This goes on the "//LO" card.
`VLAROT`: Name of the file that contains subreflector, pointing and receiver information. It goes on the "//LO" card.
`VLASYNA`: 2nd LO for the VLA A and C IFs. On the "//LO card" this number is rounded to the nearest MHz, but it should be given here exactly. It is usually near 3900 MHz. It must be a value of `N * 50 +- 10.1` MHz.
`VLASYNB`: Same as `VLASYNA` but for the VLA B and D IFs.

10.4 VLA Standard Bands.

A total of 19 standard observing bands are defined at the VLA. All projects should specify one of these bands, even when frequencies will be modified. This ensures that various defaults at the VLA get set properly. Just pick one with similar properties. For VLBI, one of the "V" bands should be chosen.

The tables below describe the bands. The first show the band names along with the synthesizer settings. The column headings are the SCHED names (not necessarily the traditional names in use at the VLA) for these parameters. The second table gives the value that SCHED would want for the VLBI `FIRSTLO` parameter when using the standard setup. If the frequencies are modified, `FIRSTLO` would need to be altered. SCHED will insure that `FIRSTLO` agrees with the frequency that will be obtained with the settings used. The other columns in the second table show the range of sky frequencies covered by the VLA band. The observing frequencies must lie in these bands. Note that the first frequency is that of the edge converted to DC, and then to 600 MHz in the signal sent to the VLBI rack. The other end of the band can be a lower frequency if there is a net lower sideband at this point (the BBC's can be used in lower sideband mode to get a final net upper sideband).

```
           VLA STANDARD BANDS - VLA SYNTHESIZER SETTINGS
VLABAND  VLAFEAB  VLAFECD  VLASYNA   VLASYNB   FLUKEA     FLUKEB  FEFILT
  44      0.00     0.00     -939.9    -939.9  112.91875  212.91875
  4P      0.00     0.00     -939.9    -689.9  112.91875  221.33750  0202
  PP      0.00     0.00     -689.9    -689.9  115.83750  221.33750  1212
  LP     -3.20     0.00     3639.9    -689.9  100.00000  221.33750  0202
  HH     -3.20    -3.20     3589.9    3639.9  115.10000  215.10000
  LL     -3.20    -3.20     3639.9    3560.1  100.00000  200.00000
  18     -3.20    -3.20     3839.9    3810.1  100.00000  200.00000
  CC      0.00     0.00     3860.1    3810.1  100.00000  200.00000
  XX     13.40    13.40     3939.9    3889.9  100.00000  200.00000
```

UU	19.60	19.60	3610.1	3660.1	100.00000	200.00000	
KK	17.60	17.60	3860.1	3810.1	100.00000	200.00000	
QQ	51.60	13.00	3689.9	3739.9	100.00000	200.00000	
VP	0.00	0.00	-689.9	-689.9	112.50000	212.50000	1111
VL	-3.20	-3.20	3839.9	3839.9	100.00000	200.00000	
VC	0.00	0.00	3960.1	3960.1	100.00000	200.00000	
VX	13.00	13.00	3560.1	3560.1	100.00000	200.00000	
VU	19.90	19.90	3510.1	3510.1	100.00000	200.00000	
VK	17.50	17.50	3710.1	3710.1	100.00000	200.00000	
VQ	51.60	13.00	3589.9	3589.9	100.00000	200.00000	

VLA STANDARD BANDS - VLBI FIRSTLO and VLA BANDPASSES

VLABAND	FIRSTLO A	FIRSTLO D	BANDPASS A	BANDPASS D
44	-526.98125	-526.98125	73.01875-123.01875	73.01875-123.01875
4P	-526.98125	-268.56250	73.01875-123.01875	331.43750-343.93750
PP	-274.06250	-268.56250	325.93750-350.93750	331.43750-343.93750
LP	839.90	-268.56250	1439.90- 1489.90	331.43750-343.93750
HH	805.00	855.00	1405.00- 1455.00	1455.00- 1505.00
LL	839.90	760.10	1439.90- 1489.90	1360.10- 1410.10
18	1039.90	1010.10	1639.90- 1689.90	1610.10- 1660.10
CC	4260.10	4210.10	4860.10- 4910.10	4810.10- 4860.10
XX	9060.10	9110.10	8460.10- 8410.10	8510.10- 8460.10
UU	15589.90	15539.90	14989.90- 14939.90	14939.90- 14889.90
KK	21860.10	21810.10	22460.10- 22510.10	22410.10- 22460.10
QQ	42689.90	42739.90	43289.90- 43339.90	43339.90- 43389.90
VP	-277.40	-277.40	322.60- 347.60	322.60- 347.60
VL	1039.90	1039.90	1639.90- 1689.90	1639.90- 1689.90
VC	4360.10	4360.10	4960.10- 5010.10	4960.10- 5010.10
VX	9039.90	9039.90	8439.90- 8389.90	8439.90- 8389.90
VU	15989.90	15989.90	15389.90- 15339.90	15389.90- 15339.90
VK	21610.10	21610.10	22210.10- 22260.10	22210.10- 22260.10
VQ	42589.90	42589.90	43189.90- 43239.90	43189.90- 43239.90

Note that IF A and C are usually at the same frequency as are B and D.

11 SINGLE DISH VLBA OBSERVING

SCHED is used primarily to schedule VLBI observations on the VLBA and most of the rest of this manual is devoted to details of how to do that. However, there are a variety of types of observations that are rather different. These are mainly single antenna observations usually done to measure system performance. SCHED is able to make the schedules for these observations. Such observations are not likely to be of interest to users other than NRAO staff involved in the testing and maintenance of the instrument.

Some items of special interest for VLBA scheduling are:

`SOURCE`: The source name is used in the usual way. However, for pointing, there is a useful capability to specify the name of a Solar System object and have SCHED determine its location from a JPL ephemeris. See the description of `SOURCE` for more details.

`OBSTYPE`: This should be set to `NONE` for single dish observations.

`PTVLBA`: This can be specified on a scan basis and causes SCHED to write out a pointing pattern. It can be turned off with `NOPTVLBA`

`TAVLBA`: This can also be specifiec on a scan basis, but not for a scan with `PTVLBA`. It is another special mode, very similar to PTVLBA, for measuring antenna temperatures. It can be turned off with `NOTAVLBA`.

`AZCOLIM`: This specifies a pointing offset in arcminutes in the azimuth direction. It is equivalent to the term used in the pointing equations to account for feed offsets so it is a constant angle on the sky. The actual change in azimuth increases at high elevation because of the cos(El) dependence of the angular effect of an azimuth change. It is available both in the setup file and in the main schedule.

`ELCOLIM`: This specifies a pointing offset in arcminutes in the elevation direction. It is equivalent to the term used in the pointing equations to account for feed offsets and encoder offsets, which are equivalent for elevation. It is in the setup file.

`PTINCR`: This is the jump in arc minutes between the on-source and half-power pointing positions for use in setting up pointing patterns. It is used in both `PTVLBA` and `TAVLBA` modes. The off-source positions are at 5 times this distance from the on-source position. This is a setup file parameter.

`PTDUR`: This parameter is a time (in the usual time format) that specifies the time spent in each pointing position of a pointing pattern. A reasonable value is 15 seconds.

`PTSLEW`: This parameter specifies the time to allow to slew to the source. It is specified in the usual time units (seconds). With dwell time scheduling or schedule optimization, it should be kept small, often equal to `PTDUR`.

`FOCUS`: This is used to increment the subreflector focus position. The value is added to the nominal value known to the on-line system for the particular receiver.

`ROTATION`: This is used to increment the subreflector rotation position. The value is added to the nominal value known to the on-line system for the particular receiver.

`ROTPAT`: This triggers generation of a focus-rotation test pattern of pointing observations.

`ROTOFF`: This is used to specify the rotation offset positions of a focus-rotation pattern.

`FOCOFF`: This is used to specify the focus offset positions of a focus-rotation pattern.

There are a number of setup files among the standard setups that are for VLBA test observations. Those that start with *pt* are for pointing or antenna temperature observations. Those that start with *pc* are for pulse cal tests.

In addition to the above parameters, it is often best to make use of one of the optimization modes to make the actual schedules. `OPTMODE=SCANS` is perhaps the most useful. With this mode, only a few template scans need be specified and SCHED will pick the ones appropriate for use in the desired time range. Below is an example of a script, including everything necessary to run SCHED on each VLBA station, for making pointing and gain check observations. This example is at a somewhat higher level of complexity than most in this document, but it shows what can be done with the program. It actually makes a different schedule for each station, taking into account the different portions of the sky that can be seen.

```
#!/bin/csh
# ========================================================
# =====  Script to make pointing files for the VLBA  =====
# ========================================================
#  Set stations to be processed.
#
#  set stalist="SC HN NL FD LA PT KP OV BR MK"
set stalist="HN FD PT"
#
#  Set times and experiment code
#
cat <<eofp >! times.par
  year    = 1996
  month   = 10
  day     = 25
  start   = 0:00:00
  opdur   = 4:00:00         !  Total project duration
  expcode = ptg
  sch     = ptg.par         !  If this changes, change next "cat" line.
eofp
# ======================================================================
# ======  For normal use, all required modifications are above here ===
# ======================================================================
# Specify the location of the setup files.
#
setenv SETDIR /home/arana/cwalker/sched/setups
#
# Put the main SCHED input in ptg.key for later use by SCHED.
#
cat <<eofs >! ptg.par
! ----------------------------------------------------------------------
! SCHED input file to be used with pointing proceedure doptg.

! -----  Cover information
version  = 1
expt     = 'STARTUP pointing'
obstype  = PTVLBA
obsmode  = 'Multi-frequency pointing observations.'
piname   = 'Operations'
phone    = '505 835 7251'
obsphone = '505 835 7251'
```

```
fax      = '505 835 7027'
email    = 'vlbaops@nrao.edu'
address1 = 'AOC'

! -----  Catalogs etc.
srcfile = '$SCHED/catalogs/sources.pttest'
stafile = '$SCHED/catalogs/stations.dat'
ephfile   = /planets/ephemeris/JPLEPH.403.2

! -----  Schedule instructions
sumitem = EL1, AZ1 ! Start elevation and azimuth in summary.
tavlba
ptdur   = 15       ! => scan length = 22*15 + 15 = 345 sec = 5:45
                   ! The autoleveling scan is 2*ptdur long for pcx.
dwell   = 5:45
ptslew  = 15
optmode = SCANS    ! Select scans that are above minimum elevation.
opminel = 20.      ! Minimum elevation.

! -----  Spectral lines
! -----  Set up for 4 channels - 2 on line, 2 off.
lineinit /
 lineset ='H2O'    restfreq=22235.08,22235.08,22285.08,22285.08 /
 lineset ='SiO431' restfreq=43122.03,43122.03,43222.03,43222.03 /
endlines /
linename='SiO431'   !  This schedule only uses 7mm SiO lines.

! -----  The detailed schedule
! The frequencies are in an order reasonable for FRM.
!  50/90 cm  CYGA,    TAUA,    3C274
!  20-4 cm   3C454.3, 3C123,   3C274
!  2, 1 cm   DR21,    3C84,    3C274
!  7 mm      RCAS,    RLEO,    WHYA, DR21, 3C84, 3C273, planets

!  Group must equal the number of scans below.
!  (Group*rep) must be less than 2000 (as of 18 Apr 1996).
group=(11*3) rep=60
setup='$SETDIR/pt90cm.set'  source 'CYGA'    nodop   bw=0,0   /
setup='$SETDIR/pt4cm.set'   source '3C454.3' nodop   bw=0,0   /
setup='$SETDIR/pt18cm.set'  source '3C454.3' nodop   bw=0,0   /
setup='$SETDIR/pt6cm.set'   source '3C454.3' nodop   bw=0,0   /
setup='$SETDIR/pt13cm.set'  source '3C454.3' nodop   bw=0,0   /
setup='$SETDIR/pt4cmsx.set' source '3C454.3' nodop   bw=0,0   /
setup='$SETDIR/pt1cm.set'   source 'DR21'    nodop   bw=0,0   /
setup='$SETDIR/pt2cm.set'   source 'DR21'    nodop   bw=0,0   /
```

```
setup='$SETDIR/pt7mm.set'   source 'DR21'    nodop   bw=0,0   /
setup='$SETDIR/pt7mm.set'   source 'RCAS'    doppler bw=2,2 qual=50 /
setup='$SETDIR/pt7mm.set'   source 'JUPITER' nodop   bw=0,0 qual=0  /

setup='$SETDIR/pt90cm.set'  source 'TAUA'    nodop   bw=0,0   /
setup='$SETDIR/pt4cm.set'   source '3C123'   nodop   bw=0,0   /
setup='$SETDIR/pt18cm.set'  source '3C123'   nodop   bw=0,0   /
setup='$SETDIR/pt6cm.set'   source '3C123'   nodop   bw=0,0   /
setup='$SETDIR/pt13cm.set'  source '3C123'   nodop   bw=0,0   /
setup='$SETDIR/pt4cmsx.set' source '3C123'   nodop   bw=0,0   /
setup='$SETDIR/pt1cm.set'   source '3C84'    nodop   bw=0,0   /
setup='$SETDIR/pt2cm.set'   source '3C84'    nodop   bw=0,0   /
setup='$SETDIR/pt7mm.set'   source '3C84'    nodop   bw=0,0   /
setup='$SETDIR/pt7mm.set'   source 'RLEO'    doppler bw=2,2 qual=50 /
setup='$SETDIR/pt7mm.set'   source 'VENUS'   nodop   bw=0,0 qual=0  /

setup='$SETDIR/pt90cm.set'  source '3C274'   nodop   bw=0,0   /
setup='$SETDIR/pt4cm.set'   source '3C274'   nodop   bw=0,0   /
setup='$SETDIR/pt18cm.set'  source '3C274'   nodop   bw=0,0   /
setup='$SETDIR/pt6cm.set'   source '3C274'   nodop   bw=0,0   /
setup='$SETDIR/pt13cm.set'  source '3C274'   nodop   bw=0,0   /
setup='$SETDIR/pt4cmsx.set' source '3C274'   nodop   bw=0,0   /
setup='$SETDIR/pt1cm.set'   source '3C274'   nodop   bw=0,0   /
setup='$SETDIR/pt2cm.set'   source '3C274'   nodop   bw=0,0   /
setup='$SETDIR/pt7mm.set'   source '3C273'   nodop   bw=0,0   /
setup='$SETDIR/pt7mm.set'   source 'WHYA'    doppler bw=2,2 qual=50 /
setup='$SETDIR/pt7mm.set'   source 'MARS'    nodop   bw=0,0 qual=0  /
! -----------------------------------------------------------------------
eofs
#
# Now run sched separately for each station.
#
foreach station ( $stalist[1*] )
   echo station=vlba_$station >! station.par
   $SCHED/bin/sched <<eofst
       @times.par
       @station.par
       overwrit /
eofst
end
#
#   Some clean up.
#
/bin/rm times.par
/bin/rm ptg.par
```

```
#
#   END
```

12 SCHED INPUT PARAMETERS

A large number of SCHED input parameters are available and are described below. However, most of the parameters default to reasonable values for Mark II VLBI projects so most users will only need those shown in the Mark II examples. Letters in lower case need not be given. The parameters are in alphabetical order. First, a list of all parameters with one line per parameter is shown in Section 12.1. Then in Section 12.2 more detailed descriptions are given for each parameter, with each description followed by a short table giving the following information:

Argument: The data type expected.

Options: A list of specific options if appropriate.

Default: The value assigned by SCHED if the parameter is not used.

Usage: Can the parameter be specified for each scan or only once? If for each scan, what happens if it is specified for one scan and not the next.

Example: An example specification of the parameter.

If a parameter for which SCHED only wants one value is specified for more than one scan, only the last value will be used. For parameters that can be specified for each scan, nearly all default to the value for the previous scan if not specified. The only exceptions are `START`, `STOP`, `REP`, `GROUP`, `TAPE`, `REWIND`, `FASTFOR`, `REVERSE`, and `COMMENT`. Normal defaulting for these parameters would produce undesirable behavior.

12.1 Summary List of SCHED Parameters

COVER INFORMATION:

`VERSION:`	Schedule version number. Helps identify latest.
`EXPT:`	Short description of project.
`EXPCODE:`	Project code.
`PINAME:`	Name of Principal Investigator.
`ADDRESS1:`	Principal Investigator's address for cover
`ADDRESS2:`	information. Up to 4 lines allowed.
`ADDRESS3:`	
`ADDRESS4:`	
`PHONE:`	Principal Investigator's phone number.
`OBSPHONE:`	Principal Investigator's telephone number during obs.
`TELEX:`	Principal Investigator's TELEX number (obsolete).
`EMAIL:`	Principal Investigator's electronic mail address(s).
`FAX:`	Principal Investigator's FAX number.

`OBSMODE:` Frequency band, recording system etc.
`OBSTYPE:` Type of observations. Mostly for tape control.
`NOTE1:` 1st of 4 comment lines for cover information.
`NOTE2:` 2nd of 4 comment lines for cover information.
`NOTE3:` 3rd of 4 comment lines for cover information.
`NOTE4:` 4th of 4 comment lines for cover information.

CORRELATOR INFORMATION:

`CORREL:` Correlator to be used. Destination for tapes and log files.
`CORAVG:` Correlator average time.
`CORCHAN:` Number of spectral channels per baseband channel.
`CORNANT:` Number of antennas to be correlated.
`CORPOL:` Polarization processing on or off.
`CORSRCS:` Origin of source positions for correlator.
`CORWTFN:` Correlator weighting function.
`CORTAPE:` Type of tape on which to send correlator output to user.
`CORSHIP1:` Shipping address for correlator output.
`CORSHIP2:`
`CORSHIP3:`
`CORSHIP4:`
`CORNOTE1:` Notes for correlator operations.
`CORNOTE2:`
`CORNOTE3:`
`CORNOTE4:`

PROGRAM CONTROL:

`DEBUG:` Turn on various debugging printouts.
`DOSTA:` Restrict processing to specific stations.
`DOVEX:` Write a VEX file.
`EXIT:` Finish interactive input.
`OVERwrit:` Overwrite files from previous run of SCHED.
`PLOT:` Invoke plotting part of SCHED.
`SCHedule:` Name of file containing rest of schedule.

CATALOGS and other other "external" input.

`LINEINIT:` Following inputs will be rest frequencies.
`SETINIT:` Name and flag for in-line setup data.
`SRCCAT:` Flag for start of in-line source catalog.
`SRCFILE:` Name of external source file.
`STACAT:` Flag for start of in-line station catalog.
`STAFILE:` Name of external station file.
`TAPEFILE:` File name for tape initialization information.
`TAPEINI:` Flag that next group of input is tape initialization.

`EPHFILE`: File containing JPL ephemeris data for planets.
`FREQFILE`: File containing standard frequency setups.

GENERAL CONTROL PARAMETERS:

`CALTIME`: Integration time for calibration data.
`IATUTC`: IAT-UTC for planetary motion cards at VLA.
`LINEPG`: Number of lines per page in operator schedules.
`LST`: Schedule is in LST for specified station.
`NCHAN`: Number of baseband channels (Obsolete).
`SUMITEM`: Items to show in the summary file.
`TANTSTA1`: List 1 of stations for Ta measurement requests.
`TANTSTA2`: List 2 of stations for Ta measurement requests.

BASIC SCAN TIMING and CONFIGURATION:

`STATions`: Station list for scan. Up to 30.
`SOURCE`: Source name.
`QUAL`: Qualifier for source.
`YEAR`: Year of first scan stop time.
`MONTH`: Month number.
`DAY`: Day number. 1 is first day of `MONTH`. Can be day of year.
`START`: Start time of scan.
`STOP`: Stop time of scan.
`DURation`: Duration of scan.
`DWELL`: Duration of scan but start when antennas on source.
`GAP`: Minimum interval between scans.
`PRESCAN`: Time to wait before starting tape.
`GROUP`: Number of scans to repeat.
`REPeat`: Number of times to repeat scan(s).
`SETUP`: Name of file containing VLBA setup information.
`COMMENT`: Comment to appear in schedule.

SCAN PROPERTIES:

`LINENAME`: Name of group of rest frequencies to use.
`DOPINCR`: Minimum increments for frequency setting.
`DOPPLER`: Set frequency based on LSR velocity for spectral line.
`NODOP`: Turn off doppler calculations.
`DOPSRC`: Set frequency based on LSR velocity of this source.
`DOPCAL`: Obsolete form of `DOPPLER`.
`FREQ`: Up to 16 baseband channel sky frequencies for VLBA.
`BW`: Baseband channel bandwidths.
`PCAL`: Mode for pulse cal generators.
`PEAK`: Peak up on source.
`NOPEAK`: Turn off peak up request.

TANT1: Turn on Ta measurement at the TANTSTA1 stations.
TANT2: Turn on Ta measurement at the TANTSTA2 stations.
TSYS: Turn on Tsys measurements.
NOTSYS: Do not measure system temperature.
PTVLBA: Do VLBA pointing sequence.
NOPTVLBA: Turn off VLBA pointing measurements.
TAVLBA: Request Tant measuring mode.
NOTAVLBA: Turn off VLBA antenna temperature measurements.
PTDUR: Duration of each step in VLBA pointing sequence.
PTSLEW: Time to allow for slewing to source in pointing sequence.
AZCOLIM: Azimuth colimation offset for scan for VLBA.
ELCOLIM: Elevation colimation offset for scan for VLBA.
FOCUS: Focus offset for scan for VLBA.
ROTATION: Subreflector rotation offset for scan for VLBA.
ROTPAT: Expand pointing patterns to include focus/rotation.
ROTOFF: Rotation offsets for ROTPAT pattern.
FOCOFF: Focus offsets for ROTPAT pattern.

TAPE CONTROL:

AUTOTAPE: Request automatic tape changes. Give tape time.
FASTFOR: Fast foreward the wide band tape.
RECord: Record on tape this scan. Non-zero to not record.
REWIND: Rewind wide band tape.
REVERSE: Reverse direction of recording of wide band tape.
TAPE: Force a tape change. Reset AUTOTAPE reference time.
TPREF: Reference time for Mark II tape changes.

OPTIMIZATION (Beware — experimental features!):

OPDUR: Duration for experimental optimizing mode.
OPELPRIO: Two elevation ranges in which OPSKIP not active.
OPMINEL: Minimum elevation for experimental optimizing mode.
OPMINANT: Minimum number of antennas in a scan in experimental optimizing mode.
OPNOSUB: Don't subarray in experimental optimizing mode.
OPSKIP: Skip source OPSKIP times unless in priority elevaion range.
OPTLOWT: Time scale for low el samples in OPTMODE = CELLS or CSUB.
OPTMODE: Optimization mode.
OPTSLEW: Time scale for slews in OPTMODE = CELLS or CSUB.
TAPESYNC: Synchronize tape changes (see warnings).

SPECIAL VLA PARAMETERS:

VLABAND: Obsolete - put in setup file.
VLABW: Obsolete - put in setup file.

`VLAMODE`: VLA observing mode.
`VLANTSYS`: Turn off VLA system temperature corrections.
`VLAPSRC`: Phasing source for VLA observations.
`VLATSYS`: Turn on VLA system temperature corrections.
`VLATYPE`: Type of VLA observations.
`VLAUSERN`: VLA user number.

12.2 Details of SCHED Parameters

12.2.1 ADDRESS1, ADDRESS2, ADDRESS3 and ADDRESS4

`ADDRESS1`, `ADDRESS2`, `ADDRESS3`, and `ADDRESS4` are used to give the Principal Investigator's address for the cover information. At least the first line must be provided if recording tape.

Argument: A character string of up to 64 characters for each of the 4 parameters.

Options: Any.

Default: Blank

Usage: Only one value used, the last.

Example:
```
ADDRESS1='1003 Lopezville Rd'
ADDRESS2='Socorro, NM 87801
ADDRESS3=' U S A '
```

12.2.2 AUTOTAPE

`AUTOTAPE` controls the style of tape changes. The times of tape changes are marked in the summary file and should be checked for reasonableness.

- Mark III or VLBA format:

  `AUTOTAPE` is used to request the VLBA systems to perform automatic tape control. `AUTOTAPE=1` or `AUTOTAPE=2` causes the on-line system to determine the tape direction, head position and track allocation automatically. The schedules will only include instructions on whether to run, stop, or rewind. `AUTOTAPE=2` also activates automatic reversal of the tapes when the low tape mark is reached, even in the middle of scans; with `AUTOTAPE=1` the tape will stop at the low tape point and wait for the next scan. The default action (any other value of `AUTOTAPE` including no value) is to have SCHED determine the tape motion and related information.

- Mark II format:

  `AUTOTAPE` requests automatic tape changes. Specifying `AUTOTAPE` without a value is the same as the default. Specify a negative number to turn off tape changes and a positive number (a time) to change the default tape length. The default length is 4 hours. Tape changes are requested at 4 hour intervals beginning with the earliest start time of the whole schedule. If this would require a change in the middle of a scan, the change is moved to the start of the scan and all following changes are moved up. This is station dependent and so can cause non-simultaneous tape changes. The tape is assumed to be kept moving between scans.

The reference time for `AUTOTAPE` can be altered with `TPREF` in the SCHED keyin file and with the `TPTIME` in the `TAPEFILE`. See Section 15 for information on `TPTIME`. `TPREF` is a time of the form `hh:mm:ss`. The automatic tape changes are requested at integral numbers of 4 hour intervals before or after `TPREF`. A date is not needed because 4 hours divides 24 hours evenly. Even if someone were to use the 2 or 6 hour VCR modes, those tape lengths still divide 24 hours evenly.

If `TAPE` is specified for a scan while `AUTOTAPE` is set, a tape change will be requested and following tape changes will occur at 4 hour intervals from the time of the forced change. One specification of `TAPE` is usually all that is needed to get the tape changing sequence right if the earliest start time is a poor reference time.

For most projects, the default action of `AUTOTAPE` should be good. The major exceptions are projects that start on the half hour and tape changes are desired on the hour, and projects where it makes sense to have a short tape at the start on some stations to avoid short tape on other stations for which the source rises later. Both of these cases can be handled nicely with `TPREF`.

Note that, if `AUTOTAPE` is turned off, no initial tape mount at the start of the project will be requested. This causes problems at some stations. It you insist on specifying all tape changes with `TAPE`, be sure to put one on the first scan for each station. This mode of setting tape changes is NOT recommended.

Argument: None or a number.

Options: Mark III or VLBA: Not `1` or `2` - SCHED sets tape direction, head position, and track assignments. `1` - VLBA on-line systems above parameters. `2` - activate mid-scan automatic tape reversals. Mark II: No argument or `0` - do automatic tape changes at 4-hour intervals. `-1` - turn off automatic tape changes. `hh:mm:ss` - time for modified tape length.

Default: Mark III or VLBA: SCHED controls tape.
Mark II: `AUTOTAPE=4:00:00`

Usage: Only one value used, the last.

Example: `AUTOTAPE=-1`

12.2.3 AZCOLIM

`AZCOLIM` can be used to specify an increment to the azimuth colimation offset value used for pointing. This is added to the nominal position known by the on-line system for the particular receiver and to the value specified in the setup file. It is also added to the values used for offsets in pointing patterns and the value from the setup file.

Argument: An azimuth colimation offset in arc minutes.

Options: Any value.

Default: 0.0

Usage: Default to previous scan.

Example: `AZCOLIM = 0.25`

12.2.4 BW

`BW` specifies the bandwidths to use for the scan. One value can be given for each baseband channel. Any unset values will be set equal to the first so it is usually only necessary to specify one. These are used mainly for VLBA files, although the value will be written to `VC` commands in snap files. If not specified for a scan, the most recent value will be used. To get back to the default, (from the setup file), specify `BW=0`. The sign of `BW` traditionally has been negative for a net lower sideband. This is no longer required or even recommended.

The use of `BW` is not be allowed when VEX files are being written because of complications that introduces to program logic. If you wish to change bandwidths in such circumstances, use a new setup file.

Argument: Up to one real number for each channel. The number is the bandwidth in MHz.

Options: `0.0625`, `0.125`, `0.250`, `0.5`, `1`, `2`, `4`, `8`, or `16`

Default: Uses bandwidth from setup file.

Usage: Uses the most recent value specified.

Example: `BW=2,2,2,2`

12.2.5 CALTIME

`CALTIME` is the integration time in seconds for calibration data from the VLBA monitor system. This includes the total and switched powers used for system temperatures and also the pulse cals.

Argument: A time in seconds for each scan.

Options: Any.

Default: `120`

Usage: Uses the most recent value given.

Example: `CALTIME=60`

12.2.6 COMMENT

`COMMENT` is a string of up to 64 characters to be written on operator and telescope files just before the scan.

Argument: Text up to 64 characters.

Options: Any.

Default: Blank

Usage: Reverts to no comment if not specified for each scan.

Example: `COMMENT='ET, call home.'`

12.2.7 CORAVG

`CORAVG` specifies the correlator averaging time in seconds. For the Socorro VLBA correlator, valid values are an integer N times the speed up factor times 0.131072 seconds. Round values such as 2, 4, 8 seconds etc may be specified and the nearest possible value will be used. This is what is expected from most users. The correlator default is 2 seconds but, at most frequencies, more is probably ok most of the time. The longer the on-line averaging, the smaller the output data rates and the smaller the output data set.

Argument: A real or integer number.

Options: Any, but see above for useful numbers.

Default: 2.0

Usage: Only one value used — the last.

Example: `CORAVG = 4`

12.2.8 CORCHAN

`CORCHAN` specifies the number of spectral channels per baseband channel (one polarization component) that the correlator will write. The VLBA correlator will typically make 256 channel spectra which are then channel averaged on-line for continuum observations. The typical number of output channels for continuum data is 16 per baseband. Over averaging can cause loss of amplitude due to "delay smearing" — the effect of large phase slopes across the channels going into an average. Corrections for this effect are made in AIPS, but the corrections are probably not perfect. Over averaging also can lead to SNR loss when bandpass calibration is done. This is because edge channels are discarded as part of bandpass calibration because of the frequency shifts required to adjust for the effects of the fringe rotators (doppler effect, essentially). It is probably wise to keep a minimum of 16 channels and keep the channel bandwidth less than 0.5 MHz. The latter constraint, due to possible delay errors, suggests that observations with 16 MHz BBC bands should use 32 output channels.

For spectral line observations, up to 1024 spectral channels per baseband channel can be provided in parallel-hand-only correlation mode and up to 256 channels in full polarization mode. Requesting too many channels can cause the data sets to be so large as to be difficult to impossible to manage. Also, the combination of the average time, the number of channels, and the number of baselines must be such that the output data rate is less than 0.5 Mbyte/sec. The data rate in bytes/sec is given APPROXIMATELY as

4 * Ns * (Ns + 1) * Nc * Nsp * P * Su / Tavg

where Ns = number of stations Nc = number of (BaseBand) channels (1, 2, ... 16) Nsp = spectral resolution (8, 16, 32 ... 512) P = 2 for polarization, 1 for none Su =

speed up factor (1, 2, 4) Tavg = time average in seconds

Argument: An integer number, usually a power of 2

Options: Any, but see above for useful numbers.

Default: 16

Usage: Only one value used — the last.

Example: `CORCHAN = 32`

12.2.9 CORNANT

`CORNANT` informs correlator operations of the number of stations scheduled. This helps determine when all logs and tapes are in and helps determine what the correlator load, both in terms of drives needed and output data rate, will be. See the discussion of `CORCHAN` for a formula to calculate the output data rate.

Argument: An integer number.

Options: Any, but it should be the expected number of antennas.

Default: Number of antennas in schedule.

Usage: Only one value used — the last.

Example: `CORNANT = 10`

12.2.10 CORNOTE1, CORNOTE2, CORNOTE3, and CORNOTE4

`CORNOTE1`, `CORNOTE2`, `CORNOTE3`, and `CORNOTE4` provide four text strings with which to pass information to correlator operations staff.

This can be used to alert correlator operations to special requirements such as multiple phase centers, special positions, non-constant processing parameters etc.

Argument: Each parameter is a string of up to 64 characters

Options: An address

Default: Blank

Usage: Only one of each used — the last.

Example: `CORNOTE1 = 'Please run the FD tape backwards.'`

12.2.11 CORPOL

`CORPOL` can be either "on" or "off". If it is "on", all polarizations (RR, LL, RL, and LR) will be done. If "off", only the parallel hand polarizations (RR and LL) will be correlated. Requesting full polarization ("on") reduces the maximum number of spectral channels per baseband channel available and increases the output data rate. However for continuum projects with modest average times and 16 or 32 channels, neither of these is of much concern and there is little harm in asking for full polarization processing. Perhaps the data will even be useful eventually.

Argument: Any 3 characters.

Options: "on" or "off" are the useful values.

Default: " " — which is not useful.

Usage: Only one value used — the last.

Example: `CORPOL = 'on'`

12.2.12 CORREL

`CORREL` specifies the correlator to which VLBI tapes and logs should be sent. This is for the cover information. SCHED will abort if this parameter is not given unless this is a VLA only observation or a single dish observation (eg VLBA pointing). Allowed values are Socorro, VLBA, Haystack, Bonn, JIVE, Washington, USNO, Jpl, Bologna, and Other (which should be followed by the name). The name is not case sensitive.

Argument: Text up to 62 characters.

Options: The first word must be one of: `Socorro`, `VLBA`, `Haystack`, `Bonn`, `JIVE`, `Washington`, `USNO`, `JPL`, `Bologna`, or `Other`

Default: Blank which causes SCHED to abort.

Usage: Only one value used, the last.

Example: `CORREL=Socorro`

12.2.13 CORSRCS

`CORSRCS` is a character string instructing the correlator staff where to get the source coordinates. `STANDARD` will imply to get them from the correlator catalog. This is an extensive list of sources based on USNO geodetic/astrometric solutions or, for sources for which VLBI positions are not known, from the VLA calibrator list. `SCHEDULE` will mean to get the positions from those used in this schedule. Other statements can be made - this information will be read by the correlator operations staff. If more room is needed, see the `CORNOTE` parameters.

Argument: Text of up to 64 characters.

Options: `STANDARD` and `SCHEDULE` are useful. Others can be used.

Default: `STANDARD`

Usage: Only one used — the last.

Example: `CORSRCS = 'PI will provide before correlation.'`

12.2.14 CORSHIP1, CORSHIP2, CORSHIP3, and CORSHIP4

tt CORSHIP1, CORSHIP2, CORSHIP3, and `CORSHIP4` privide four character strings in which to specify the place to ship the correlator distribution tapes.

Argument: Each parameter is a string of up to 64 characters

Options: An address

Default: Blank — And I bet you really do want your data!

Usage: Only one of each used — the last.

Example:
```
CORSHIP1 = 'Phil Diamond'
CORSHIP2 = 'NRAO'
CORSHIP3 = 'P.O. Box O'
CORSHIP4 = 'Socorro, NM, 87801'
```

12.2.15 CORTAPE

CORTAPE specifies the type of tape that should be used for the data distribution from the correlator. This must be DAT, EXABYTE, or 9TRACK.

Argument: A string of up to 16 characters

Options: DAT, EXABYTE, or 9TRACK

Default: Blank — Not too useful.

Usage: Only one used — the last.

Example: `CORTAPE = 'DAT'`

12.2.16 CORWTFN

CORWTFN specifies the weighting function to be used on the VLBA correlator. The weighting function is applied by weighting the data points before they are sent to the FFT. Valid options are: UNIFORM and HANNING. Most users should use UNIFORM which means that no weights are applied. Be warned that HANNING is Hanning weighting on the individual station spectra and so is a "Hanning squared" function in the output power spectra. This is probably not what people want. Eventually more options will be available.

Argument: Any text string of up to 16 characters

Options: UNIFORM and HANNING are the useful options.

Default: UNIFORM

Usage: Only one value used — the last.

Example: `CORWTFN = 'HANNING'`

12.2.17 DAY

DAY is the day number of /em stop time of scan. Day 1 is the first day of the month specified with the MONTH parameter, which defaults to 1 so that DAY is the day of year. If LST was specified, DAY must be the (modified?) local sidereal day number for the reference station. These numbers are printed on the right side of VLA monthly schedules and are near 56800 in 1996.

Argument: Integer.

Options: Any.

Default: Required for first scan - no default.

Usage: Defaults to previous scan. Only need for first scan if using durations even if project crosses day boundary.

Example: `DAY=135`

12.2.18 DEBUG

`DEBUG` is a switch that turns on some debug printouts. It is unlikely to be useful to users, only to programmers.

12.2.19 DOPCAL

`DOPCAL` is an obsolete form of the parameter `DOPPLER`. It is no longer recommended because of possible confusion with *DO PCAL*.

12.2.20 DOPINCR

`DOPINCR` sets the frequency increments to use in setting frequencies using `DOPPLER`. The frequencies will be rounded to the nearest multiple of `DOPINCR`. The default is 10 kHz, the setting interval for the BBCs in VLBA and Mark III/IV systems. However VSOP requires a 1 MHz interval. The value is in kHz. A new value may be given for each scan, although usually a single value would be used for the whole experiment.

Argument: A number specifying a frequency in kHz.

Options: Any number.

Default: 10 kHz.

Usage: A value for each scan. Defaults to previous scan.

Example: `DOPINCR = 1000` (appropriate for VSOP)

12.2.21 DOPPLER and NODOP

`DOPPLER` and `NODOP` control Doppler calculations for this scan. `DOPPLER` turns them on, `NODOP` turns them off. See Section 9 for details.

Note that channels assigned to the same BBC will be given the same frequency as the first channel on that BBC, no matter what velocities etc are given for the other channels. This will be the case when there are upper/lower sideband pairs. Their frequencies cannot be set independently. Because of the different sidebands, they will, however, cover different velocity ranges.

Argument: None.

Options: `0` or nothing to get Doppler calculations. A non-zero value will turn them off, but use of `NODOP` is a more convenient way to do the same thing.

Default: Don't do Doppler calculations.

Usage: Reverts to previous scan.

Example: `DOPPLER`

12.2.22 DOPSRC

`DOPSRC` is the name of the source for which the Doppler calculation should be done. This is allowed to be different from the source being observed to allow for observing continuum calibrators at the same frequency as the line source. If it is blank, the source being observed will be used. If it is not specified, the previous value will be used so it must be set to blank after use in earlier scans if it is desired to return to the original default.

Argument: A source name.

Options: Any source in the source catalogs.

Default: Blank - use `SOURCE`.

Usage: Reverts to previous scan. Can set to `' '` to return to default behavior.

Example: `DOPSRC='W3OH'`

12.2.23 DOSTA

`DOSTA` tells SCHED to process only those stations whose names match the value given for `DOSTA` to as many characters as given for `DOSTA`. This is intended primarily for telescope friends who wish to rerun SCHED using the keyin file provided by the observer and who do not want output for all stations. Requireing a match only on the specified characters allows `DOSTA='VL'` to be specified to obtain all VLBA and VLA files. DOSTA affects the stations read for the current scan. Normally it would be specified among the first set of inputs and not changed. In this case, it will affect the whole schedule.

Argument: Text of up to 8 characters.

Options: Any station name or portion thereof.

Default: None

Usage: Defaults to previous scan.

Example: `DOSTA='VLBA'` makes all VLBA files.

12.2.24 DOVEX

`DOVEX` tells SCHED to write a VEX format output file. VEX is the format used by PCFS, the NASA/Goddard field system that controls EVN, geodetic and other stations. It will also be used by MkIV correlators (under construction). A VEX file is only required if a station controlled by PCFS is included or if the observation is to be processed on a correlator that requires a VEX file. Pure VLBA or VLBA plus other stations that use VLBA control files (VLA, EB_VLBA, GB_VLBA) do not require a VEX file.

If any station in the schedule requires a VEX file, as specified in the CONTROL input in the station catalog, DOVEX will be set automatically. The only occasions in which DOVEX will need to be specified by the user are those when an observation with no VEX stations is to be correlated at a VEX driven correlator. This is likely to be rare and currently impossible. Note that SCHED should not be used to prepare observations that are to be correlated at a MkIII correlator (e.g. Bonn), because it doesn't produce the proper Mark III ".drg file".

Argument: None.

Options: No augument required. If one given, DOVEX will be false.

Default: DOVEX will be false unless a VEX station is found.

Usage: Only one value used — the last.

Example: `DOVEX`

12.2.25 `DURation`

`DURation` specifies the length of the current scan. Usually this is used instead of `STOP`. It is assumed to be a UT time interval unless `LST` was specified, in which case it was assumed to be an LST time interval. `DWELL` is a very similar parameter except that, with `DURation`, the scan starts `GAP` seconds after the previous stop time while with dwell, the scan will start at least `GAP` seconds after the previous stop time, but if necessary, will wait longer to allow all antennas to reach the source. Note also that tape start time is `PRESCAN` seconds after the start time set by other paramters. This can be positive for a delayed start and negative for an early start to, for example, allow for correlator sync up time. The start time reported in the summary file is the tape start time after the `PRESCAN` adjustment.

Argument: A time in format `hh:mm:ss`, `mm:ss`, or `ss`.

Options: Any.

Default: Not used.

Usage: Defaults to previous scan.

Example: `DUR=13:00`

12.2.26 `DWELL`

`DWELL` is an alternate way to specify the duration of a scan. With all ways of specifying the duration, if `START` or `STOP` are specified, they fix the scan times. However if neither of those is specified for the scan, there are a variety of options. If the duration is specified with `DURation`, the scan will begin at the stop time of the previous scan plus the time specified with `GAP`. If it is specified with `DWELL`, the scan will begin at the stop time of the previous scan, plus the time specified with `GAP`, plus any additional time required for all antennas to reach the source (Assuming, of course, that all the required slew characteristics are properly specified in the station catalog.) plus a settling time specified by `TSETTLE` in the stations catalog (which can include acceleration and deceleration time, computer overhead, and any required calibration time).

Once the scan start time has been specified as above, the actual time that tapes starts rolling is adjusted further with `PRESCAN`. The tape will start the amount of time specified with `PRESCAN` *after* the scan start time. `PRESCAN` can be negative to allow for pre-starting tapes which gives the correlator time to sync up while the antennas are still slewing. If a negative `PRESCAN` is specified that is large enough that it requests that the tape start during the previous scan, the tape is just left running but the scan times are not changed.

For all types of scheduling, if the gap between scans is less than 10 seconds, the tapes are left running.

The start and stop times reported in the summary and operator schedule files are the times that the tapes start and stop and are, therefore, sensitive to `PRESCAN`.

Argument: A time in any allowed time format (hh:mm:ss, mm:ss, sss etc.)

Options: Any time

Default: The duration of the scan must be specified with some combination of `START, STOP, DURation,` and `DWELL`.

Usage: Reverts to previous scan.

Example: `DWELL=110` (which is equivalent to `DWELL=1:50`)

12.2.27 ELCOLIM

`ELCOLIM` can be used to specify an increment to the elevation colimation offset value used for pointing. This is added to the nominal position known by the on-line system for the particular receiver and to the value specified in the setup file. It is also added to the values used for offsets in pointing patterns and to any value from the setup file.

Argument: A elevation colimation offset in arc minutes.

Options: Any value.

Default: 0.0

Usage: Default to previous scan.

Example: `ELCOLIM = 0.25`

12.2.28 EMAIL

`EMAIL` gives the principal Investigator's electronic mail address for the cover information. Use an Internet address where possible. Either of EMAIL or FAX must be provided if recording tape. Both should be provided.

Argument: Text of up to 64 characters.

Options: Any.

Default: Blank

Usage: Only one value used, the last.

Example: `EMAIL=cwalker@nrao.edu`

12.2.29 EPHFILE

`EPHFILE` is used to specify the location of the JPL ephemeris file. This is only needed if SCHED is being asked to calculate the position of one or more objects using the ephemeris. This is done by including a recognized planet (or other body) name among the sources and not providing a source catalog entry for it (if there is a catalog entry, that is used instead).

The objects that SCHED understands are Mercury, Venus, Moon, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto, and Sun. Topocentric positions and rates will be provided for VLBA antennas if one of these is specified. Geocentric positions along with rates and horizontal paralax are provided for the PM cards for the VLA. Note that SCHED does not understand how to specify moving objects to antennas that don't use the VLA or VLBA control file types.

Under unix, environment variables may be used. For example, if `SCHED` is defined to mean `/home/arana/cwalker/sched`, the base area under which all sched stuff is kept (substitute your local directory), then one can specify the ephemeris file with `EPHFILE = $SCHED/catalogs/newfile.eph`, if that were where it is (it isn't!). Use the `setenv` (c or t shell) or export (korn shell) to set environment variables.

At the AOC, for now, the ephemeris file is on Brian Butler's computer in the location shown in the example below. There is also a copy in the SCHED catalogs subdirectory.

Note that planetary observations cannot be specified to stations that use the VEX file.

Argument: Text of up to 80 characters - a file name.

Options: Any valid file

Default: 'NONE'

Usage: Only one value used, the last.

Example: `EPHFILE=/planets/ephemeris/JPLEPH.403.2`

12.2.30 EXIT

`EXIT` terminates interactive input. It has the same effect as reaching the end of file when input to SCHED is from a keyin file. It should be issued after the "/" after the last scan and needs a "/" of its own. Any inputs issued with it will be ignored. Since *SCHED* is nearly always used with an input file, this parameter should rarely be used.

Argument: None which implies 0.D0.

Options: None.

Default: Not issued if non-zero.

Usage: Will terminate program so only can be used once.

Example: `EXIT /`

12.2.31 EXPT

EXPT is a description of the project for the listings.

Argument: Text up to 72 characters.

Options: Any.

Default: None.

Usage: Only one value used, the last.

Example: `EXPT='3C345 March 11, 1988 Mark II'`

12.2.32 EXPCODE

EXPCODE is the project code from the Network or from NRAO. This is used as the first few characters of many file names. Only the first 6 characters are used in the VLA observe files.

Argument: Text of up to 8 characters. Best to use 6 or less. In fact, only 5 characters will be kept by much of the NRAO bookkeeping system.

Options: Any.

Default: 'NUG'

Usage: Only one value used, the last given.

Example: `EXPCODE=BW005`

12.2.33 FASTFOR

FASTFOR: requests that the wide band tape (Mark III or VLBA) be run at the maximum foreward speed during the prescan. Usually the intent is to get to the end of the tape prior to the start of the scan. If no argument is given, all stations will be issued with a fast forward instruction. If a list of stations is given, only those stations in the list will be fast forwarded. The station code may be used instead of the station name (not case sensitive).

Argument: None or a list of stations.

Options: None or a list of any stations in the scan. Not case sensitive.

Default: No fast forward unless there is insufficient room on the tape to complete the scan while recording in the current direction.

Usage: Reverts to no fast forward on next scan.

Example: `FASTFOR` or `FASTFOR=VLBA_BR`

12.2.34 FAX

FAX is the Principal Investigator's FAX number for the cover information. Either an EMAIL address or FAX number must be provided when recording tape. Both should be provided.

Argument: Text of up to 64 characters.

Options: Any.

Default: Blank

Usage: Only one value used, the last.

Example: `FAX='+1-505-835-7027'`

12.2.35 FOCOFF

`FOCOFF` gives the offsets in focus for a focus/rotation raster. See `ROTPAT` for details.

The values are offsets to be multiplied by the nominal offset for the band as understood by the program.

Argument: Up to 20 real numbers - the number of nominal recrements in focus for each position of a focus/rotation raster.

Options: Any number. 1.0 or 1.5 typically.

Default: 0.0

Usage: Only one set used per experiment.

Example: `FOCOFF=0,-1,0,1,0`

12.2.36 FOCUS

`FOCUS` is used in VLBA test observations to specify an increment to the focus value used for the subreflector position. This is added to the nominal position known by the on-line system for the particular receiver.

Argument: A focus position in cm.

Options: Any focus positon.

Default: 0.0

Usage: Default to previous scan.

Example: `FOCUS = 98.5`

12.2.37 FREQ

`FREQ` specifies the LO sum observing frequencys for the baseband channels in MHz. When not specified, the last value specified is used. If `0` is specified, or `FREQ` is not given for any scan, the default from the setup file is used. Any channels not specified will be set to the same frequency as the first. This is usually not what is desired. Whenever the frequencies change, a comment appears in the operator schedule file; the appropriate changes are made to the BBC frequencies for antennas using VLBA or VEX control files; and for snap files, dummy video converter commands are written without the correct video converter number and with the full LO sum (personnel at "snap" sites must edit in the correct video converter numbers and subtract the first LO). Since both the VLBA and Mark IV systems can only set frequencies to the nearest 10 kHz and the Mark III video converters are often used for Mark II projects, do not try to set a frequency that is not an even 10 kHz. Actually, SCHED will round to this value, or to `DOPINCR`, if it is given.

Argument: Up to 16 real numbers in MHz.

Options: Any.

Default: Use the setup file values.

Usage: Uses the last value specified.

Example: `FREQ=22236.78,22238.78`

12.2.38 FREQFILE

`FREQFILE` is used to specify the file containing the standard frequency setup information. This file is provided with SCHED and most users only need to point to it. If you want a setup that does not match one of the standards, SCHED will allow you to use one although it will issue warnings to remind you to be sure you know what you are doing.

On unix, an environment variable may be used.

Note that the list of frequencies for EVN and other foreign telescopes is currently (Feb 1997) under construction and not entirely complete. For additions or corrections on EVN telescopes, contact Huib van Langevelde at `huib@jive.nfra.nl`.

A file name of up to 80 characters. Any. `$SCHED/catalogs/freq.dat` Uses the last value specified. `FREQFILE=/home/arana/u/cwalker/sched/catalogs/freq.dat`

12.2.39 FREQLIST

`FREQLIST` is used to request a table of information from the `FREQFILE` be written to *frequencies.list*. It takes two arguments giving a frequency range to be covered in the list (in MHz). If the second argument is omitted, it will be set equal to the first. This may be the only parameter given to SCHED — no others are needed. SCHED will quit after the table is made. This facility should be useful for determining which antennas can observe certain frequencies.

2 real numbers which are frequencies in MHz Any. Not used. No table written. Uses the last value specified. `FREQLIST=4900,8600`

12.2.40 GAP

`GAP` is the minimum gap in time between the previous stop time and the current scan start time when scheduling with `DURation` or `DWELL`. For scheduling with `DURation`, it will be that time interval. For scheduling with `DWELL`, the interval might be longer if required for slews, but it will not be shorter. Note that `PRESCAN` is applied after the scan times are established and a negative `PRESCAN` could make the period during which the tape is stopped shorter than `GAP`. Note that, if `START` is specified, `GAP` will be ignored.

For all types of scheduling, if the gap between scans is less than 10 seconds, the tapes are left running.

The current status of PCFS software requires an interval of 40 seconds between all scans in order to produce a valid VEX file. This time is required by the PCFS that controls the telescopes to prepare for the next scan. This can be forced using `GAP` or `PRESCAN`, or by using `START times`. `GAP` is probably the prefered mechanism.

> **Argument:** A time in any approved time format (hh:mm:ss, mm:ss, sss etc.)
>
> **Options:** Any time
>
> **Default:** Zero.
>
> **Usage:** Reverts to previous scan.
>
> **Example:** `GAP=2:00` (which is equivalent to `gap 120`).

12.2.41 GROUP

SCHED has the ability to accept loops through scans. The two parameters that allow this are `GROUP` and `REPEAT`. They should be specified along with the parameters of the first scan in the loop. `GROUP` specifies the number of scans to be involved in a loop. `REPEAT` specifies how many times to go around the loop. Any start or stop times specified for the scans of the loop will only apply to the first pass. `DURation` or `DWELL` should be used to set the scan lengths.

> **Argument:** Integer.
>
> **Options:** Any.
>
> **Default:** Not used.
>
> **Usage:** Reverts to not being used if not specified for a scan.
>
> **Example:** `GROUP=2`

12.2.42 IATUTC

`IATUTC` sets the value of IAT-UTC. This is about 30 seconds now. This is only used if "//PM" cards are needed for the VLA since the zero-offset epoch must then be specified in IAT. SCHED does not use IAT for anything else.

> **Argument:** An integer number of seconds.
>
> **Options:** Any integer - should be correct value.
>
> **Default:** `0`, which is not correct.
>
> **Usage:** Only one value accepted, the last.
>
> **Example:** `IATUTC=29`

12.2.43 LINEINIT

`LINEINIT` indicates that the next few keyin input groups are rest frequency specifications for spectral line observations. See Section 9 for details. `LINEINIT` should not be mixed with other indicaters of in-stream data such as `SRCCAT`, `STACAT`, `SETINIT`, or `TAPEINI`.

If `LINEINIT` is found, the end of the input group (everything up to the "/") is not considered the end of inputs for this file. The next inputs after the line data are entered will continue to apply to the current file (usually the first).

Argument: None.

Options: None.

Default: Not set.

Usage: Should only be given once in schedule.

Example: `LINEINIT /`

12.2.44 LINENAME

`LINENAME` gives the name of the rest frequency group to use for this scan. The rest frequencies and names are specified in the `LINEINIT` input. See Section 9 for details.

Argument: A name of up to 8 characters.

Options: Must be one of the names in the `LINEINIT` input.

Default: Must use if `DOPPLER` set.

Usage: Reverts to previous scan.

Example: `LINENAME='OH1665'`

12.2.45 LINEPG

`LINEPG` is the number of lines on a page for the operator schedule files and summary files.

Argument: Integer.

Options: Any.

Default: 55

Usage: Only one value used.

Example: `LINEPG=60`

12.2.46 LST

`LST` causes SCHED to assume that all input times are in local sidereal time. If no argument is given, the "local" refers to the VLA. Otherwise, a station name can be given to allow scheduling in lst for some other station. When `LST` is specified, `DAY` is assumed to be the (modified?) local sidereal day number as found on the VLA monthly schedules, and `YEAR` and `MONTH` are ignored. This parameter is mainly intended for use for VLA-only scheduling.

Argument: Text of up to 8 characters giving the station name.

Options: Any.

Default: Not used if not given. 'VLA' if given without argument.

Usage: Only one value used.

Example: LST='VLBA_PT'

12.2.47 MONTH

MONTH is the month of the stop time of the scan. The day of year of the first day of the MONTH, minus 1, is added to the value for SCHED parameter DAY to get the day of year of the project. Thus MONTH can be specified and DAY given as the day of the month, or MONTH can be left at the default of 1 and DAY can be given as the Day of Year (DOY). Other combinations are also possible, but don't make much sense.

Argument: Integer.

Options: Any beteen 1 and 12.

Default: 1

Usage: Defaults to previous scan.

Example: MONTH=10, meaning October.

12.2.48 NCHAN

NCHAN is an obsolete parameter used in conjunction with FREQ and BW. Now that setup files are required, the number of channels is obtained from them.

12.2.49 NOTE1, NOTE2, NOTE3, and NOTE4

NOTE1, NOTE2, NOTE3, and NOTE4 are 64-character text strings that can be used to pass any information in the cover section. Instructions regarding pointing, Tsys measurement, and where to send logs are typically provided this way.

Argument: Each of the 4 parameters takes a character string of up to 64 characters.

Options: Any text.

Default: Blank

Usage: Uses only one value, the last.

Example: NOTE1='Please measure Tsys for every scan.'

12.2.50 OBSMODE

OBSMODE gives basic information on the technical nature of the project. The receiver wavelength and the recording system to be used should be noted. Any non-standard setup should be noted here, and expanded on with NOTE1, etc. This is for the cover information.

Argument: Text of up to 58 characters.

Options: Any - include receiver wavelength and recording system.

Default: Blank

Usage: Only one value used, the last.

Example: `OBSMODE='6cm Mark II Standard Network setup'`

12.2.51 OBSPHONE

`OBSPHONE` is the phone number for Principal Investigator during the observations for the cover information.

Argument: Text of up to 49 characters.

Options: Any - usually a telephone number.

Default: Blank

Usage: Only one value used, the last.

Example: `OBSPHONE='+1-505-835-7392'`

12.2.52 OBSTYPE

`OBSTYPE` tells SCHED what type of observation this project is. There are really only four options, although there are several ways to specify most of them. They are:

Mark II. Specifying either `OBSTYPE = MKII` or `MARKII` causes SCHED to assume that the Mark II recording system will be used. This system is now obsolete, although not totally gone, so this should not be common. It causes tape change requests to occur at time intervals specified by `AUTOTAPE` and assumes the Mark II tape is to be left running.

Wide band recordings. Specifying `VLBI`, `VLBA`, `MKIII` or `MKIV` causes SCHED to assume that the wide band recorders are in use. For the wide band recording modes, the necessary information on tape speed, passes per index position, etc., is taken from the setup file and the `TAPEFILE`. If there is a gap between the stop time of one scan and the start time of tape motion in the next (after taking into account `START, DWELL, GAP, and PRESCAN`), then SCHED will insert a dummy scan with no tape motion (or possibly a rewind or fast-forward) during this gap. Note that there is no requirement that the `FORMAT` in the setup file match which `OBSTYP is specified`. In fact, it is allowed to mix types at different stations. `MARKIII` and `MARKIV` can be used instead of `MKIII` and `MARKIV`.

SCHED does not support Mark III recordings on other than VLBA systems — the snap output contains no tape commands. The Mark IV support is still under development.

Pure VLA observations. If `OBSTYPE = VLA`, SCHED will assume that only the VLA is being scheduled and that no tape setup or commands are required. This is the mode in which SCHED can be used for many types of VLA scheduling.

Single dish observing. `OBSTYPE = NONE` or `PTVLBA` (the default) causes tape handling to be ignored. This is mainly for VLBA single dish pointing observations. This does set up the channels in the Data Aquisition System (BBCs, IF distributers etc), but does not spin tape.

Argument: Text of up to 8 characters, not case sensitive.

Options: `MKII`, `MARKII`, `VLBI`, `VLBA`, `MKIII`, `MARKIII`, `MKIV`, `MARKIV`, `VLA`, `PTVLBA`, or `NONE`.

Default: `NONE`

Usage: `Only one value used per project.`

Example: `OBSTYPE=MKIII`

12.2.53 OPDUR

`OPDUR` is the total duration of project being scheduled with an optimizing mode. Some of the optimizing modes keep generating new scans until they run out of time scheduled for the project. This parameters informs SCHED of the total project duration.

Note that the optimizing modes are somewhat experimental. If they are used, the output schedule should be checked carefully.

Argument: A time in time format (eg hh:mm:ss)

Options: Any time that is to be used as the length of the project.

Default: 0

Usage: Only one value used per project

Example: `OPDUR = 13:30:00`

12.2.54 OPELPRIO

`OPELPRIO` is used to specify two elevation ranges (4 values) to give high priority when optimizing a schedule. With `OPTMODE=SCANS`, scans on a source that falls within these elevation ranges will be taken every time while scans falling outside these ranges at all stations may be skipped depending on the setting of `OPSKIP` and on what happened on previous opportunities to observe the source. For geodesy projects, for example, priority might be given to very low elevations (for atmospheric determination) and very high elevations (to get good leverage on the parameter fits).

Note that the optimizing modes are somewhat experimental. If they are used, the output schedule should be checked carefully.

Argument: Four real numbers to be interpreted as elevations in degrees.

Options: Any valid elevation (0 to 90 degrees)

Default: All zero.

Usage: Only one set of values, the last, used for the project.

Example: `OPELPRIO = 2., 15., 75., 90.`

12.2.55 OPMINEL

OPMINEL specifies the minimum elevation in degrees below which sources will be considered to be "down". In all modes, if less than OPMINANT antennas are up, the scan will be skipped.

This is used mainly for optimizing modes to help select scans, and for experiment planning in order to, for example, plot the uv coverage available if all low elevation data and all data with less than several antennas will be discarded. The default will have no effect on schedules.

Argument: A real number to be interpreted as an elevation.

Options: Any valid elevation.

Default: 0.0

Usage: Only one value used for the project — the last.

Example: `OPMINEL = 15.`

12.2.56 OPMINANT

OPMINANT sets minimum number of antennas for which the source must be up for the scan to be accepted. To be up, a source must be above the telescope slew limits, any specified horizon, and above OPMINEL.

This is used mainly for optimizing modes to help select scans, and for experiment planning in order to, for example, plot the uv coverage available if all low elevation data and all data with less than several antennas will be discarded. The default will have no effect on schedules.

Argument: An integer.

Options: Any

Default: 0

Usage: Only one value used for the project — the last.

Example: `OPMINANT = 4`

12.2.57 OPNOSUB

OPNOSUB tells the SCHED optimizing modes not to allow subarraying. All antennas are to be scheduled in all scans, regardless of whether the source is up.

Note that the optimizing modes are somewhat experimental. If they are used, the output schedule should be checked carefully.

Argument: None

Options: None

Default: Not set — allow subarraying.

Usage: Only one value used for schedule — the last.

Example: `OPNOSUB`

12.2.58 OPSKIP

In optimizing mode "SCANS", skip each source OPSKIP times after it is last seen, unless it is in the OPELPRIO elevation range.

Note that the optimizing modes are somewhat experimental, especially this one! If they are used, the output schedule should be checked carefully.

> **Argument:** An integer, usually small.
>
> **Options:** Any
>
> **Default:** 0
>
> **Usage:** Only one value used for schedule — the last.
>
> **Example:** `OPSKIP = 2`

12.2.59 OPTMODE

OPTMODE sets the optimization mode. The valid modes are:

NONE. This is the default. The input schedule will be used as specified.

SCANS. For this mode, the schedule will be followed as specified. However only scans with more than OPMINANT antennas with the source up (above the horizon and within the slew limits) and above OPMINEL will be accepted. For each accepted scan only those antennas that are up and above OPMINEL will be scheduled unless OPNOSUB is specified. DWELL would normally be specified to allow for slews. Subarraying will happen if two successive souces can only be seen by different antennas since the optimization keeps track of the previous scan on a per-antenna basis.

The usual way to use this mode is to specify a loop containing all the desired sources (and frequencies etc.) and lasting longer than the desired total time. Then the optimization will pick the scans that make sense and will quit after OPDUR. This mode is especially useful for scheduling pointing observations.

There is a trick available, triggered by OPSKIP, that is an attempt to emphasize scans in desirable elevation ranges (set by OPELPRIO. If a loop is used, this will cause scans to be skipped OPSKIP times before they are used again unless they are in the desired elevation ranges.

CELLS. For this mode, the input scan list is treated as a pool of possible scans. The sky over each antenna is divided into 9 cells (3 X 3 in Az and El) and the time that each cell was sampled is recorded. For each output scan, all input scans are checked for which cells they sample and a weight is calculated based on the time since the last time that cell was sampled. The weight is adjusted to discourage long slews with the characteristic time scale of that discouragement set by OPTSLEW in minutes. Also, if some low elevation cells for a station have not been sampled in a long time (characteristic time scale set by OPTLOWT, the weight for other low elevation cells will be increased. This tries to compensate for edge stations that have no mutual visibility with the rest of the array for sources at low elevation in certain directions. The input scan to use is then selected based on the adjusted weights.

This mode is an attempt to provide a mechanism for scheduling geodetic type observations. Parameters `OPMINANT, OPMINEL, OPDUR,` and `OPNOSUB` have the same meanings for `CELLS` mode as for `SCANS`. The `CSUB` mode is able to do almost the same thing as this mode plus it handles subarraying. It may eventually completely replace the `CELLS` mode.

`CSUB`. This mode is much like the `CELLS` mode except that it uses subarrays. The sky over each antenna is divided into 9 cells. For each possible pair or sources, a scan is constructed with each antenna observing the source for which the priority is highest. The priority is the result of the time since the cell the source is in was sampled adjusted to downweight long slews (`OPTSLEW`) and upweight low elevation scans when other low elevation cells are not being sampled (`OPTLOWT`). If the minimum number of antennas per scan (`OPMINANT`) is not satisfied, some are shifted so that it is. Then the subarrayed scan is compared with single source scans with each of the two sources and the best option chosen. There is a weighting factor which favors the single source cases and has been adjusted so that something less than half the scans include all stations. Some day this should be made an input parameter. Finally, if there are more than 2 antennas left over, they are put in a third subarray with an optimized source.

Like the `CELLS` mode, this mode is for geodetic type observations. Various parameters have the same meaning here as for the other modes except that OPNOSUB is not allowed since it doesn't make sense. Also, OPMINANT is a goal. The third subarray can have less as can one of the other two under certain very special circumstances.

Note that the optimization modes are somewhat experimental. If they are used, the output schedule should be checked carefully.

Argument: A mode.

Options: `'NONE', 'SCANS', 'CELLS'` or `'CSUB'`

Default: `NONE`

Usage: `Only one used in schedule --- the last.`

Example: `OPTMODE 'CELLS'`

12.2.60 OPTLOWT

`OPTLOWT` is a time scale in minutes for upweighting any low elevation data in optimization modes `CELLS` and `CSUB` if other low elevation cells are not being sampled. See `OPTMODE` for more details.

Argument: Any time in minutes (mmm.mm format)

Options: Any time

Default: 15 — this is a reasonable value.

Usage: Only one value used for project.

Example: `OPTLOWT = 10`

12.2.61 OPTSLEW

`OPTSLEW` is a characteristic time scale in minutes for slews beyond which to start discouraging use of scans on the grounds that the slews are too long. This is used for several optimizing modes. See the description of `OPTMODE` for more details.

Argument: Any time in minutes (mmm.mm format)

Options: Any time

Default: 1.0 — a reasonable value.

Usage: Only one value used for project

Example: `OPTSLEW=2.0`

12.2.62 OVERwrit

If `OVERwrit` is specified, SCHED will overwrite any output files that already exist on disk. By default, SCHED will abort if it finds any old files of the same names as those it is trying to create. That mode is provides some protection against errors, but may be annoying when running lots of test cases.

Argument: None

Options: None

Default: Do not overwrite files.

Usage: Only one specification used — the last

Example: `OVERWRIT`

12.2.63 PCAL

`PCAL` sets the mode of the pulse cal generators on the VLBA. The generators can be off or can generate tones every 1 MHz or every 5 MHz. The input here can be used to change the mode from scan to scan. A default can be established in the setup file.

Control over the phase cal detection is not implemented for telescopes controlled by means of the VEX file. See notes on MkIV and S2 for details. In the EVN, standard practice is to use 1 MHz spaced tones at integer MHz values. Spectral line users that want to switch phase-cal insertion off should send special instructions to individual telescopes.

Argument: The pulse cal mode.

Options: `'  '`, `'off'`, `'1MHz'`, or `'5MHz'`. A `' '` causes the setup file value to be used.

Default: Use the setup file value. If none there, use `'1MHz'`.

Usage: Defaults to previous scan.

Example: `PCAL='off'`

12.2.64 PEAK and NOPEAK

`PEAK`, if specified, will cause commands to be issued to tell some antennas to peak up their pointing. `NOPEAK` causes SCHED to stop issuing those commands.

For Green Bank (NRAO type files), "cards" will be issued that request that the antenna peak up on source. This will happen for any `PEAK` argument greater than or equal to zero. It can be turned off by setting a negative argument or by specifying `NOPEAK`.

For the VLA, if `PEAK` is greater than `0`, the scan will be done in "IR" mode which will cause the on-line system to do a pointing pattern and put the results in memory. If `PEAK=0`, a "T" will be put in a column in the VLA observe file that causes the results of the reference pointing to be used. `PEAK` less than `0`, or, equivalently, specifying `NOPEAK` turns off reference pointing. A pointing pattern takes 100 seconds if the VLA correlator integration time equals the default 10 seconds, and some extra time should be added. Use 150 seconds (after arrival at source) for one pointing pattern and 4 minutes for two patterns. Two patterns are recommended. Reference pointing should not be done above 70 degrees elevation. *Warning:* a separate pointing scan should be provided since the "IR" mode must be used rather than one of the usual VLBI modes such as `VA`, `VX`, or `VS`. It is suggested that this pointing scan be at `VLABAND='XX'`.

For the VLBA, if `PEAK` is greater than `0`, a peakup will be done using the channel number specified by the `PEAK` argument.The peakup begins when the antenna reaches the source but the program will wait for a maximum of 30 or 40 seconds. If it will take longer than that to reach source, a dummy scan should be inserted. The peakup routine reads the total power after being on each position for 2 seconds and then goes on to the next position. The pattern contains 10 points. Therefore the peakup will take 20 seconds plus slew times which may be as little as 30 seconds - call it 45 seconds to be conservative - at high frequencies. It could take significantly longer at low frequencies but there is no good reason to use reference pointing there. After the peakup is done, the results will be used until either another peakup is done or the project code changes. Hopefully, we'll have some way to turn it off eventually. Note that if `PRESCAN` is being used the peakup will happen during the prescan, which is likely to be the desired behavior.

This command has no effect on the VEX file, there is currently no means to peak up telescopes that are controlled through the PCFS.

Argument: A digit that for the VLBA is a baseband channel number.

Options: See discussion above.

Default: Don't peak up.

Usage: Defaults to previous scan.

Example: `PEAK=3`

12.2.65 PHONE

`PHONE` is the Principal Investigator's telephone number before and after the project. See `OBSPHONE` for the number during the project. It is for the cover information. It must be provided for tape recording observations.

Argument: Text of up to 64 characters.

Options: Any.

Default: Blank.

Usage: Only one value used, the last.

Example: `PHONE='+1-505-835-7392.  (Ask for ET).'`

12.2.66 PINAME

`PINAME` is the name of the Principal Investigator. Actually, the person who should be used here should be the one who is organizing the project, not necessarily the one leading the proposal. With 64 characters, more than one person could be given. SCHED will abort if `PINAME` is not given for tape recording observations. This is for the cover information.

Argument: Text of up to 64 characters.

Options: Any.

Default: Blank, causing SCHED to abort.

Usage: Only one value used, the last.

Example: `PINAME='E.T. Smith'`

12.2.67 PLOT

`PLOT` is a switch that activates the plotting section of SCHED which is described more fully in Section 5. If plotting is desired, it is best to start SCHED interactively and specify `PLOT` and `SCHEDULE=yourfile.key /`. SCHED will then go get the schedule from `yourfile.key` (substitute your actual schedule file name) and then come back for interactive input to the plot section.

Argument: None.

Options: None.

Default: No plotting.

Usage: Only one used per schedule — the last.

Example: `PLOT`

12.2.68 PRESCAN

`PRESCAN` specifies a time by which to delay the start of VLBA tape motion from what would otherwise have been the start of the scan. If necessary, a dummy scan is inserted before the main scan in the VLBA files to prevent tape motion for the desired time. This once was the primary means of inserting gaps between scans, but the more recent parameters `GAP` and `DWELL` are now the preferred mechanisms and `PRESCAN` should be treated entirely as a way of offsetting the start of tape motion from the scan start determined by other inputs.

A negative value of `PRESCAN` is allowed, which causes the tape to start early to, for example, allow some time for tape sync at the correlator when using dwell time scheduling. This is now expected to be the main use of this parameter. If a negative value specifies a tape start time that is before the end of the previous scan, the tape is just left running. The scan times are not otherwise adjusted.

The start times of the scans used in the summary file, the sch files and some control files (not VLBA), are the start of tape motion so they are sensitive to `PRESCAN`.

The current status of PCFS software requires an of 40 seconds between all scans in order to produce a valid VEX file. This can be invoked with `START` times, `GAP`, or `PRESCAN`. It is probably best to use `GAP`.

Argument: A time.

Options: Any time.

Default: Not used.

Usage: Defaults to previous scan.

Example: `PRESCAN=-20`, meaning start the tape 20 seconds early.

12.2.69 PTDUR

`PTDUR` is the duration of each scan during a pointing loop for the VLBA. This parameter should not be of concern to anyone but VLBA operations staff.

Argument: A time in seconds.

Options: Any.

Default: `20`

Usage: Only one value accepted, the last.

Example: `PTDUR=15`

12.2.70 PTSLEW

`PTSLEW` is the time allowed in a pointing sequence to get to source before beginning the raster. This parameter should only be of interest to VLBA operations staff. In actual use, if a scan start time is specified, the interval between that start time and the previous stop time is added to the `PTSLEW` to set the duration of the slewing scan. For most pointing observations, it is probably best to set `PTSLEW` to something small, perhaps the same as `PTDUR`, and use dwell time scheduling.

Argument: A time in seconds.

Options: Any

Default: `160`, a sensible choice.

Usage: Defaults to previous scan.

Example: `PTSLEW=180`

12.2.71 PTVLBA and NOPTVLBA

`PTVLBA` tells SCHED to write a VLBA pointing sequence in the VLBA control file for this scan. `NOPTVLBA` tells SCHED to stop writing such sequences. These parameter should only be of interest to VLBA operations staff. Note that this is not a peak in the sense that the antenna does not go to the derived position after the pattern. It is used for measuring pointing offets and pointing equations. Parameters `PTSLEW` and `PTDUR` set, respectively, the time allowed to get to source and the time spent at each position in the pointing pattern.

Argument: None.

Options: None to set. `NOPTVLBA` to go back to non-pointing modes.

Default: Not used.

Usage: Reverts to previous scan if not specified.

Example: `PTVLBA`

12.2.72 QUAL

`QUAL` specifies a qualifier that will be written along with the source name to the VLA and VLBA schedules. It is useful for distinguishing scans of different types on the same source.

`QUAL` is not passed to a VEX file.

Argument: An integer of up to 3 digits.

Options: Any integer of up to 3 digits including sign.

Default: `0` but `1` for first scan of frequency switching if something else not specified. Depends on scan for pointing.

Usage: Reverts to previous scan if not specified.

Example: `QUAL=34`

12.2.73 RECord and NORECord

`RECord` tells SCHED to record on Mark III or VLBA tapes for this scan. Recording can be turned off by specifying `NORECORD`. This can be convenient for, as an example, VLA phasing scans.

NORECORD will insert scans in the VEX file, which have 0 seconds lengths. This probably will not lead to the desired function, which is a complete scan, but without tape spinning. It is advised not to use this option in VEX schedules.

Argument: None. Actually a non-zero argument would have the same effect as specifying `NORECORD`

Options: None.

Default: Make the recording.

Usage: Reverts to previous scan.

Example: `RECORD`

12.2.74 REPeat

`REPeat = n` causes the scan to be repeated `n` times. If `GROUP` is specified with a value of `m`, it causes `m` scans, starting with this one, to be repeated `n` times. `DURATION` or `DWELL` should be used if `REPEAT` is used. `REPEAT` and `GROUP`, together, provide a simple looping capability.

Argument: An integer.

Options: Any.

Default: `1`

Usage: Reset to `1` on next scan.

Example: `REP=5`

12.2.75 REVERSE

`REVERSE` requests that the direction of motion of the wide-band Mark III or VLBA tape be reversed at the start of the scan. No rewinds or fast forwards will be done if this is requested. `REVERSE` is not needed normally. SCHED checks each scan to see if it will fit in the current direction. If not, the tape will be reversed before the next scan begins. If `REVERSE` is specified with no argument, the tape will be reversed at all stations. If one or more station names are given, the tapes will be reversed at only those stations. Station codes may be used instead of station names.

Argument: None or a list of stations.

Options: No argument or the name of any stations in the scan. Not case sensitive.

Default: No reverse.

Usage: Reverts to no reverse on next scan.

Example: `REVERSE` or `REVERSE=VLBA_KP,VLBA_LA`

12.2.76 REWIND

`REWIND` requests that the wide-band Mark III or VLBA tape be rewound before the scan starts and during the prescan. If `REWIND` is specified with no argument, the tape will be rewound at all stations. If one or more station names are given, the tapes will be rewound at only those stations. Station codes may be used instead of station names.

Argument: None or a list of station names.

Options: No argument or the names of any stations in the scan.

Default: No rewind, unless there is insufficient room left during a backward pass to fit the next scan or a tape change is requested.

Usage: Reset to no rewind for next scan.

Example: `REWIND` or `REWIND='vlba_fd'`

12.2.77 `ROTATION`

`ROTATION` is used in VLBA test observations to specify an increment to the subreflector rotation value used for the subreflector position. This is added to the nominal position known by the on-line system for the particular receiver.

Note that changing the rotation also changes the pointing offset in a frequency dependent manner.

Argument: A rotation angle in degrees.

Options: Any rotation angle

Default: 0.0

Usage: Default to previous scan.

Example: `ROTATION = 10`

12.2.78 :

`ROTPAT`

`ROTPAT` causes SCHED to expand pointing patterns to include a raster in focus and rotation. The position offsets in this raster are specified by `FOCOFF` and `ROTOFF`. `ROTPAT` is only expected to be used by VLBA testers.

`ROTPAT` have a value which is the number of positions in focus/rotation in the pattern. It can only be used for 2cm, 1cm, 7mm, and 3mm. Note that the overall scan must be `ptslew` plus `rotpat` times 12 times `ptdur` long to fit a full pattern.

A typical set of offsets would be `ROTOFF=-1.5, 0, 0, 0, 1.5` and `FOCOFF=0, -1, 0, 1, 0` with `FOCPAT=5`.

Argument: A number of focus/rotation positions. Up to 20.

Options: Any number up to 20.

Default: 0 - Only do the central focus/rotation position.

Usage: Only one used for the experiment

Example: `ROTPAT=5`

12.2.79 `ROTOFF`

`ROTOFF` gives the offsets in subreflector rotation for a focus/rotation raster. See `ROTPAT` for details.

The values are offsets to be multiplied by the nominal offset for the band as understood by the program.

Argument: Up to 20 real numbers - the number of nominal recrements in rotation for each position of a focus/rotation raster.

Options: Any number. 1.0 or 1.5 typically.

Default: 0.0

Usage: Only one set used per experiment.

Example: `ROTOFF=-1.5,0,0,0,1.5`

12.2.80 `SCHedule`

`SCHedule` allows SCHED to be started interactively to specify options that might vary from run to run (such as `PLOT, DEBUG` etc.) and still get most of it's input from an external file. That external file is specified with `SCHedule`.

Under unix, environment variables may be used. For example, if `SCHED` is defined to mean `/home/arana/cwalker/sched`, the base area under which all sched stuff is kept (substitute your local directory), then one can specify one of the example schedules with `SCHEDULE = $SCHED/examples/manual_1.key`. Use the `setenv` (c or t shell) or export (korn shell) to set environment variables.

Argument: A file name of up to 80 characters.

Options: Any valid file name.

Default: Use interactive input.

Usage: Only one used. It will apply to all following input.

Example: `SCH=/home/arana/cwalker/bw12.key`

12.2.81 `SETINIT`

Setup file information can be specified in the main input file. If `SETINIT` is specified, the next groups (to `ENDSET`), are assumed to be setup file information. The setup name will be the argument to `SETINIT`. Multiple setup files can be specified this way. An argument must be specified or the setup information will not be read.

If `SETINIT` is found, the end of the input group (everything up to the "/") is not considered the end of inputs for this file. The next inputs after the setup data are entered will continue to apply to the current file (usually the first).

Argument: A setup file name of up to 80 characters.

Options: Any character string. Must not be blank.

Default: Will not assume that setup information will follow.

Usage: Will revert to assuming no setup information will follow.

Example: `SETINIT=BW008.6CM.SET`

12.2.82 SETUP

The argument to `SETUP` is a file name where setup information can be found. A setup file must be specified. See Section 17 for details of what should be in the setup files. A new setup file can be specified for each scan for mode switching. The `SETUP` file name may refer to an external file that can be read by SCHED or it may refer to a setup imbedded in the main SCHED input following a `SETINIT` command, whose argument is the setup file name.

Under unix, environment variables may be used. For example, if `SCHED` is defined to mean `/home/arana/cwalker/sched`, the base area under which all sched stuff is kept (substitute your local directory), then one can specify the setup file with `SETUP = $SCHED/setups/v6cm-128-4-2.set`. Use the `setenv` (c or t shell) or export (korn shell) to set environment variables.

Argument: A file name of up to 80 characters.

Options: A valid file name.

Default: No setup file used.

Usage: Defaults to previous scan.

Example: `SETUP='/home/arana/cwalker/sched/v6cm-128-4-2.set'`

12.2.83 SOURCE

`SOURCE` is used to specify the source name. It is required for the first scan and whenever there is a change. The name must match, in a case-insensitive sense, one of the names of a source in the source catalogs (recall that 5 different names or aliases are allowed for each source).

`SOURCE` may be the name of a Solar System object. If so, if an `EPHFILE:` has been specified, and if the object is not in the source catalog, SCHED will determine the position and proper motion of the object using a JPL ephemeris. This position is very good — certainly good enough for use for pointing which is the primary use envisioned (note that much work would be required on the correlator to correlate planetary observations).

The Solar System objects that SCHED understands are Mercury, Venus, Moon, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto, and Sun. Topocentric positions and rates will be provided for VLBA antennas if one of these is specified. Geocentric positions along with rates and horizontal parallax are provided for the PM cards for the VLA. Note that SCHED does not understand how to specify moving objects to antennas that don't use the VLA or VLBA control file types. Specifically, solar system sources are not currently supported for VEX output files.

Argument: Text of up to 12 characters.

Options: Any source in the catalogs.

Default: None.

Usage: Defaults to previous scan.

Example: `SOURCE='3C120'`

12.2.84 SRCCAT

SRCCAT is a flag to indicate that the following inputs are to be treated as an in-line source catalog. See Section 13 for details of source catalog contents. The catalog input is terminated by ENDCAT / to resume schedule input. It is best to specify SRCCAT / as a separate line not part of other SCHED keyin input. SCHED stores the source catalog information in internal arrays which have a maximum size that may depend on the computer but is 500 in the distributed version. All sources found in in-line catalogs are stored in these arrays because they may be read before all scheduled sources are known. In contrast, when an external source catalog is read, only scheduled sources are kept. See the examples in Section 8.1 for illustrations of how in-line source catalogs are used.

If SRCCAT is found, the end of the input group (everything up to the "/") is not considered the end of inputs for this file. The next inputs after the source data are entered will continue to apply to the current file (usually the first).

Argument: None.

Options: None.

Default: Not used.

Usage: There can be as many in-line catalogs as desired, consistent with the maximum number of allowed sources in the in-line catalogs.

Example: SRCCAT /

12.2.85 SRCFILE

SRCFILE is used to specify the name of the external source file. See Section 13 for the required formats. The default SRCFILE is $SCHED/catalogs/sources.vlba. Assuming the environment variable $SCHED is set (see below), this is the usual SCHED source file. If SRCFILE='none' is specified then no external catalog will be read.

Under unix, environment variables may be used. For example, if SCHED is defined to mean /home/arana/cwalker/sched, the base area under which all SCHED stuff is kept (substitute your local directory), then one can specify the source file with SRCFILE = $SCHED/catalogs/sources.vlba. Use the setenv (c or t shell) or export (korn shell) to set environment variables.

Argument: A file name of up to 80 characters.

Options: Any file name or none.

Default: '$SCHED/catalogs/sources.vlba'

Usage: Use only once.

Example: SRCFILE='/home/arana/cwalker/sched/sources.obs'

12.2.86 STACAT

STACAT is a flag to indicate that the following entries are part of the stations catalog. See Section 14 for details of the format. In-line catalogs can occur more than once in the SCHED keyin file. The station catalog input is terminated with a separate entry containing `ENDCAT /`.

If `STACAT` is found, the end of the input group (everything up to the "/") is not considered the end of inputs for this file. The next inputs after the station data are entered will continue to apply to the current file (usually the first).

Argument: None.

Options: None.

Default: Not used.

Usage: Can occur as often as desired.

Example: `STACAT /`

12.2.87 STAFILE

`STAFILE` is the name of the external stations file. See Section 14 for the required formats. If `STAFILE` is not specified, it defaults to `$SCHED/catalogs/stations.dat`. If `STAFILE='none'` is specified then no external catalog will be read.

This must be specified among the first scan inputs since SCHED will read the station catalog while setting up the first scan. If `STAFILE` is not specified with the first scan's inputs, SCHED will read the default catalog. This is done because, while reading the scans, SCHED needs to know some station information (like codes in case you choose to specify them for the STATIONS input).

Under unix, environment variables may be used. For example, if `SCHED` is defined to mean `/home/arana/cwalker/sched`, the base area under which all sched stuff is kept (substitute your local directory), then one can specify the station file with `STAFILE = $SCHED/catalogs/stations.dat`. Use the `setenv` (c or t shell) or export (korn shell) to set environment variables.

Argument: A file name of up to 80 characters.

Options: Any valid file name or `none`.

Default: `$SCHED/catalogs/stations.dat`

Usage: Only specify once.

Example: `STAFILE='/home/arana/cwalker/sched/stations.dat'`

12.2.88 START

`START` is used to specify the start time of the scan in UT. If `LST` was specified, `START` is assumed to be in local sidereal time. `START` must be specified for the first scan. For later scans, it will default to the stop time of the previous scan if not specified. Note that the start time will be adjusted by `PRESCAN` to the time that the tape motion starts.

Argument: A time in `hh:mm:ss` format.

Options: Any time.

Default: No default - SCHED will stop if first `START` is not given.

Usage: Defaults to stop time of previous time.

Example: `START=13:15:00`

12.2.89 `STATions`

`STATions` is used to specify the list of stations to be included in this scan. If there is any change to the list, the whole list must be given again. The station names given must match ones available in the station catalogs. The scans for any specific station must be in time order. Note that `STATN` is no longer an acceptable alternative.

The maximum number of stations that SCHED will handle is set in a parameter statement in an include file and can be varied according to the capabilities of the computer in use. At the time this was written, it was 22, but that may change.

You may specify the station code for any or all stations instead of the name. Sched will determine the station name from the catalog information and use it for the rest of scheduling. This use of station codes is only offered for `STATions`, `FASTFOR`, `REWIND`, `TAPE`, and `REVERSE`. All other inputs requiring station names must use the names as given in the station catalog.

Argument: A list of station names of up to 8 characters each.

Options: Any stations in the station catalog.

Default: At least one must be given for first scan.

Usage: Defaults to previous scan.

Example: `STATION=EB_VLBA,GB_VLBA,VLBA_NL,VLA27,VLBA_MK`

12.2.90 `STOP`

`STOP` is used to specify the stop time of the scan in UT. If `LST` is specified, the time is in local sidereal time. Either a `STOP` time, a `DURation`, or a `DWELL` must be given for each scan, although the `DURation` or `DWELL` can default to a previous value. If `STOP` and one of the others are both given then the implied stop times are compared, and if those times differ by more than 10 seconds, a complaint is generated. A simple check of a long schedule made in durations is to include the stop time for the last scan; if the schedule has problems, there will be an error message.

Argument: A time in `hh:mm:ss` format.

Options: Any time.

Default: Start time plus duration.

Usage: Either `DURation`, `DWELL`, or `STOP` is required for each scan. `DURation` or `DWELL` will default to previous scan.

Example: `STOP=13:45:00`

12.2.91 SUMITEM

`SUMITEM` is used to control the items listed in the summary file for each antenna. Two items are listed for each scan for each antenna on each summary pass. Up to 10 items can be requested causing up to 5 summaries to be produced in the *.sum* file. The items that can be requested are:

`EL1`: The elevation at the start of the scan. For scans where the source is below the hardware limits or the horizon, a letter code will be included.

`EL2`: The elevation at the end of the scan. The limit code will be included.

`AZ1`: The azimuth at the start of the scan. The limit code will be included.

`AZ2`: The azimuth at the end of the scan. The limit code will be included.

`PA1`: The paralactic angle at the start of the scan.

`PA2`: The paralactic angle at the end of the scan.

`HA1`: The hour angle at the start of the scan.

`HA2`: The hour angle at the end of the scan.

`EARLY`: The number of seconds that the antenna arrived on source before the scan started. Negative numbers are common and are the number of seconds that the antenna arrived on source after the scan started.

`DWELL`: The number of seconds of on-source time in the scan.

`TAPE1`: The tape drive in use, the recording direction, and the head index position.

`TAPE2`: The set of heads in use (for example which of the `TRACKn` inputs is in use) and the tape footage in thousands.

If any other items are desired, please inform Craig Walker.

Users of EVN antennas (and any others controlled by the PCFS and VEX) are advised to study the listing created by `EARLY`. Currently there is no mechanism for PCFS to monitor whether the telescope was on source when the tape starts spinning. Data taken during this time are invalid, but are not flagged automatically. Therefore it is advisable to make schedules with `DWELL` or inspect the listing for telescopes that arrive late on source.

Argument: Up to 10 character strings.

Options: See the description above for valid parameters.

Default: `EL1, EL2, TAPE1, TAPE2`

Usage: Only one value used, the last.

Example: `sumitem=el1, az1`

12.2.92 `TANT1 and TANT2`

`TANT1` requests that SCHED turn on antenna temperature measurement at stations in the `TANTSTA1` list, if it knows how to do so for those antennas. `TANT2` does the same thing for stations in the `TANTSTA2` list.

This command currently has no effect on VEX output.

> **Argument:** None or a non-zero value.
>
> **Options:** None or `0` to turn on Ta measurements. Specify a non-zero value to turn off Ta measurements.
>
> **Default:** Make the Ta measurements.
>
> **Usage:** Defaults to previous scan.
>
> **Example:** `TANT1=-1 TANT2`

12.2.93 `TANTSTA1 and TANTSTA2`

`TANTSTA1` is used to specify a list of stations for which `TANT1` will turn on and off Ta measurements. These stations must have Green Bank or snap type files, or SCHED will abort.
tt TANTSTA2 specifies the stations whose antenna measurements are controlled by `TANT2`.

> **Argument:** A list of station names of up to 8 characters each. Should match names of stations used in the schedule.
>
> **Options:** Any station names. Unrecognized names will be ignored.
>
> **Default:** Any stations in the schedule that have `NRAO` or `SNAP` control file types.
>
> **Usage:** Only one list, the last given.
>
> **Example:** `TANTSTA1='BONN','JODRELL' tantsta2=nrao`

12.2.94 `TAPE`

`TAPE` requests that SCHED force a tape change at the start of the scan. This will override any automatic tape changing that is going on and will reset the reference time for any following automatic tape changes. If no argument is given, the tape will be changed at all stations. If a list of stations is given, the tapes will only be changed at those stations; if a station is given that is not in the scan, an error message will be generated and SCHED will abort. Station codes my be used in place of station names.

For stations that only have one tape drive (all except the VLBA and VLA), be sure to allow enough idle time to complete the tape change. This usually means 15 minutes and SCHED will issue warnings if it is less than this. Some stations claim to be able to do it in 10. If postpasses are required, and they are currently (Feb 1997) being done at thin tape stations, an additional up to 33 minutes is required. The station operators can override the postpass to save time, at the risk of damaging tapes which cost over $(US)1000 each. An alternative is to schedule the last pass at such stations without stopping the tape. If SCHED detects that this has been done, it will issue an UNLOAD command instead of POSTPASS. Note that the automatic postpass will only be requested at sites using VLBA control files. The VEX format does not (yet) include this concept.

Argument: None or a list of up to 30 station names.

Options: No argument or a list of any stations in the scan. Not case sensitive.

Default: Not used. Automatic tape changes by default.

Usage: Must specify whenever needed.

Example: `TAPE` or `TAPE=VLBA_MK,VLBA_NL`

12.2.95 `TAPEFILE`

`TAPEFILE` gives the name for the tape initialization file. See Section 15 for content details. The alternative is to have the tape initialization details imbedded in the SCHED input following `TAPEINI` or to use the defaults which are fine for the VLBA.

Under unix, environment variables may be used.

Argument: A file name of up to 80 characters.

Options: Any file name.

Default: `'NONE'`, causing defaults or parameters specified after `TAPEINI` to be used.

Usage: Only one accepted, the last.

Example: `TAPEFILE='vlba.head'`

12.2.96 `TAPEINI`

`TAPEINI` is a flag to inform SCHED that the next group of input parameters will be tape initialization information, equivalent to one line from the `TAPEFILE`. See Section 15 for content details. Once the tape initialization parameters have been read, SCHED will return to reading the inputs for the current scan, usually the first.

Argument: None.

Options: None.

Default: Not used.

Usage: Should not be used more than once.

Example: `TAPEINI /`

12.2.97 `TAPESYNC`

`TAPESYNC` requests that SCHED try to synchronize tape changes at the stations. This is advisable to avoid slightly staggered tape changes that would naturally result from a subarrayed schedule. Such staggered tape changes can result in lost data because there is a minimum of about 3 minutes per correlator job and a new job is needed when a station changes tape. This is a temporary restriction but was in effect in late 1996.

WARNING: `TAPESYNC` could cause very strange behavior if used with a schedule in which some stations are being scheduled separately from others. It should only be used when the scans as specified to SCHED are in roughly time order (for subarrays, there can be small deviations from time order and that will be ok). It is only recommended for use in conjunction with the optimization options. For any schedules in which every scan is specified in the input, it would be best to use `TAPE` to force the tape changes at reasonable times, if necessary.

Also, be sure that any automatically generated tape change requests occur at times with sufficient gaps at single tape stations (all except the VLBA and VLA). See the discussion of `TAPE` for details.

Argument: None.

Options: None.

Default: Not used.

Usage: Last value used.

Example: `TAPESYNC /`

12.2.98 `TAVLBA` and `NOTAVLBA`

`TAVLBA` tells SCHED to write a VLBA antenna-temperature measuring sequence in the VLBA control file for this scan. `NOTAVLBA` tells SCHED not to write such a sequence. Parameters `PTSLEW` and `PTDUR` are used as they are for `PTVLBA`. If antenna temperature measurements are desired as part of a VLBI project, a separate scan with `TAVLBA` set should be requested before or after the main VLBI scan. Do not rely on a long `PTSLEW` to get the VLBI data since during the setup part of the scan, the requested pointing position is at a half power point.

Use of `TAVLBA` is not the recommended calibration method for the VLBA. The apriori gains should be used instead. The VLBA antennas are not set up for accurate single dish measurements. The *a priori* values were obtained during good weather when this is not so much of a problem. If the weather is good for the VLBI project, the *a priori* values will be good to a few percent, probably better than any Ta measurement. If the weather is poor, the Ta measurements will probably be nearly useless.

This has no effect on VEX files.

Argument: None.

Options: None set. `NOTAVLBA` to go back to non-pointing modes.

Default: Not used.

Usage: Reverts to previous scan if not specified.

Example: `TAVLBA`

12.2.99 TELEX

`TELEX` is the Principal Investigator's TELEX number for the cover information. This parameter is still provided only for backward compatibility. Don't bother with it. Are telexes still in use?

> **Argument:** Text of up to 64 characters.
>
> **Options:** Any.
>
> **Default:** Blank.
>
> **Usage:** Only one value used, the last.
>
> **Example:** `TELEX='+1-910-988-1710'`

12.2.100 TPREF

`TPREF` is the reference time for Mark II tape changes. When automatic tape changes are specified, as is done by default, they will occur at times that are an integral number of tapelengths (default 4 hours) before or after this time. Since the only really valid Mark II tape length of 4 hours divides a 24-hour day evenly, no provision is provided to specify a day.

> **Argument:** A time.
>
> **Options:** Any valid time between `0` and `24` hours.
>
> **Default:** Not used; rather start time of earliest scan of the schedule is used.
>
> **Usage:** Only one value accepted.
>
> **Example:** `TPREF=5:0:0`

12.2.101 TSYS and NOTSYS

By default, SCHED requests that system temperatures be made every scan in the NRAO (Green Bank) and snap control file types. The VLA and VLBA measure Tsys continuously so no such request is needed. For Green Bank, the system temperatures are measured at the start of every scan and after the end of the scan if there is a source change. For stations using snap files, there is no concept of "go to source, then do something", so Tsys requests are only made at the end of each scan. `NOTSYS` turns off the Tsys requests. The Tsys measurements take a bit of time so it may be desirable to turn them off when switching rapidly between sources; however, by doing so, calibration may be compromised. The measurement of system temperatures can be turned back on with `TSYS`.

This has no effect on VEX files.

> **Argument:** None.
>
> **Options:** Use it or not.
>
> **Default:** Ask for system temperature measurements.

Usage: Defaults to previous scan.

Example: `NOTSYS`

12.2.102 `VERSION`

`VERSION` Version number of the schedule for the cover information. Usually this will be `1` for the first, `2` for the second, etc. Often stations get a schedule, then the PI changes his/her mind about something, or finds and error, and so creates a new version. Later at the station, it is not always obvious which is the latest version. This version number is meant to make it obvious. SCHED will abort if `VERSION` is not specified.

Argument: Any real number, with decimals is desired as it will be printed in F10.2 format.

Options: Any but integers are typical.

Default: `0` which causes SCHED to abort.

Usage: Only one value used, the last.

Example: `VERSION=1`

12.2.103 `VLABAND` and `VLABW`

These are obsolete parameters that specified the VLA observing mode and the VLA backend filter width. They should now be specified in the setup file. Any values specified in the main input will be ignored.

12.2.104 `VLAMODE`

`VLAMODE` gives the VLA observing mode.

Argument: Text of 2 characters.

Options: `'  '` - normal VLA continuum. `'VS'` - single antenna VLBI. `'VA'` - auto phasing. `'VX'` - extended phasing (holding phases from previous `VA` scan.) Other valid options are `'IA'`, `'IB'`, `'IC'`, `'PA'`, `'PB'`, `'PC'`, `'PD'`, `'D '`, `'TE'`, `'TF'`, `'O '`, and `'ON'`; consult VLA documentation for details.

Default: None - required for VLA.

Usage: Defaults to previous scan.

Example: `VLAMODE='VX'`

12.2.105 `VLATSYS and VLANTSYS`

The VLA on-line system normally applies a

Tsys-based amplitude correction to data from the VLA correlator. In order to calibrate 3-antenna and phased VLA data taken with the VLA as a VLBI station, it is necessary to have raw correlation coefficients. If the Tsys correction is made, the raw correlation coefficients are lost. The old DEC10 scheme for obtaining the VLBI calibration data was based on the standard VLA correlator output as archived, so it was necessary to request that the Tsys correction be turned off. The new scheme for obtaining the VLBI calibration information involves extraction of the correlation coefficients by the on-line system before the Tsys corrections are made. Therefore it is no longer necessary to turn the corrections off and leaving them on makes it easier to use the VLA correlator data to make VLA images. The default action of SCHED is now to leave the corrections on and that should be correct for essentially all observations. However, `VLATSYS` and `VLANTSYS` can be used to turn the corrections on and off, respectively, on a scan basis just in case someone still wants to do so.

Argument: None

Options: No value (a non-zero value turns has the effect of the opposite parameter)

Default: Keep Tsys corrections on.

Usage: Defaults to previous value.

Example: `VLANTSYS` or `VLATSYS`

12.2.106 VLAPSRC

`VLAPSRC` can be used to specify the source to use for phasing the VLA. If the scan is mode `VX` and `VLAPSRC` differs from `SOURCE`, then a scan will be inserted in the VLA observe file in `VLAPSRC` with mode `VA`. The tape control file will not be affected. The stop time of the phasing scan will be 1 minute before the start of the VLBI scan or 3 minutes after the stop of the previous VLBI scan, whichever is later. If less than 2 minutes of the VLBI scan remain as a result, a complaint will be generated. It is wise to take the VLA observe file into the NRAO VLA OBSERVE program to check the slew and dwell times, since the default timing used for `VLAPSRC` will not always be reasonable and the phasing scan stop time may need to be adjusted. Note that, since SCHED does not generate a phasing scan for a mode `VA` scan or when `VLAPSRC` equals `SOURCE`, `VLAPSRC` need not be specified or changed for such scans; this may minimize the number of times `VLAPSRC` needs to be specified.

Argument: Any source name of up to 8 characters.

Options: Any source in the catalogs.

Default: Uses `SOURCE`, which causes no phasing scan to be written.

Usage: Defaults to previous scan.

Example: `VLAPSRC='0255+164'`

12.2.107 VLATYPE

`VLATYPE` specifies the type of the observation for the VLA observe file.

Argument: Text of up to 9 characters.

Options: 'VLBI' - VLBI observation. 'CONTINUUM' - normal VLA continuum observation. 'LINE' - VLA spectral line observation.

Default: 'VLBI'

Usage: Use only once.

Example: VLATYPE='CONTINUUM'

12.2.108 VLAUSERN

VLAUSERN is the VLA user number. Provide the PI's VLA number (same as the Socorro AIPS number) if desired. For VLBI runs the default of 600 is fine.

Argument: Integer.

Options: Any VLA user number.

Default: 600

Usage: Only last value entered is used.

Example: VLAUSERN=332

12.2.109 YEAR

YEAR specifies the year of the stop time of the scan. This must be specified for the first scan. It is possible to specify it more often, but that will almost never be necessary.

Argument: Integer.

Options: Any valid year.

Default: None - SCHED will stop if not given for first scan.

Usage: Defaults to previous scan.

Example: YEAR=1996

13 SOURCE CATALOG

SCHED uses a catalog to get source information such as names, positions, and LSR velocities. This catalog is in keyin format. Entries are terminated with a "/". There are standard source catalogs, one of which will probably have most sources in a project. The scheduler may just refer to this catalogs, or may copy the desired entries into catalog sections in the main SCHED input. If the schedule file is to be sent somewhere else to be run, it is generally safer to include the source catalog information in it. In any case, the scheduler should consult the catalog to be sure that the right source names are being used in the schedule.

SCHED input parameter SRCFILE is used to point to any desired external catalog. A file name of up to 80 characters can be specified. The default source file is:
SRCFILE=$SCHED/catalogs/sources.vlba.
On unix systems with the environment variable SCHED properly defined, this is the

standard catalog. The version of this catalog in use at the AOC can be examined at /HOME/ARANA/CWALKER/SCHED/CATALOGS/SOURCES.VLBA.
This is the catalog distributed with SCHED.

Source catalog information can be given in the main SCHED keyin file. If the keyword `SRCCAT` appears, all input after the next "/" is assumed to consist of source catalog entries until a line containing the keyword `ENDCAT` and a "/" is encountered (don't combine this keyword with a catalog entry). Such "in-line" catalogs may appear anywhere in a SCHED keyin file, although it is probably best to put them at the beginning. If you do not want SCHED to look in the standard catalog for sources it does not find in the in-line catalog, specify `SRCFILE=NONE`.

Both in-line catalog entries and an external catalog may be used for either the source catalog. For example, the standard catalog (which on the Caltech and NRAO systems contains the VLA calibrator list and all geodetic sources) could be used for amplitude check sources, while unique program sources could be entered in an in-line catalog. SCHED will look in the external catalog for any source not found in an in-line catalog. If you wish to prevent SCHED from looking in external catalogs, specify `SRCFILE=NONE`.

The in-line catalogs are especially useful for the source catalog if the SCHED keyin file is to be transfered to another computer and run there - for example - as part of schedule distribution through NRAO or if any observatory wants the control file instead of the output file (the VLBA, for one).

The parameters for each entry in the source catalog are below. Lower case letters in this list are optional. All catalog parameters except `EPOCH` revert to a default unless specified for a source. `EPOCH` defaults to the last specified.

`Source:` Up to 5 source names to handle aliases. Up to 12 characters per name. Note that snap files require source names of 10 characters or less. Also, the VLA observe files have a total of 13 characters for the source name plus qualifier. If the qualifier is 0 (default), no characters are needed for it. Otherwise, the qualifier needs however many digits it uses (*e.g.*, 2 digits for qualifier "33") plus one for a blank to separate it from the source name. If either the VLA or a snap file needs shorter name, SCHED will use the first alias of 8 characters or less, so be sure to include such an alias if it will be needed. Also, do not include imbedded blanks in source names, as they cause problems at a variety of places in processing. Finally, beware that the Mark III correlators and the geodetic software have 8 character source name limits.

`Ra:` Right ascension. Remember that the VLA and Westerbork need sub-arcsecond positions for phasing.

`Dec:` Declination.

`Epoch:` Epoch of the observations. Allowed values are `B1950`, `J2000`, and `DATE`.

`Calcode:` Single-character calcode used for VLA observe files. Optional for SCHED.

`Velocity:` LSR velocity (km/s) of a spectral line source. Up to 8 (16?) values can be given, one per base band channel. The value for the first base band channel will be used for any other channels for which no velocity is specified.

PMEPOCH: For proper (or planetary) motion, the offset from the RA and DEC are assumed to be zero at this time. The format is PMEPOCH = yyyy,mm,dd,hh:mm:ss; for example, PMEPOCH = 1995,12,7,15:0:0 for 15 hours UT on 1995 December 7.

DRA: Rate of change of RA in seconds of time per UT day. This acts in coordinates of date.

DDEC: Rate of change of DEC in arcseconds per UT day. Note that the azimuth and elevation reported by SCHED will not take into account DRA and DDEC. This acts in coordinates of date.

Below is a sample of a few sources from a source catalog.

```
SOURCE='J0432-5109','0431-512','J0432-51'
     RA=04:32:21.178125 DEC=-51:09:25.188093 EPOCH='J2000' CALCODE='C'
     REMARKS='USNO - Ref Frame 1995-1, Eubanks Mar 1995' /
SOURCE='J0433+0521','0430+052','3C120','J0433+05'
     RA=04:33:11.095564 DEC= 05:21:15.620136 EPOCH='J2000' CALCODE='C'
     REMARKS='USNO - Ref Frame 1995-1, Eubanks Mar 1995' /
SOURCE='J0437+2940','J0437+29'
     RA=04:37:04.174700 DEC= 29:40:15.136000 EPOCH='J2000' CALCODE='C'
     REMARKS='VLA Calibrator Source List' /
SOURCE='J0437-1844','0434-188','J0437-18'
     RA=04:37:01.482725 DEC=-18:44:48.612354 EPOCH='J2000' CALCODE='C'
     REMARKS='USNO - Ref Frame 1995-1, Eubanks Mar 1995' /
SOURCE='J0438+4848','J0438+48'
     RA=04:38:59.107800 DEC= 48:48:46.582000 EPOCH='J2000' CALCODE='C'
     REMARKS='VLA Calibrator Source List' /
```

14 STATION CATALOG

SCHED uses a catalog to get station information such as names, positions, horizons, slew characteristics and more. This catalog is in keyin format. Entries are terminated with a "/". There is a standard station catalog which will almost certainly have all stations used by a project. The scheduler may just refer to this catalog, or may copy the desired entries into catalog sections in the main SCHED input. It is usually adequate to refer to the standard catalog. In any case, the scheduler should consult the catalog to be sure that the right source names are being used in the schedule. The most current released version of the station catalog can be examined at /HOME/ARANA/CWALKER/SCHED/CATALOGS/STATIONS.DAT. This is the catalog distributed with SCHED.

SCHED input parameter STAFILE is used to point to any desired external catalogs. A file name of up to 80 characters can be specified. The default is the standard catalog: STAFILE=$SCHED/catalogs/stations.dat

Station catalog information can be given in the main SCHED keyin file. If the keyword STACAT appears, all input after the next "/" is assumed to consist of station catalog entries until a line containing the keyword `ENDCAT` and a "/" is encountered (don't combine this keyword with a catalog entry). Such "in-line" catalogs must appear in the SCHED keyin file before the all of the input for the first scan is complete. This allows the use of station codes to specify stations in each scan.

Both in-line catalog entries and an external catalog may be used for the station catalog. This would mainly be useful if there is a non-standard antenna in the schedule. That antenna's parameters can be put in the in-line catalog while all other antennas are picked up from the external catalog. If you wish to prevent SCHED from looking in external catalogs, specify `STAFILE=NONE`.

The parameters of the station catalog are given below. Lower case letters are optional.

`STAtion`: Station name. Up to 8 characters.

`STCode`: Station code. Up to 3 characters. Usually there are 2 characters. See Appendix C for a list of codes.

`CONtrol`: Telescope control file type. Valid options are `VLBA` for VLBA control files, `VEX` for Mark IV stations and any other stations with that understand the VEX format, `SNAP` for most stations (Mark II only — does not handle Mark III or Mark IV), `NRAO` for 140-ft type control files, `VLA` for VLA observe files, `VSOP` for VSOP type DRUDG files (Japanese version only), and `NONE` for no control file. A `V` in the 5th character will cause a VLBA control file to be produced without non-DAS (Data Aquisition System — BBC's, formatter, tape recorder etc) to be produced. If the first 4 characters were VLBA, this will be the only file. If they were something else, both the other type of file and the reduced VLBA file will be produced. This is the default when `CONTROL = VLA`. Option `SN50` is also available for snap files with forced B1950 coordinates. The `VEX` option for even one station triggers production of a VEX format .skd file (once this software is ready) for all stations in addition to any antenna specific files requested.

`DAR`: Gives the type of Data Aquisition Rack present. This is mainly to identify the type of formatter is at the station which will let the program know about the capabilities available. Valid types are: `VLBA`, `MKIV`, `MKIII`, `S2`, `K4`, `VSOP` and `NONE`. Note that for Mark II scheduling (basically obsolete), any site scheduled will be assumed to have Mark II equipment.

`RECORDER`: Gives the type of tape recorder(s) present Valid options are: `VLBA`, `MKIV`, `MKIII`, `S2`, `K4`, `VSOP` and `NONE`.

`NBBC`: Tells SCHED how many BBC's or VC's are at the site.

`NDRIVES`: Gives the number of tape drives at the sites. Most have only 1 but all VLBA sites, for example, have 2. This can be overridden for a schedule using the NDRIVES parameter in the tape initialization information.

`NHEADS`: Gives the number of recording head blocks on each VLBA or MKIV drive. This will be useful mainly for MKIV which will usually have 2.

ELev: Station elevation in meters above (mean?) sea level for geodetic coordinates or meters from the center of the Earth for geocentric coordinates; these cases are distinguished by value magnitude.

LAT: Station latitude, either geodetic or geocentric. The format is `dd:mm:ss`. Positive in Northern Hemisphere.

LONG: Station longitude, either geodetic or geocentric. The format is `ddd:mm:ss`. Positive in Western Hemisphere.

ZALim: Zenith angle limit in degrees. Can be used to limit elevation coverage for stations with other than AZEL mounts. The antenna will be assumed to point below this limit to whatever limits are specified with AX1LIM and AX2LIM for purposes of slew calculations. However, if the antenna is below this limit, the source will be considered to be down during any optimizations.

X: Station X coordinate in meters. This is in the direction of the Greenwich meridian.

Y: Station Y coordinate in meters. This makes a right handed coordinate system with X and Z.

Z: Station Z coordinate in meters. This is in the direction of the north pole.

DEScrip: Any text up to 80 characters (not used by SCHED).

NDRIVES: Number of wide band tape recorders at each site. Not used by SCHED. Should be in the tape initialization file.

HOR_AZ: Up to 200 azimuths at which horizon elevations are given in HOR_EL.

HOR_EL: Up to 200 elevations for the horizon at the azimuths specified by HOR_AZ. SCHED's down, rise, and set notes will take these horizons into account. They will also be used in the optimization mode.

AX1LIM: The slew limits for the first axis which is usually azimuth, hour angle or X. The units are degrees for azimuth or X and hours for equatatorial mounts. There are up to 3 pairs of numbers giving the lower and upper limits for 3 different parts of the sky. This is required to describe the limits for the 140' at Green Bank. Zero is to the north and positive is clockwise looking down on the antenna.

AX2LIM: The slew limits for the second axis which is usually elevation, declination, or Y. The units are degrees in all cases. There are 3 pairs of numbers which define the three parts of the sky over which the 3 pairs of AX1LIMs apply. The ranges should not overlap, although they can touch.

AX1RATE: The slew rate for the first axis in degrees per minute for all mount types.

AX2RATE: The slew rate for the second axis in degrees per minute.

TSETTLE: The time in seconds (or mm:ss etc) to add to the slew time for dwell time scheduling to determine when the antenna is ready to observe. This will include acceleration and deceleration time, any computer overhead, and time to make calibration observations.

MOUNT: The type of mount. SCHED uses this, along with the axis limits and rates, to calculate slew times. The understood options are ALTAZ, EQUAT, and XYNS. Note that XYNS is for an XY axis system with the fixed axis in the north-south direction (for example, Fairbanks). Someday, XYEW should be added for the other orientation (for example, Hobart).

Below is a sample segment of the standard station catalog.

```
  STATION=VLBA_MK   STCODE=Mk  CONTROL=VLBA
    ELEV=3720.00  LONG=155:27:28.95    LAT=19:48:15.85
    MOUNT=ALTAZ  AX1LIM=-90,450 AX2LIM=2.25,90 AX1RATE=90 AX2RATE=30
    TSETTLE=2  DAR=VLBA  RECORDER=VLBA  NDRIVES=2  NHEADS=1 NBBC=8
    ! MK    From 150 K Ts line by Beasley and Medcalf  Aug 1992.
    HOR_AZ =   0,  5, 10, 15, 20,120,125,130,135,140,145,150,155,160,
             165,170,175,185,190,195,200,205,210,215,220,255,260,270,
             275,280,285,290,295,300,305,310,315,320,325,330,335,340,
             345,350,355,360
    HOR_EL =   5,  4,  3,  3,  2,  2,  4,  5,  5,  4,  4,  6,  8,  8,
              11, 12, 13, 13, 11, 11,  9,  7,  5,  3,  2,  2,  3,  3,
               5,  6,  8, 10, 12, 14, 12, 11,  9, 10, 11, 10, 12, 14,
              12,  9,  7,  5
  /
  STATION=VLBA_HN   STCODE=Hn  CONTROL=VLBA
    ELEV=309.00  LONG=071:59:11.69    LAT=42:56:00.96
    MOUNT=ALTAZ  AX1LIM=-90,450 AX2LIM=2.25,90 AX1RATE=90 AX2RATE=30
    TSETTLE=2  DAR=VLBA  RECORDER=VLBA  NDRIVES=2  NHEADS=1 NBBC=8
    ! HN    From 150 K Ts line by Beasley and Medcalf  Aug 1992.
    HOR_AZ =   0,  5, 30, 35, 40, 45, 65, 70, 80, 85, 90, 95,100,105,
             110,115,120,125,130,135,140,145,150,155,160,165,170,190,
             195,200,205,210,220,225,230,235,240,245,250,255,270,275,
             290,295,315,320,325,330,335,345,350,355,360
    HOR_EL =   6,  6,  6,  4,  5,  4,  4,  5,  5,  4,  5,  4,  4,  5,
               3,  4,  4,  5,  4,  6,  5,  7,  7,  5,  3,  5,  4,  4,
               2,  5,  5,  6,  6,  5,  6,  4,  5,  5,  4,  5,  5,  4,
               4,  5,  5,  6,  5,  5,  6,  6,  5,  5,  6
 /
!   Some stations with VLBA terminals and control computers:
!   See other entries if Mark~III versions are desired.
  STATION=EB_VLBA   STCODE=Eb  CONTROL=VLBA  ZALIM=78.000
    MOUNT=ALTAZ AX1RATE=30 AX2RATE=15 AX1LIM=33,507 AX2LIM=9,89
```

```
    TSETTLE=2  DAR=VLBA  RECORDER=VLBA  NDRIVES=1  NHEADS=1 NBBC=4
    ELEV= 6365911.00  LONG=-006:53:03.98    LAT= 50:20:09.70     /

  STATION=JODRELL2   STCODE=Jb  CONTROL=SN50
    MOUNT=ALTAZ AX1RATE=22.5 AX2RATE=22.5 AX1LIM=-85,325 AX2LIM=3,89
    ELEV= 6364546.00  LONG= 002:18:24.01    LAT= 53:03:06.01
    TSETTLE=2  DAR=MKIII  RECORDER=MKIII  NDRIVES=1  NHEADS=1 NBBC=14
   /
  STATION=MEDICINA  STCODE=Mc  CONTROL=SNAP
    MOUNT=ALTAZ AX1RATE=48 AX2RATE=30 AX1LIM=90,540 AX2LIM=5,88.5
    ELEV=     100.00  LONG=-011:18:00.00    LAT= 44:30:00.00
    TSETTLE=2  DAR=MKIII  RECORDER=MKIII  NDRIVES=1  NHEADS=1 NBBC=14
   /
```

15 TAPE INITIALIZATION FILE

The tape initialization information tells SCHED details about the tapes to be used at each site. Usually the defaults should be ok and the information can be left out. If needed, the information can be obtained from an external file, the `TAPEFILE`, or can be imbedded in the main file following the parameter `TAPEINI`. It is often inserted by the analysts in files delivered to the AOC for the final run through SCHED.

The capability to have a separate `TAPEFILE` is part of an attempt to deal with the general case of VLBA tape handling. Users other than VLBA staff are very unlikely to need to know about it. The full operational VLBA case requires dealing with tape changes that are not simultaneous at each station and that do not coincide with project changes. In addition, many combinations of tape speed and number of heads being recorded at once are allowed. Eventually the VLBA on-line systems will take care of all of this and the users will only need to worry about some very general restrictions.

Automatic tape allocation and automatic reversals can be requested using SCHED's `AUTOTAPE` parameter; however, these options are not fully operational as of 1996 November and are not planned for stations controlled by VEX files. SCHED contains parameters that are a first cut at dealing with the general VLBA case, but with the following restrictions:

1. The tape drive and head position for each station are assumed to be known ahead of time. The array scheduling must specify both the time range and the amount of tape to be used.

2. The number of heads in use at a time (8, 16, or 32), which determines the number of passes per head index position (1, 2, or 4 as specified by `TPMODE` in the *setup file*), is not allowed to change during a project at a station, although different stations may use different values for `TPMODE`. SCHED checks all the requested setups for a station and remembers the largest number of heads (smallest `TPMODE`) and allocates tape for all scans as if that value were in use. This is wasteful of tape, but allows some tests to be done with mode switching.

3. The two-tape, 512-Mbps mode is not yet supported.

The following capabilities are supported:

1. Different tape lengths at different stations.

2. Different bit densities, and hence tape speeds, at different stations.

3. Tape drive and index position at program start specified for each station.

4. Tape speed, bandwidth, and sample rate can change during run. Beware of operational restrictions on the use of this capability as of early 1996. See the guidelines for preparing observing schedules available from the NRAO WWW home page under VLBA.

5. Different number of tape drives at each station.

The tape initialization file is used to specify the initial conditions for each project. It is possible that such a file will be maintained by VLBA operations for use during the preparation of the final schedules, although it is now looking more likely that multiple projects per tape will not be implemented until automatic tape allocation is properly tested. Anyway, if the tape initialization scheme is used, PI's could run SCHED ahead of time with default startup conditions to test their schedule. As long as there are two tape drives at each site, so that no time need be allocated for tape changes, it should not matter where the project gets put on the tape when SCHED is run again later with the actual startup conditions. The name of the tape initialization file is specified with the 80 character parameter `TAPEFILE` in the SCHED keyin file.

A full tape initialization file would contain a set of inputs for each project. Each set of inputs must be followed by a "/". The file can also contain a default set for use by other projects. Note that SCHED contains a reasonable set of defaults, so no tape initialization file will be needed in many cases while the VLBA is still in a mode of having separate tapes for each project.

A single set of tape initialization conditions can be specified in the SCHED keyin file using `TAPEINI` followed by a "/", in much the same way that in-line catalogs are given. Unlike the source and station catalogs, only one input group will be read and that group will be terminated by a "/". No `ENDCAT` or equivalent is required, or even allowed.

15.1 Summary List of Tape Initialization Parameters

The input parameters of the `TAPEFILE` are:

`NDRIVES`:	Number of drives at the site.
`NHEADPOS`:	Number of head positions in use at site.
`OBSCODE`:	Experiment code for this observation.
`TPSTA`:	Station name for this group of parameters.
`TPDRIVE`:	The drive to begin the observation on.
`TPINDEX`:	The tape index at which to start the observations.
`TPLENGTH`:	The length of the tapes to be used at the site.

DENSITY:	Are tapes at sites high or low density.
TPTIME:	Mark II tape length in time.

An example of a tape initialization group, corresponding to the SCHED defaults, is shown below. Note the NDRIVES is not given so that it is picked up from the station catalog. Note that the example file for VLBI at the VLAontains a tape initialization group to show what it is like. Usually it should be reasonable to take the defaults.

```
obscode ='default'
tpsta   ='vlba', 'vla1', 'vla27', 'eb_vlba', 'gb_vlba', 'default'
tpdrive =1,      1,      1,       1,         1,         1
tpindex =1,      1,      1,       1,         1,         1
tplength=17600,  17600,  17600,   17600,     17600,     8800
nheadpos=14,     14,     14,      14,        14,        14
density =H,      H,      H,       H,         H,         L
        /
```

15.2 Details of Tape Initialization Parameters

15.2.1 NDRIVES

NDRIVES if the number of tape drives at each station. This parameter can also be given in the station catalog and only need be given here for abnormal configurations. The value in the tape initialization information will override the number in the station catalog.

The VLBA sites and the VLA normally have 2 drives. Other sites will usually have 1.

Note that the schedule can be forced to use a single tape drive other than number 1 by setting NDRIVES=1 and TPDRIVE=N where N is the desired drive (usually 2). This is useful if, for example, tape drive 1 is out of service.

For S2 stations NDRIVES indicates the number of transports in the S2 recorder (usually 8).

> **Argument:** An array of up to 30 integers, one for each station in the TPSTA list.
>
> **Options:** 1 or 2 are the likely choices.
>
> **Default:** 2 for the VLBA and VLA, 1 for others.
>
> **Usage:** Defaults to the previous group.
>
> **Example:** NDRIVES=1,1,2,2,1,2

15.2.2 NHEADPOS

NHEADPOS is the number of head positions to use at the station. The traditional number for Mark IIIa sites is 12. However, the VLBA uses a head position sequence with 14 positions. This allows more data to be put on a tape. This input is provided mainly to allow the number of head positions to be forced to 12 to match a schedule made to allow time for tape changes every 12 head positions. This is likely to be common for Mark III projects.

The MkIV schedules are currently (Feb 1997) scheduled with similar transverse tape format as the VLBA; normally the same 14 head positions are used. For S2 recorders this parameter is ignored, the different groups in an S2 format can be set by `TPMODE`.

Argument: An array of up to 30 integers, one for each station in the `TPSTA` list.

Options: `12` or `14` are the likely choices but the program will take any value.

Default: `14`

Usage: Defaults to previous group.

Example: `NHEADPOS=12,12,14,14,12,14`

15.2.3 `OBSCODE`

`OBSCODE` is the Project code for the project for which this group of inputs applies.

Argument: Character of length 8.

Options: Any valid project code.

Default: `DEFAULT`. Implies that this group will give the default information.

Usage: Defaults to previous group, which is not likely to be useful.

Example: `OBSCODE='BW005B'`

15.2.4 `TPSTA`

`TPSTA` is an array of up to 30 station names. One can be `'DEFAULT'` which means that the corresponding parameters will be used for stations not explicitly in the list. A station `VLBA` will match any VLBA stations that are not specified explicitly. Actually it matches any stations with the first four characters "VLBA". A station `VLA` matches any station with the first 3 characters "VLA" that is not otherwise specified explicitly. For example, it matches "VLA1" and "VLA27".

Argument: Character of length 8.

Options: Any station name.

Default: Blank

Usage: Defaults to previous value if none are specified. This is likely to be the normal mode of use with the station list only given for the first observation. If any stations are given, it is assumed that a complete new list is being given.

Example: `TPSTA='VLBA_PT','VLBA_KP','VLA27'`

15.2.5 TPDRIVE

`TPDRIVE` is the tape drive on which to start the project. Each element in the array applies to the station in the corresponding element in the `TPSTA` array. If `NDRIVES=1`, the schedule will use the tape drive specified by `TPDRIVE` for all scans. This is useful for cases when tape drive 1 is out of service.

Argument: An array of 30 integers.

Options: `1` or `2` for VLBA sites. `1` for most others.

Default: 1

Usage: Defaults to previous value.

Example: `TPDRIVE=2,1,1`

15.2.6 TPINDEX

`TPINDEX` is the head index position on which to start. It will be assumed that there are no previously recorded data at this index position. A value for each station in `TPSTA`. With the new head position sequence all forward passes start on odd numbered index positions. SCHED will require `TPINDEX` be odd and will add 1 to any even value.

Argument: An array of 30 odd integers.

Options: Integer between `1` and `13`.

Default: 1

Usage: Defaults to previous value.

Example: `TPINDEX=5,6,2`

15.2.7 TPLENGTH

`TPLENGTH` is the length of the tapes in use at each site. For VLBA, Mark III, and Mark IV tapes, the length is in feet. Normal Mark III stations will use 9000 foot tapes while the VLBA, VLA and some others will use 17600 foot or longer tapes.

For S2, in order to produce numbers that print well with the same formats as for the other tape types, use `TPLENGTH` equal to the time of the tape in seconds. The tape boxes usually show the time in minutes for the SP mode. The LP mode that is used has more time per tape. Appropriate values are `TPLENGTH=13800` for SP120 tape and `TPLENGTH=20520` for SP182 tape. The corresponding speed, which is the default for S2, is 12 inchs per second (equal to 1 foot per second). Of course these are dummy numbers that make the bookkeeping come out right. I have no idea how long an S2 tape actually is.

S2 tape length should be given in seconds, corresponding to Standard Play in a US VCR. A tape with label ST-120 (or SE-180) should be scheduled with TPLENGTH = 7200

Argument: An array of 30 integers giving tape lengths in feet.

Options: Any value, but 9000 and 17600 are likely to be the true values.

Default: 17600 for the VLBA and VLA, 8800 for others.

Usage: Defaults to previous value.

Example: `TPLENGTH=17600,8800,8800`

15.2.8 DENSITY

`DENSITY` specifies whether the tape is to be written at high or low density. The tape speeds corresponding to each density can be specified in the setup file using `TPSPEEDH`SP:TPSPEEDH and `TPSPEEDL`SP:TPSPEEDL or, better, they can be allowed to default.
For S2 tapes, density "`H`" refers to `SLP` and "`L`" to `LP`.

Argument: An array of character strings of up to 8 characters each, of which only the first character will be used.

Options: The first letter of each string must be "`H`" or "`L`" (not case sensitive).

Default: `H` for the VLBA and VLA, `L` for others

Usage: Defaults to the previous value.

Example: `DENSITY=H,L,L`

15.2.9 TPTIME

`TPTIME`. This is for Mark II. It specifies the reference time for tape changes at each site. The tapes at the station will be changed an integral number of 4 hour intervals before or after this time. In effect, it is a station dependent `TPREF`. This value, if specified, will override `TPREF` for the corresponding station.

Argument: An array of 30 times in `hh:mm:ss` format.

Options: Any valid time between `0` and `24` hours.

Default: `-1` which causes it not to be used. `TPREF` or the first scan of the project will be used instead.

Usage: Defaults to previous value.

Example: `TPTIME=2:0:0,3:0:0,2:0:0`

16 FREQUENCY CATALOG

SCHED is able to fill in many items in setup files based on knowledge of possible frequency setups at the stations as described in the frequency catalog. This allows the user to only specify basic information. A reasonable minimum set would be: `STATION`, `NCHAN`, `FREQREF` (and `FREQOFF`, `BBFILTER`, `BITS`, `POL` (can be `DUAL`), and `FORMAT`. To avoid possible confusion, it is also best to specify `BBC` and `NETSIDE` rather than taking the defaults on those. The frequency catalog also allows SCHED to check user specified values against standard sets to warn of any oddities.

Most users will not touch the frequency catalog. If they need a setup that does not conform to what is in the catalog, they should just make the necessary `setup files` and ignore the warnings after making sure that the special files are correct. Be very careful doing this. There are filters on many of the LO and IF cables, at least on the VLBA, that most users probably are not aware of. Any special setup files that do not match one of the standards should be shown to Craig Walker for approval. If it is a good one, it may be added to the standards. However, the standard set is essentially complete for the VLBA. If SCHED complains about your's, it is likely to be in error.

There is a lot of information about available frequencies, receivers, frequency ranges, filters etc, especially at the VLBA, in the standard frequency catalog. A table of information about possible setups for observations within a frequency range can be made by running SCHED with `FREQLIST = lowfreq, highfreq` (eg `freqlist=4800,8900`) as the only input. The frequencies are in MHz. If only one frequency is given, the second will be set equal to the first. SCHED will produce a table in file *frequencies.list* containing details of the information available on how to set up these frequencies at all known sites. SCHED will then quit. Note that it is not necessary to transfer this information to your setup files — SCHED will do that automatically based on your frequency and polarization requests in the setup file. To examine the catalog itself, look at *$SCHED/catalogs/freq.dat* or (WWW users) click on: standard frequency catalog, *freq.dat*.

16.1 List of Frequency File Parameters

The parameters of the frequency file tell SCHED over what frequency range the group if usable and on which stations. Most of the parameters are the same as parameters in the setup file since they are meant for direct substitution once the correct frequency group has been identified. There is no defaulting between groups of inputs — all parameters are reset to zero, blank, or some equivalent value.

For the VLA, IF's A and C will be assumed to apply to VLA27 while IF's B and D will be assumed to apply to VLA1. All standard frequency groups will have both VLA IF's on the same frequency. Anything more complicated requires a setup file from the user.

`STATIONs` Up to 10 stations with this setup. This will be matched against the station name in the setup file. The name `VLBA` will be a default for all VLBA stations.

`PRIOrity` A ranking with low values prefered. This allows preference of one setup over another if both match the required frequencies. For example, the narrow band 50 cm receiver would be chosen over the wide band one for narrow band observations despite the fact that both would match the requested frequencies.

`NAME` A name for the frequency group. It is used in listing and error notes to help the user find the right one. Up to 12 characters long. Any string ok.

`NOTE` A comment about the setup that will go to various listings. It is wise to note any limitations here that might not be obvious to a user. Up to 80 characters.

`IFNAME` The name of the IF for up to 8 IF descriptions (eg. A, B, C, D). There are a larger number than there are phsical IFs to allow description of such systems as the VLBA 50/90 cm system where there are more than one signal in each IF.

For antennas in the EVN that have VLBA DARs, the codes in use are usually A and C (LCP and RCP). For MkIV antennas there are two IF distributors that can one can choose to connect to either IF channel. Each distributor is connected to a fixed subset of the BBC's, either the odds or the evens. The normal situation has IF 1N on LCP and 2N on RCP, but alternate channels 1A or 2A can be connected if more than the first 7 BBC's need to be set to a single polarization.

`RF1` The low edge of the RF frequency range covered by each IF. SCHED will try to find the group with all the channels best centered in the IF. However, some channels will allowed to be outside the range if necessary, as is common on the VLA.

`RF2` The high edge of the RF frequency range covered by each IF.

For Mark IV systems, the frequency ranges in the frequency catalog are calculated with the constraint that the complete range can be obtained with the station preferred patching, i.e. with consistently using high or low output on the IF distributor. More frequency coverage can be obtained with detailed knowledge and requires a manual setup.

`CH1RF1` The lowest RF frequency for channel 1. If non-zero, channel 1 will be required to fall in the range specified by `CH1RF1` and `CH1RF2`. This is mainly to be sure that the right filter is used at 2cm on the VLBA.

`CH1RF2` The highest frequency for channel 1. See `CH1RF1`

`LO1` The `FIRSTLO` for each IF channel.

`FE` The `FE` (receiver specification) for each channel. Use `omit` for unused channels.

`POL` The polarization of the channel (RCP or LCP).

`SYN` The `SYNTH` setting for each of the three front end synthesizers on the VLBA.

`DUALX` Use the wideband scheme at 4 cm on the VLBA. See the setup parameter `DUALX`.

`LCP50CM` Setting for the 50 cm filter. See setup file parameter `LCP50CM`

`RCP50CM` Setting for the 50 cm filter. See setup file parameter `RCP50CM`

`CHNSTA` Only use this IF if `CHNSTA` matches the station name. This allows the same groups to be used for VLA1 and VLA27, but to differ in the IFNAME.

`VLABAND` The VLA frequency band. See setup file parameter `VLABAND`

`VLABW` The VLA bandwidth codes. See setup file parameter `VLABW`

`VLAFEAB` The VLA first LO. See setup file parameter `VLAFEAB`

VLAFECD The other VLA first LO. See setup file parameter VLAFECD

VLAIF The VLA gain file name. See setup file parameter VLAIF

VLAROT The VLA first LO. See setup file parameter VLAROT

VLASYNA The VLA AC F6 setting. See setup file parameter VLASYNA

VLASYNB The VLA BD F6 setting. See setup file parameter VLAFECD

FEFILTER The VLA BD F6 setting. See setup file parameter FEFILTER

17 SETUP FILES

Setup files are used to provide station-specific input parameters. Most are for the VLBA, which requires complete configuration information be present in each VLBA control file, and the VLA, which requires information for the frequency setup. For each scan in a schedule, the setup file is specified with SETUP. Once specified, it need not be given again unless it changes. Several setup files may be used in a schedule — usually for switching between frequency bands.

SCHED will not run without a setup file specified for each scan.

Setup files can be imbedded in the main program input, much like source and station catalogs. The group of inputs immediately before the setup file should contain the parameter SETINIT with an argument that gives this "setup file" (which may contain more than one group of stations) a name. This proceedure may be used multiple times to specify several "setup files". In the main schedule, the name given the imbedded file can be used as the argument to SETUP as if it were an external file.

The setup files can be used to control many aspects of the hardware setup at the stations. Mostly it is used to set frequencies and recording modes, but it also has pulse cal detection, pointing, and a number of other items. Most parameters can be left unspecified and SCHED, with the help of the frequency catalog, will find reasonable defaults. See the discussions of individual parameters for details. A reasonable minimum set would be: STATION, NCHAN, FREQREF (and FREQOFF, BBFILTER, BITS, POL (can be DUAL), and FORMAT. To avoid possible confusion, it is also best to specify BBC and NETSIDE rather than taking the defaults on those.

If you don't take the defaults, SCHED will check your setup against the information it has internally and in the frequency catalog. If your setup does not match one in the frequency catalog in terms of the setup of the IF's, SCHED will complain, but not stop. If the complaint is about a VLBA setup, you are probably using a poor set of synthesizer settings or have some other such problem because the frequency catalog contains an essentially complete list of reasonable setups. Please be aware that there are filters in the LO and IF signal paths of the VLBA that many users do not know about. If your setup is not in the frequency catalog, you may simply have specified the wrong IF or synthesizer or you may be trying to use a signal outside of the band of some filter. For other stations, the frequency catalog is not so complete. If SCHED complains, double check your parameters to be sure they are right. In such cases, it is best to email your setup to Craig Walker (cwalker@nrao.edu) for further checking.

If only generic parameters such as those above are specified, multiple stations can be specified for a setup group. SCHED will actually take those multiple stations and create multiple setup groups before filling in the defaults, many of which will be station dependent.

17.1 Standard Setup Files

Over 200 standard setup files have been created, covering many of the normal modes of observing. They are available at the same place as the code for SCHED in a "setups" subdirectory. The majority of projects should be able to use one or more of the standard files. If none of the standard files matches the exact needs of a project, there is likely to be one that is close and can be modified as required. This is generally safer than creating a setup file from scratch because it will be clear what parameters are required.

The standard setup files take advantage of the defaulting ability of SCHED. If you are interested in what most of the setup parameters will actually be set to, the best way to do this is to run a simple dummy schedule that uses the setup and look at the details reported in the summary file. A simple file like the simple example given earlier should do (with `OBSTYPE`et to `VLBI`), although cover and correlator information will be required.

Standard setup files are named according to the following conventions:

"*v*" files: These are setup files for VLBI observations using VLBA recording formats. The VLBA system is very flexible so there are large numbers of options. There is much more information in the name which might be best described with an example. The file *v6cm-128-4-2-L.set* is for 6 cm observations in VLBA format. The first number after a "-" gives the total bit rate in Mbits/s which is 128 in this case. The next number is the number of channels (4). The last number is the number of bits per sample (2). If the file only uses one polarization, there will be an "L" or an "R" at the end. If the file uses upper and lower sidebands where all upper sidebands could be used on the VLBA, there will be a "UL" appended. These files can be used when observing with sites such as Effelsberg which have a limited number of BBCs. All setup files, by convention, end in "*.set*". Note that one can deduce the bandwidth and sample rate from the above information assuming Nyquist sampling. With 128 Mbits/s and 4 channels, the channel bit rate must be 32 Mbits/s. With 2 bits per channel, this means that the sample rate is 16 Msamples/s. Nyquist sampling implies 8 MHz bandwidth per channel, which, with 4 channels, gives 32 MHz overall bandwidth.

"*m3*" files: These are setup files for Mark III observations. SCHED only supports Mark III observing for systems with VLBA control computers and data aquisition systems. These include the VLBA, the VLA, Green Bank, and, optionally, Effelsberg. An example file would be *m3e18cmd.set*. This means Mark III, mode E (4 passes per head position), 18 cm observing wavelength, double speed. Here, double speed means recording at 8 Mbits/s per track. With Mark III, there is a one-to-one correspondence between tracks and channels and there are a total of 28 possible tracks. Also, all sampling is in one bit mode. Mode E uses 7 tracks (channels) at a time so this setup specifies a total bit rate of (7 * 8) = 56 Mbits/s and, with Nyquist sampling, 28 MHz total bandwidth.

"*vla*" **files:** These are setup files for VLA-only observations. The don't specify any tape related information.

"*pt*" **files:** These are setup files for VLBA pointing and antenna temperature measurements.

"*pc*" **files:** These are setup files for VLBA pulse cal tests.

"*nug*" **files:** These are setup files for Mark II observations. The standard "nug" files are not being maintained any more and may will not have the stations in them that are doing Mark II. They will need to be modified if anyone uses them. If they are, please send examples to **cwalker@nrao.edu** so new standards can be established. Mark II is no longer available on most antennas, including all that are operated by NRAO.

17.2 Examples of Setup Files

The standard setup files described above (Section /refSSEC:SETSTD) can be used as examples. However a few of them are shown here to show what they are like to someone who does not have easy access to the machine readable files.

The examples below show the setup files for a for a Mark III mode B observation that requires much more information for formatter and tape control; for a spectral line Mark II observation that (daringly) includes the VLA; and for a VLBA observation using a common VLBA continuum setup. The allowed keyin parameters are listed after the example. Construction of setup files, other than minor changes in frequency for example, is best left to someone who knows the VLBA on-line system.

The first example is of a fairly simple file for 6 cm VLBA observations. It is the standard setup file *v6cm-128-4-2-L.set*. This is about the minimum information needed for an observation.

```
! v6cm-128-4-2-L.set
!      Setup file produced by MAKESETUP.
!       Tape length  Density  Tape speed  Time/pass
!          17600      High      80.0         44:00
!           8800      Low      133.33        13:12
!      128 Mbps - 1 pass/headpos
  format   = VLBA1:4
  nchan    = 4
  bits     = 2
  bbfilter = 8.0
  bbc      = 1, 2, 3, 4
  netside  = U, U, U, U
!      For the 6 cm band.
!        Radio Astronomy allocation: 4990-5000
!        Radio Astnomomy footnote:   4950-4990
!        VLA 50MHz 4960.1 to 5010.1 with VC mode.
!        VLA 6cm receiver falling off at high end.
  station  = VLBA, VLA1, VLA27, GB_VLBA, EB_VLBA
  freqref  = 4990.99         !  Mark II network standard.
  pol      = LCP
  freqoff  = -19.5, -11.5, -3.5, 4.5   /
```

This example is for a Mark III mode B observation. This shows a number of items being specified that do not actually need to be specified since the defaults are reasonable. In particular, these are the track assignments and the pulse cal extractor assignments. The example just shows how one might specify all of these items if desired. Please start with the standard m3b6cm.set, rather than this, for any normal observations.

```
 ---------------------------------------------------------------------
 EXAMPLE:   Mark~III observations, Mode B (with extra inputs)
 ---------------------------------------------------------------------
! m3b6cm.set
!  Tape length  Density  Tape speed  Time/pass
!     17600      High      80.0         44:00
!      8800      Low      135.0         13.02
nchan = 14  samprate = 4.0  bits = 1  bbfilter = 2.0  !   56 Mbps
tpmode = 2  format = MARKIII
bbc      = 1,  1,  2,  2,  3,  3,  4,  4,  5,  5,  6,  6,  7,  7
netside  = L,  U,  L,  U,  L,  U,  L,  U,  L,  U,  L,  U,  L,  U
ifchan  = L,L,L,L,L,L,L, L,L,L,L,L,L,L
freqoff = -16, -16, -12, -12, -8, -8, -4, -4, 0, 0, 4, 4, 8, 8
track1=4,18,6,20,8,22,10,24,12,26,14,28,16,30
track2=5,19,7,21,9,23,11,25,13,27,15,29,17,31
pcalxb1  =  S1,  S2,  S3,  S4,  S5,  S6,  S7,  S8,
            S9, S10, S11, S12, S13, S14,  S1,  S2
pcalxfr1 = 990,  10, 990,  10, 990,  10, 990,  10,
           990,  10, 990,  10, 990,  10,1990, 1010
!    Radio Astronomy allocation: 4990-5000
!    Radio Astnomomy footnote:   4950-4990
!    VLA 50MHz 4960.1 to 5010.1 with VC mode.
!        VLA 6cm receiver falling off at high end.
station  = VLBA
freqref  = 4990.99  !  Mark II network standard.
fe(1)    = '6cm'   fe(3) =  '6cm'
synth(2) = 4.1
firstlo  = 4100.00    rchan = A  lchan = C
   /
station  = VLA27
vlaband  = VC     vlabw = '0000'
firstlo  = 4360.10    rchan = A  lchan = C
   /
station  = VLA1
fe(2) = '6cm'  fe(4) = '6cm'
rchan    = B  lchan = D
   /
station  = GB_VLBA
fe(1)    = '6cm'   fe(3) =  '6cm'
firstlo  = 4260.0   rchan = A  lchan = C
```

```
   /
station  = EB_VLBA
firstlo  = 4100.0   rchan = A  lchan = C    /
```

This example shows a setup file for dual frequency, wide spanned bandwidth, geodetic style observations. Note that the firstlo has to be specified separately for each channel because it varies.

```
! vgeo-128-8-1.set
!      Setup file produced by MAKESETUP.
!       Tape length  Density  Tape speed  Time/pass
!          17600      High      80.0         44:00
!           8800      Low      133.33        13:12
!      128 Mbps - 1 pass/headpos
  format   = VLBA1:4
  nchan    = 8
  bits     = 1
  bbfilter = 8.0
  bbc      = 1, 2, 3, 4, 5, 6, 7, 8
  netside  = U, U, U, U, U, U, U, U
!      For dual frequency 13cm/4cm observations.
!        Space Research (eg DSN) allocation: 2290-2300
!        Space Research (eg DSN) allocation: 8400-8450
  station  = VLBA, EB_VLBA
  pol      = RCP
  freqref  = 2220.49, 2220.49, 2220.49, 2220.49,
             8150.49, 8150.49, 8150.49, 8150.49
  freqoff  =    0.0,    10.0,    70.0,   100.0,
                0.0,    80.0,   260.0,   400.0
  /
```

17.3 Summary List of Setup File Parameters

A list of the setup parameters is given below, followed by detailed information on each setup paramater in Section 17.4. All of the parameters revert to the previous value if not specified for a station. This allows most to be specified only once per setup file. Some of the more difficult parameters, such as track assignments and pulse cal configurations have defaults in SCHED that should nearly always be used. There needs to be a separate group for each station, but after the first, the group may only contain the station name. The generic station "VLBA" can be used for all VLBA stations. If it is desired to specify one VLBA station differently from the the rest, that specific station (eg "VLBA_PT") should be given before the generic "VLBA" station. All parameters can have different values for different stations.

Note that the VLBA uses the concept of baseband channels. Many of the parameters take an array of arguments, one for each baseband channel. The corresponding elements of the arrays specify the required information for the baseband channel, such as the BBC from which the signal will come, the VLBA IF that BBC is attched to, the bandwidth of the BBC, and the frequency of the BBC. There is nothing to prevent more than one baseband channel from being assigned to one BBC/sideband. In such cases, care should be taken to insure that the same frequency, bandwidth, and input VLBA IF are assigned for each such baseband channel. If this is not done, the on-line system can get confused about what signal is in each baseband channel.

`AZCOLIM:`	Colimation offset in azimuth.	
`BARREL:`	Control barrel roll mode.	
`BBFILTER:`	BBC bandwidth for each baseband channel.	
`BBC:`	BBC assigned to each baseband channel.	
`BBSYN:`	BBC frequency setting for each baseband channel.	
`BBSYN2:`	Second set of BBC frequencies for frequency switching.	
`BITS:`	Number of bits per sample.	
`DUALX:`	Mode allowing more than 500 MHz at X band.	
`ELCOLIM:`	Colimation offset in elevation.	
`FE:`	Receivers to be used.	
`FEFILTER:`	VLA front end filter specification for " //LO" card.	
`FIRSTLO:`	Sum of all LOs except the one set if `FREQ` used.	
`FLUKEA:`	VLA A Fluke frequency for "//FI" card.	
`FLUKEB:`	VLA B Fluke frequency for "//FI" card.	
`FLUKESET:`	VLA Fluke set to specify on "//FI" card.	
`FORMAT:`	Recording format to use — (`VLBA1:2` etc.	
`FREQOFF:`	Value to add to `FREQREF` for each baseband channel to get LO sum.	
`FREQREF:`	LO sum is `FREQREF+FREQOFF`. Alternative to `BBSYN`.	
`FRSWITCH:`	Specifies frequency switching.	
`IFCHAN:`	IF channel to BBC for each baseband channel.	
`IFDIST:`	Attenuation of and input to IF Distributers.	
`LCHAN:`	`IFCHAN` to use if `IFCHAN=L` (LCP).	
`LEVEL:`	Attenuator setting for BBCs.	
`LOGGING:`	Type of logging to be done.	
`LCP50CM:`	Controls narrow band filter at 50 cm for LCP.	
`NCHAN:`	Number of baseband channels.	
`NETSIDE:`	Net sideband of baseband channel.	
`NOISE:`	Noise diode switching mode.	
`PERIOD:`	Averaging time in the BBCs.	
`PCAL:`	Mode for pulse cal generator.	
`PCALFR1:`	Pulse cal frequencies to be detected by detector ch1.	
`PCALFR1:`	Pulse cal frequencies to be detected by detector ch2.	
`PCALXB1:`	Bit and channel assignment of ch1 of a pcal detector.	
`PCALXB2:`	Bit and channel assignment of ch2 of a pcal detector.	
`PTINCR:`	Step size for pointing patterns.	
`RCHAN:`	`IFCHAN` to use if `IFCHAN=R` (RCP).	
`RCP50CM:`	Controls narrow band filter at 50 cm for RCP.	
`SAMPRATE:`	Sample rate.	
`SIDEBAND:`	BBC sideband for each baseband channel.	
`STATION:`	Station name.	
`STRING1:`	80 character string to pass to VLBA file.	
`STRING2:`	Another string.	For any parameters
`STRING3:`	Another string.	not understood

STRING4: Another string. by SCHED.
SWTCHDUR: Duration of the scans in a frequency switching loop.
SYNTH: 2-16 GHz synthesizer settings.
TPMODE: Number of passes per index position.
TPSPEED: Speed of the recorder in inches per second (obsolete).
TPSPEEDH: Tape speed in inches per second at high density.
TPSPEEDL: Tape speed in inches per second at low density.
TRACK1: Tape tracks for pass 1 at an index position.
TRACK2: Tape tracks for pass 2.
TRACK3: Tape tracks for pass 3.
TRACK4: Tape tracks for pass 4.
TRACK5: Tape tracks for pass 5.
TRACK6: Tape tracks for pass 6.
TRACK7: Tape tracks for pass 7.
TRACK8: Tape tracks for pass 8.
VLABAND: Band code for VLA.
VLABW: Bandwidth code for VLA.
VLAFEAB: VLA first LO frequency for "//LO" card.
VLAFECD: VLA first LO frequency for "//LO" card.
VLAIF: VLA gain file name for "//LO" card.
VLAROT: VLA rot file name for "//LO" card.
VLASYNA: VLA AC F6 frequency for "//LO" card (not rounded).
VLASYNB: VLA BD F6 frequency for "//LO" card (not rounded).

17.4 Details of Setup File Parameters

17.4.1 AZCOLIM

AZCOLIM sets the azimuth colimation offset to add to the nominal one used by the VLBA on-line computers for pointing. Usually this will be 0.0. This allows the pointing for a VLBA antenna to be adjusted.

Argument: A pointing offset in arc minutes.

Options: Any real number.

Default: 0.0

Usage: Defaults to previous station.

Example: AZCOLIM=1.2

17.4.2 BARREL

BARREL sets the mode of the barrel roll. The barrel roll is designed to protect data against bad recording tracks. Within each head group of 8 tracks, or in some modes, within a pair of head groups, the data for each "track" is actually recorded first on it's assigned track, then the next frame (20,000 data bits) is recorded on the next track, and the next frame on the next track and so forth. After 8 or 16 frames, depending on mode, the track is back on it's original assigned head. With this happening, if a recorder track is bad, some of all channels in the roll group are lost, but no channel is lost completely. Thus there is just a drop in sensitivity rather than a distortion of the information being measured. Very nearly all users should take the default of `roll_auto`. The options for `BARREL` are:

No Barrel roll is supported by the PCFS system (VEX files). Although SCHED knows how to write the Roll in proper VEX files, this will not be interpreted at the stations, and will currently (Feb 1997) cause an error.

`roll_off` turns off the barrel roll.

`roll_8` rolls within one group of 8 heads.

`roll_16` rolls within two groups of 8 heads each.

`roll_auto` tells the on-line system to pick the best roll it can do.

One case where the user may need to set the roll is when the data will be correlated with 2048 point FFT's (1024 point output spectra). This cannot be done with a 16 track roll and so one of the lesser rolls should be forced.

Argument: A string of up to 9 characters.

Options: One of the 4 options listed above.

Default: `roll_auto`

Usage: Defaults to previous station.

Example: `BARREL=roll_8`

17.4.3 BBFILTER

`BBFILTER` sets the baseband channel bandwidth. There is one value for each baseband channel. Any that are not specified will be set equal to the first so in the usual case that all channels have the same bandwidth, only one needs to be set. The value must be a multiple of 2 times 0.0625 MHz up to a maximum of 16 MHz. Up to 16 values can be accepted. If two or more baseband channels are assigned to the same BBC/sideband, they should have the same `BBFILTER` assigned. If not the last will probably be used.

If not specified, one half of the `SAMPRATE` will be used for all channels, if `SAMPRATE` was specified.

Argument: Up to one real number for each channel giving bandwidths in MHz.

Options: `0.0625`, `0.125`, `0.250`, `0.5`, `1.0`, `2`, `4`, `8`, `16`.

Default: `0` - If one is specified, it will be used for all channels. If none are specified, half the sample rate will be used.

Usage: Defaults to revious station.

Example: `BBFILTER = 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2`
which is same as `BBFILTER = 2`

17.4.4 BBC

`BBC` is used to specify the Base Band Converter (BBC) to which each baseband channel is assigned. Typically a value should be given for every channel.

If values are not given, SCHED will attempt to generate them. This will only be done if `SIDEBAND` is not present and `FREQREF` is present. Those tests help avoid cases where there may be conflicting information that has not been dealt with at the time the defaults are set.

For MkIV telescopes SCHED will complain if the file is not consistent with "astronomical patching". This means that the odd BBC's should be connected with IF1 (1N for LCP and 1A for RCP) and the evens to IF2 (2N for RCP and 2A for LCP).

Argument: Up to one integer per baseband channel.

Options: Integers between `1` and `8` make sense on the VLBA. Higher numbers make sense on some systems.

Default: `0`

Usage: Defaults to previous station.

Example: `BBC=1,1,2,2,3,3,4,4,5,5,6,6,7,7`

17.4.5 BBSYN

`BBSYN` is used to set the frequency for the BBC assigned to each baseband channel. This number will be overridden if `FREQ` or `DOPPLER` is specified in the SCHED keyin file. Even if `DOPPLER` is specified, this value serves as the default for continuum sources for which no velocity or `DOPSRC` is specified. All baseband channels assigned to the same BBC should be assigned the same frequency. If not, the last will probably be used and the monitor system will get confused about what signals are present. Please see `FREQREF` for a discussion of required parameters.

For MkIV all BBCs at a given station should fall in the range 100 - 220 (the "Low patch") or 220 - 500 the "High patch").

Argument: Up to 16 frequencies in MHz.

Options: Any multiple of 0.01 MHz from 500.0 to 999.99 MHz.

Default: `0` - should be specified.

Usage: Defaults to previous station.

Example: `BBSYN=720.99,720.99,724.99,724.99`

17.4.6 BBSYN2

If frequency switching is specified, `BBSYN2` is the set of frequencies for the second scan of the switching loop. Frequency setting using `FREQREF` and any pcal defaults are not used for the second frequency set. `BBSYN2` must be specified for this frequency set.

Frequency switching is not allowed when writing VEX files.

Argument: Up to 16 frequencies in MHz.

Options: Any multiple of 0.01 MHz from 500.0 to 999.99 MHz.

Default: `0` - should be specified if frequency switching is requested but not needed otherwise.

Usage: Defaults to previous station.

Example: `BBSYN2=728.99,728.99,732.99,732.99`

17.4.7 BITS

`BITS` sets the number of bits per sample for each baseband channel. If any channel is not specified, it will be set to the first. Since an experiment will typically use the same number of bits per sample for all channels, it is usually only necessary to specify one value.

If `BITS` is `2`, the first magnitude bit is placed on assigned track plus 8 for `FORMAT = VLBA1:4`, on assigned track plus 4 for `FORMAT = VLBA1:2`, and on assigned track plus 2 for `FORMAT = VLBA1:1`.

Argument: An array of integers, one for each baseband channel.

Options: `1` or `2`

Default: `1` for all baseband channels if none are set. Same as baseband channel 1 if one or more are set.

Usage: Defaults to previous station.

Example: `BITS=1`

17.4.8 DUALX

`DUALX` is a switch to turn on the mode where the B and D IFs are both assigned to RCP at 4 cm, but with separate first LOs. IF B uses `SYNTH` 1 while IF D uses `SYNTH` 3. This allows more than 500 MHz to be spanned instantaneously in this band and is used for geodetic and astrometric observations.

Argument: None.

Options: Do or do not specify.

Default: B is RCP, D is LCP and both use `SYNTH` 1.

Usage: Defaults to previous station.

Example: `DUALX`

17.4.9 ELCOLIM

`ELCOLIM` specifies the elevation colimation offset to be added to the one used by the VLBA on-line computers. It can be used to adjust the VLBA pointing.

Argument: A pointing offset in arc minutes.

Options: Any real number.

Default: `0.0`

Usage: Defaults to previous station.

Example: `ELCOLIM=1.2`

17.4.10 FE

`FE` gives four front end specifications for VLBA antennas, one for each IF (A, B, C, and D). Note that the 2cm front end on the VLBA has 4 filters; the on-line system chooses which to use based on the frequency of baseband channel 1, with the dividing points for the filter choice are 12.9, 13.9, and 14.9 GHz. `FE = omit` may be specified to cause a channel not to be used.

Argument: A character string containing one of the options.

Options: For elements 1 or 3: `20cm`, `13cm`, `6cm`, or `7mm`. For elements 2 or 4: `90cm`, `50cm`, `4cm`, `3cm`, `2cm`, `1cm`, or `omit`.

Default: `0` - should be specified.

Usage: Defaults to previous station if none are specified. If any are specified, only the new values are used.

Example: `FE(1)='20cm' FE(3)='20cm'`

17.4.11 FEFILTER

`FEFILTER` specifies the VLA front end filter. Some options are: `'0000'` - 50 MHz. `'1111'` - 25 MHz. `'2222'` - 12.5 MHz. These are used to help avoid RFI especially at the lower frequencies. They are centered or close to the normal 50-MHz band. Anyone using these should understand the VLA system well.

Note that, if any of `FLUKEA`, `FLUKEB`, `VLAFEAB`, `VLAFECD`, `VLASYNA`, `VLASYNB`, `VLAIF`, `FEFILTER`, or `VLAROT` are specified, both LO and FI cards will be made. In such cases, any other parameters allowed to default will be set to the standard value for the specified `VLABAND`.

Argument: A four character string.

Options: `'    ', '0000', '1111', and '2222'.`

Default: Takes VLA default for the specified band.

Usage: Defaults to previous station.

Example: `FEFILTER='1111'`

17.4.12 FIRSTLO

`FIRSTLO` gives the LO sum for each baseband channel for all mixes other then the one that will be set if `FREQ` or `DOPPLER` is specified. For most stations, this is for use by SCHED only; it is not written to the output file. However for stations that use VLBA control files, but are not proper VLBA stations, it will be written in a parameter that passes the information to the logging and correlator systems so that they can figure out the observing frequency. Please see `FREQREF` for a discussion of required parameters. If a value is not specified for a channel, it will be set to the first. Since most observations use the same firstlo for all channels, it is usually only necessary to specify one.

For the VLBA: For frequencies below 16 GHz this is just the front end synthesizer as specified by `SYNTH`. For 1 cm, it is the sum of synthesizers 2 and 3. For 7 mm, it is the sum of synthesizer 1 and 3 times synthesizer 3. For 4 mm, it is the sum of synthesizer 1 and 6 times synthesizer 3. At 90cm the value should be -500.0 MHz to make any frequency calculations come out right; that mix is an up-convert.

For the VLA, use the following equations:

20, 6, and 1 cm — FIRSTLO = F1 + F6 + 900 + FA - 600

4 and 2 cm — FIRSTLO = F1 - F6 - 900 - FA + 600

7mm — FIRSTLO = F1ab - F1cd + F6 + 900 + FA - 600

For the BD VLA channels, substitute 800 + 2*FB for the 900 + FA where:

F1 = VLAFEAB(LS)*1000 for VLA A and B channels.

F1 = VLAFECD(LS)*1000 for VLA C and D channels.

F6 = VLASYNA(LS) for VLA A and C channels - not rounded.

F6 = VLASYNA(LS) for VLA B and D channels - not rounded.

FA = FLUKEA(LS) AC Fluke setting.

2*FB = FLUKEB(LS) BD Fluke setting (usually FA + 100).

F1ab = VLAFEAB(LS)*1000, F1cd = VLAFECD(LS)*1000

If the VLA frequency parameters are set, SCHED will calculate the `FIRSTLO` that will be provided by these frequencies and compare it with the `FIRSTLO` given by the user. If the match fails, SCHED will complain and abort. SCHED also checks that each synthesizer setting conforms to the rules required by that piece of hardware.

Argument: An array of frequecies in MHz.

Options: Any valid LO sum.

Default: `0` - must specify at least baseband channel 1 if `FREQ` or `DOPPLER` is used. Any other unset baseband channels will be set equal to baseband channel 1.

Usage: Defaults to previous station.

Example: `FIRSTLO = 2400, 2400`

17.4.13 FLUKEA and FLUKEB

FLUKEA and FLUKEB are used to set the VLA fluke synthesizer frequencies. See the discussion of FIRSTLO for more details on what this does to the observing frequency. The numbers to give are the numbers for the "//FI" card in the VLA observe file, which is twice the actual synthesizer setting for FLUKEB but is the frequency mixed with the data. To get the same frequency on the VLA's AC and BD IFs, make FLUKEB equal FLUKEA plus 100.00.

Note that, if any of FLUKEA, FLUKEB, VLAFEAB, VLAFECD, VLASYNA, VLASYNB, VLAIF, FEFILTER, or VLAROT are specified, both LO and FI cards will be made. In such cases, any other parameters allowed to default will be set to the standard value for the specified VLABAND.

Argument: A real number giving the frequency in MHz.

Options: FLUKEA: Values between about 100 and 150. FLUKEB: Values between about 200 and 250.

Default: The VLA default for the band is used.

Usage: Defaults to previous station.

Example: FLUKEA=102.11 FLUKEB=202.11

17.4.14 FLUKESET

FLUKESET specifies which set of Fluke synthesizers to use at the VLA. Usually this should be 1 for phased array or normal VLA observations and 2 for single antenna VLBI. The VLA operators should be warned to check this in case the normal pattern is not being followed. The default 0, written as blank, may usually be best. Let the VLA operator select the flukeset.

Argument: Integer.

Options: 1 or 2.

Default: 0 - written as blank.

Usage: Defaults to previous station.

Example: FLUKESET=1

17.4.15 FORMAT

FORMAT is used to specify the tape recording format. Options are:

VLBA formats - VLBA type systems only:
VLBA - Let SCHED choose the fan out.
VLBA1:1 - 1 bitstream on 1 tape track. VLBA format.
VLBA1:2 - 1 bitstream on 2 tape tracks (fan out).
VLBA1:4 - 1 bitstream on 4 tape tracks (fan out).
VLBA2:1 - 2 bitstreams on 1 tape track (fan in).

VLBA4:1 - 4 bitstreams on 1 tape track (fan in).
MKIV formats - Mark IV systems only:
MKIV - Let SCHED choose the fan out.
MKIV1:1 - 1 bitstream on 1 tape track. Mark IV format.
MKIV1:2 - 1 bitstream on 2 tape tracks (fan out).
MKIV1:4 - 1 bitstream on 4 tape tracks (fan out).
MKIV2:1 - 2 bitstreams on 1 tape track (fan in).
MKIV4:1 - 4 bitstreams on 1 tape track (fan in).
MARKIII format - Mark III and VLBA systems.
MARKIII - Mark III tape format. No fan in or out.
S2 - Canadian S2 record systems.
S2 - All S2 recordings.
Others:
MARKII - No action. Use for Mark II and single dish.
NONE - No tape to be used, as for pointing.

Note on track assignments: Track assignments are an easy thing to get wrong. SCHED will make track assignments automatically for some modes if they are not specified in the setup file. Most users should take advantage of this facility. Automatic track assignments will be made for MARKIII modes with 1 bit only, and for VLBA1:1, VLBA1:2, and VLBA1:4 modes with 1 or 2 bits. The barrel roll is on by default (can be controlled with BARREL) in VLBA modes and off in MARKIII mode. The roll is within 8 or 16 track groups, advancing one track for each frame.

For the fan in modes, VLBA2:1 and VLBA4:1, give the same track assignment to 2 or 4 channels. These modes have not yet been tested. In the fan in modes, if there are 2 bits per sample, the two bits will be put on the same track so there will be one channel per track for VLBA2:1 mode and two channels per track for VLBA4:1 mode.

For the fan out modes, VLBA1:2, VLBA1:4, MKIV1:2, and MKIV1:4, give the first track assignment for the baseband channel. Sequential formatter track assignments are used for the other tracks associated with that baseband channel. The resulting recorder track assignments are then given below:

VLBA1:2, MKIV1:2:
forward, track for 1st bit - 3 7 11 15 19 23 27 31
forward, track for 2nd bit - 5 9 13 17 21 25 29 33
reverse, track for 1st bit - 2 6 10 14 18 22 26 30
reverse, track for 2nd bit - 4 8 12 16 20 24 28 32
VLBA1:4, MKIV1:4:
forward, track for 1st bit - 3 11 19 27
forward, track for 2nd bit - 5 13 21 29
forward, track for 3rd bit - 7 15 23 31
forward, track for 4th bit - 9 17 25 33
reverse, track for 1st bit - 2 10 18 26
reverse, track for 2nd bit - 4 12 20 28
reverse, track for 3rd bit - 6 14 22 30
reverse, track for 4th bit - 8 16 24 32

Note that MkIII modes on MkIV telescopes are currently (Feb 1997) not supported in PCFS or SCHEDVEX.

Argument: Text string of up to 8 characters.

Options: See above text. Anything else will cause SCHED to abort.

Default: None - must be specified.

Usage: Defaults to previous station.

Example: `FORMAT=MARKIII`

17.4.16 `FREQOFF`

`FREQOFF` gives the increment to the LO sum for the baseband channel in MHz. This will only be used if `FREQREF` is used. The LO sum for baseband channel `i` will be set to `FREQREF(i)` plus `FREQOFF(i)`, and `BBSYN` will be set to the absolute value of the difference between the LO sum and `FIRSTLO`. Please see `FREQREF` for a discussion of required parameters.

Argument: Up to 16 frequencies in MHz.

Options: Any valid frequency offset that gives a `BBSYN` in the allowed range.

Default: `0.0` - no offset.

Usage: Defaults to previous station.

Example: `FREQOFF=-6.,-4.,-2.,0.,2.,4.,6.`

17.4.17 `FREQREF`

`FREQREF` is the LO sum to use for the baseband channel in MHz. `FREQOFF` will be added to it. The LO sum is the sum of the `FIRSTLO` plus or minus, depending on sideband, the BBC synthesizer setting `BBSYN`. A `FREQ` specification in the SCHED keyin file will override `FREQREF` plus `FREQOFF`, as long as the BBC settings stay within range and there are no sideband changes.

To set pulse cals properly and to deal with non-VLBA stations correctly, it is best to know all of the LO sum, the first LO, and the BBC settings, along with all of the required sidebands. Strictly speaking, valid VLBA schedules can be written without knowing all these, but SCHED can be made significantly simpler and more reliable if all this information is required. Not all of these values need to be specified since they are related. There are four possible complete combinations, and if more values are specified than necessary then a consistency check will be done. These complete combinations are:

1. `FREQREF` plus `FREQOFF`, `FIRSTLO`, `NETSIDE`
2. `FREQREF` plus `FREQOFF`, `FIRSTLO`, `SIDEBAND`
3. `BBSYN`, `SIDEBAND`, `NETSIDE`, `FREQREF` plus `FREQOFF`
4. `BBSYN`, `SIDEBAND`, `NETSIDE`, `FIRSTLO`

Argument: Up to 16 frequencies in MHz.

Options: Any valid frequency.

Default: `0.0` for `FREQREF(1)` which means don't use it. For baseband channels 2 and higher, will be set to `FREQREF(1)`.

Usage: Defaults to previous station.

Example: `FREQREF = 1662.49`

17.4.18 FRSWITCH

`FRSWITCH` is a switch that turns on frequency switching. If specified, a second group of synthesizer settings should be given in `BBSYN2`. This is used for VLBA files only. In fact, the program will die if frequency switching is attempted when a VEX output file is required.

In general, frequency switching is probably better handled with a scan loop.

Argument: None.

Options: Do or don't specify it.

Default: Not set.

Usage: Defaults to previous station.

Example: `FRSWITCH`

17.4.19 IFCHAN

`IFCHAN` is used to specify the IF channel attached to each baseband channel for VLBA observations using VLBA data aquisition systems. For the VLBA, it should be `A` or `C` for 20, 13, or 6cm. For 90, 50, 4, 3, 2, or 1.3cm, it should be `B` or `D`. `A` and `B` are RCP; `C` and `D` are LCP. If `DUALX` is specified, both `B` and `D` are RCP. As an alternative, `R` or `L` can be specified. Then if `RCHAN` and `LCHAN` are specified in the setup files, `IFCHAN='R'` will be replaced with `RCHAN` and `IFCHAN='L'` will be replaced with `LCHAN`. If a bad `RCHAN` or `LCHAN` value is specified, SCHED will then complain about a bad `IFCHAN` specification.

1N, 1A, 2N, 2A are allowed values for MkIV telescopes. See `BBC` and the frequency file parameter `IFNAME` for more details.

Argument: An array of up to 16 characters of length 1.

Options: `A`, `B`, `C`, `D`, `R`, or `L`.

Default: None - should specify.

Usage: Defaults to previous station.

Example: `IFCHAN=A,C,A,C,A,C,A,C,A,C,A,C`

17.4.20 IFDIST

`IFDIST` specifies the attenuation to apply in the IF distributers. There is one value for each of the four IFs. This is only used to attenuate the signals from solar observations or to select alternate inputs, for example, for mm observations at VLBA sites with links to other antennas.

This currently (Feb. 1997) is not implemented for VEX files.

Argument: A character string of up to 3 characters. The integers `0` and `20` are also acceptable.

Options: `0`, `20`, `'A'`, `'20A'`, or `'A20'` but nothing else. `0` - normal input, no attenuation. `20` - normal input, 20db attenuation. `A` - alternate input, no attenuation. `20A` and `A20` - alternate input, 20db attenuation.

Default: `0`

Usage: Defaults to previous station.

Example: `IFDIST=0,0,'A',0`

17.4.21 `LCHAN` and `RCHAN`

`LCHAN` specifies the `IFCHAN` to use if `IFCHAN='L'` as in LCP. `RCHAN` serves the same purpose for RCP. If an invalid argument is used, SCHED will complain that `IFCHAN` is bad. This allows IFCHAN to be specified by polarization which is more meaningful to the observer. It also makes it easier to deal with antennas, such as the VLA, that might have different IF assignments than the VLBA.

Argument: A single character.

Options: `A`, `B`, `C`, or `D`

Default: None. Must specify if `IFCHAN='L'`.

Usage: Defaults to previous station.

Example: `LCHAN=A RCHAN=C`

17.4.22 `LEVEL`

`LEVEL` specifies the setting of the attenuators in the base band converters (BBCs). Values between `-1` and `256` can be used. If `-1` is set, the autoleveling will be activated. If `256` is set, the value from the previous scan will be used, thereby locking in an autolevel value for, for example, pointing. Any value in between sets a specific attenuation, but such values are rarely used. Only one value is accepted but SCHED writes that value out separately for each baseband channel.

This currently (Feb. 1997) has no effect on the VEX file.

Argument: An integer giving the level setting.

Options: `-1` to `256`. See above.

Default: `-1`

Usage: Defaults to previous station.

Example: `LEVEL=-1`

17.4.23 LOGGING

LOGGING specifies the type of logging to be done on the VLBA. STANDARD is appropriate for normal observations of almost any kind. POINTING is for pointing observations, although current pointing observations actually use STANDARD. NONE causes the system to do only the same background monitoring that is done when the antenna is idle. SPECIAL or a specific file name uses a special list of monitor points and logging intervals provided by the VLBA operators. If one of these special files is used, it is wise to put a comment in the experiment cover information that the special logging file is needed. Someone (PI or analyst) should add this to the operators questionnaire. STANDARD, NONE, and POINTING are not case sensitive. Any special file name must match in case the name of the file loaded at the sites. Contact the chief VLBA operator to get special files made.

One of the uses of this system is to allow monitoring of system temperatures at very short intervals. Monitoring at 5 second intervals is ok with the STANDARD logging. For 2 second points, a special file is available called dblog2.

This has no effect on the VEX file.

Argument: Character string - special file names are case sensitive.

Options: STANDARD, NONE, POINTING, or the name of a special logging file that the operators have put at the stations.

Default: STANDARD

Usage: Defaults to previous station.

Example: LOGGING = 'dblog2'

17.4.24 LCP50CM and RCP50CM

LCP50CM and RCP50CM controls the LCP and RCP narrow-band (609 to 613 MHz) filter in the 50cm system on the VLBA. BROAD means do not use the filter, while NARROW means use it. This band is in the UHF TV bands (channel 37) and at some sites the RFI without the filter is so bad that the system will saturate, even for the 90cm system (since the IF will saturate). The filter should be used if at all possible.

Argument: Character string.

Options: BROAD or NARROW

Default: NARROW

Usage: Defaults to previous station.

Example: LCP50CM = BROAD RCP50CM = BROAD

17.4.25 NCHAN

NCHAN gives the number of baseband channels. A baseband channel is the smallest unit that was once an analog signal. One sideband from one BBC is a baseband channel. Nothing prevents the user from assigning several channels to the same BBC/sideband. In such cases, the data in the two channels will be identical.

Argument: An integer.

Options: Any integer between `1` and the maximum number of channels which on the VLBA is `16`.

Default: `0` - it should be specified.

Usage: Defaults to previous station.

Example: `NCHAN=14`

17.4.26 NETSIDE

`NETSIDE` gives the net sideband. Usually to be used in conjunction with `FREQREF` and `FIRSTLO`. If `SIDEBAND` is not set to `U` or `L`, it will be set based on `NETSIDE` and the frequency settings. Please see `FREQREF` for a discussion of required parameters.

Sched will attempt to make a default for `NETSIDE` if it is not specified. The default will depend on the number of channels in the setup file and the number of BBC's available at the station. All upper sideband will be specified if possible. Upper/lower pairs will be specified otherwise (not in Mark III mode). This defaulting will not be attempted if `SIDEBAND` is specified (might generate conflict) or if `FREQREF` is absent (frequency might end up inconsistent with defaults).

Argument: An array of up to 16 single characters.

Options: `U` or `L`. Otherwise will not be used.

Default: `0` - defaulted or determined from other parameters.

Usage: Defaults to previous station.

Example: `NETSIDE=U,L,U,L,U,L,U,L`

17.4.27 NOISE

`NOISE` is the specification for each IF of the switching mode of the noise cals on the VLBA. The usual for VLBI is `'low-s'` which means that the low noise cal, about 3 K, is switching continuously at 80 Hz for continuous system temperature measurements, while `'low-c'` means low continuous. `'high-s'` and `'high-c'` are the same requests for the high (solar) cals; beware that most receivers do not have solar cals.

This has no effect on the VEX file.

Argument: 4 character strings of up to 6 characters each, one for each IF.

Options: `'off'`, `'low-s'`, `'low-c'`, `'high-s'`, `'high-c'`

Default: `0` - should be specified.

Usage: Defaults to previous station.

Example: `NOISE='low-s','low-s','low-s','low-s'`

17.4.28 `PERIOD`

`PERIOD` gives the integration time for detected powers in the base band converters (BBCs). One value is accepted here although SCHED will write that value out separately for each baseband channel. It would be ideal to set this to 30 seconds or so, but this time is also used for the auto-leveling time constant so it should be significantly less, with values of `1` or `2` typical. A value of `0` implies do not integrate beyond the 1/80 sec cal cycle time.

> **Argument:** An integer giving the integration time in seconds.
>
> **Options:** Any integer `0` or greater.
>
> **Default:** 1
>
> **Usage:** Defaults to previous station.
>
> **Example:** `PERIOD=2`

17.4.29 `PCAL`

`PCAL` sets the mode of the pulse cal generator on the VLBA. Note that this can also be controlled from the main schedule. Most setup files will set this to the 1 MHz setting. If it should be turned off, as for spectral line observations which might be confused by the presence of the tones, it is likely that the user will want it on for some scans (calibrators, for example) and off for others. In such cases, it is most convenient to control it from the main schedule.

This currently (Feb 1997) cannot be controlled by means of the VEX file. Most MkIV stations only support "1MHz" or "off". Around the EVN, 1 MHz insertion is the default and switching it off is a manual operation that must be brought to the attention of the local Friend of VLBI.

> **Argument:** 4 characters - see options.
>
> **Options:** `'    '` - use default `'1MHz'`. `'off'` - turn off pulse cal generator. `'1MHz'` - generate tones every 1 MHz. `'5MHz'` - generate tones every 5 MHz.
>
> **Default:** `'    '`
>
> **Usage:** Defaults to previous station.
>
> **Example:** `PCAL='5MHz'`

17.4.30 `PCALFR1` and `PCALFR2`

There are 16 pulse cal detectors in the VLBA formatters, each with the ability to detect signals from 2 bit streams. Each can be set to detect a tone at a different frequency at any multiple of 10 kHz in the baseband. `PCALFR1` and `PCALFR2` are arrays of 16 frequencies in kHz for the 16 detectors. *ACTUALLY, UNTIL A FORMATTER UPGRADE IS COMPLETE, THERE ARE ONLY 8 DETECTORS.* If a frequency of `0` is given, the detector will be used to count bits in each state. `PCALFR1` applies to the first channel of the detector, while `PCALFR2` applies to the second; they need not be the same. SCHED is capable of setting PCALFR1, PCALFR2, PCALXB1, and PCALXB2 automatically, and this is probably the option that most users should take. SCHED will use the automatic settings if PCALXB1(1) is not set. If the PCALFR and PCALXB values are defaulted, they will be adjusted on a scan by scan basis for any changes in observing frequency, including those requested by FREQ or DOPPLER in the SCHED keyin file.

The default will be to set up all available channels to detect, using sign bits only, first tone near the lower edge of the band in each channel, then a second tone near the high edge of the band in each channel, and then state counts (sign and magnitude for 2 bit data) for each channel, then a third tone which is (usually) 1 MHz away from the first tone being detected. As many of these tones will be detected as possible up to a total number of detected signals that does not exceed the number of available detectors.

There is usually no problem with setting the PCALFR and PCALXB parameters when PCAL is off, so there is usually no need to turn off this default. The one exception would be if the frequencies are being switched rapidly in such a way that the PCALFR frequencies are changing. Each time they are changed, the formatter is reconfigured, which blocks data output to the tapes for up to about 15 seconds. To prevent this, specify the pulse cal detector parameters and they will be kept constant.

Detection of Phase cal is not currently (Feb 1997) implemented on the PCFS, although the VEX file has a way of specifying the desired detection. On MkIV telescopes this requires the installation of additional hardware, but even on PCFS controlled telescopes with VLBA hardware this is not yet supported.

Argument: An array of 16 integers, each giving a frequency in kHz.

Options: Any multiple of 10 from 0 to 16000.

Default: See above.

Usage: Defaults to previous station.

Example: PCALFR1=10,10,10,10,7010,7010,7010,7010

17.4.31 PCALXB1 and PCALXB2

PCALXB1 and PCALXB2 determine what the pulse cal detectors measure. There are 16 pulse cal detectors in each formatter and 1 formatter at each VLBA station. (*FOR NOW, THERE ARE ONLY 8 DETECTORS AT EACH STATION*) Each detector can process two bit streams. In each bit stream, either counts of bits can be determined (PCALFR1=0) or a pulse cal tone can be detected. If the two bit streams are from the same (2 bit) channel, and the frequency is the same for both detectors (PCALFR1 and PCALFR2 the same), the results will be combined for a single measured amplitude and phase. The arguments are treated as character strings. They begin with a letter indicating whether to look at the sign (S) or the magnitude (M) bit. The letter is followed by a number to indicate the channel from which the bits are to come. PCALXB1 specifies the source of the first bit stream for each detector, while PCALXB2 specifies the source of the second bit stream. "Channel number" means the same quantity that is used as the index for most setup parameters. A detector can be turned off by specifying 'off'.

Most users should not need to worry about setting the pcal detection parameters.

SCHED defaults to a reasonable set which is described in the section on `PCALFR1` and `PCALFR2`.

Argument: An array of up to 16 character strings specifying Sign or Magnitude bit and the channel number.

Options: `S1`, `S2`, ... `S16`, `M1`, `M2`, ... `M16`, or `off`

Default: See `PCALFR1` and `PCALFR2`.

Usage: Defaults to previous station.

Example: `PCALXB1=S1,S2,S3,S4,S5,S6,S7,off`, which could be used to measure 1 tone in each channel of a Mark III mode E observation.

17.4.32 `POL`

`POL` is used to specify the polarization of a channel. This may be used when asking SCHED to set a lot of defaults. Or it may be used to tell SCHED the polarization in cases where it is not clear from other inputs. Such cases arise when `RCHAN`, and `LCHAN` are not used AND the setup does not correspond to one in the frequency catalog..

`POL` should be `RCP, LCP,` or `DUAL`. One value per channel can be given. Any channels not set will default to the same value as the first so it is usually sufficient to just specify one value. If `POL = DUAL` for the first channel, SCHED will set alternate channels to `RCP` and `LCP`.

Argument: An array of polarization specifications, one per channel.

Options: `RCP`, `LCP`, or `DUAL`

Default: Will try to set based on other inputs or frequency catalog.

Usage: Defaults to previous station.

Example: `POL=DUAL`

17.4.33 `PTINCR`

`PTINCR` is used to set the step size for pointing patterns on the VLBA in arc minutes. A 10-point pattern is used with off, half-power, on, half-power, and off positions in azimuth, and then in (?) declination. `PTINCR` gives the offset between the on and the half-power positions.

Argument: A real number giving the offset in arcmin.

Options: Any number but it should be near 1/2 of the FWHM of the beam.

Default: `0` - not too useful.

Usage: Defaults to previous station.

Example: `PTINCR=4.0`

17.4.34 SAMPRATE

SAMPRATE is used to set the sample rate in million samples per second. Only one value is used for all baseband channels. This is usually, but not always, twice the baseband bandwidth specified with BBFILTER. Not used for Mark II.

If not specified, twice the maximum bandwidth will be used, if BBFILTER was specified.

Argument: Sample rate in million samples per second.

Options: 0.25, 0.5, 1, 2, 4, 8, 16, or 32

Default: 0 - Default from BBFILTER

Usage: Defaults to previous station.

Example: SAMPRATE=4

17.4.35 SIDEBAND

SIDEBAND is used to specify the baseband converter (BBC) sideband for each channel. This may not be the same as the net sideband if the first mix is lower sideband, as for the VLBA it always is at 20cm and 13cm and can be at other bands. Please see FREQREF for a discussion of required parameters.

Argument: A single character for each baseband channel.

Options: U or L

Default: 0 - must specify.

Usage: Defaults to previous station.

Example: SIDEBAND=U,L,U,L,U,L,U,L

17.4.36 STATION

STATION gives the names of the stations for which this group of setup parameters applies. SCHED deals with multiple stations by expanding the input group out into a separate group for each station specified. This allows the defaults picked up later, for example from the frequency catalog, to be station dependent. Therefore, if only using very generic inputs, one can lump the stations together even if their final parameters are different.

There are two defaults allowed, VLBA and DEFAULT. The program first looks for a perfect match to the station. If it finds one, it uses that setup group. If not, it checks whether the station is a VLBA station (first 4 characters in the station name are VLBA) and whether there was a station=vlba specified. If both conditions are met, SCHED uses the parameters from the vlba group. If that does not help, SCHED checks whether there was a station=default specified. If so, it uses that setup group, but issues a warning that it is doing so. This should be useful mainly for Mark II and for experiment planning. If there was no station=default and there was no better match, SCHED complains and dies. Generally, station=default should not be used.

Argument: Up to 30 station names of up to 8 characters each.

Options: Any valid station names. `'VLBA'` will match any VLBA station.

Default: None.

Usage: ??? Defaults to previous station.

Example: `STATION='VLBA_PT'`

17.4.37 STRING1, STRING2, STRING3, and STRING4

`STRING1`, `STRING2`, `STRING3`, and `STRING4` are 80-character string that will be placed in the VLBA control file without modification. This allows for new scheduling parameters provided by the on-line group to be used before they get properly built into SCHED. Comments could be passed this way by preceeding them "!*" and following them with "*!".

Argument: Any 80 character string.

Options: It just needs to be understood by the on-line system.

Default: Blank - not passed to VLBA control file.

Usage: Defaults to previous station.

Example: `STRING1=' !* Special scan *!'`

17.4.38 SWTCHDUR

For frequency switched observations, with `FRSWITCH` set, `SWTCHDUR` gives the time spent on each switch cycle. The scan must be long enough to allow a full scan setup. 15 seconds is probably the minimum reasonable switch time. For observations to be processed on Mark III correlators, there are additional restrictions on the possible integration times; multiples of 5 seconds are OK, as are some other times.

Argument: An integer number of seconds.

Options: Any integer. `15` is typical.

Default: `0` - specify it if `FRSWITCH` set.

Usage: Defaults to previous station.

Example: `SWTCHDUR=15`

17.4.39 SYNTH

`SYNTH` is a 3 element array of frequency settings for the three 2-16 GHz synthesizers for the VLBA. This is the LO for the first mix. After this mix (or 2 mixes for 1.3cm and 7mm), the signal must be in the 500-1000 MHz IF band.

Argument: 3 frequencies in GHz.

Options: N*500 +- 100 MHz and between 2 and 16 GHz.

Default: `0` - should be specified.

Usage: Defaults to previous station.

Example: `SYNTH=15.9,4.1,15.9`

17.4.40 TPMODE

`TPMODE` sets the number of passes at each head index position. Allowed values are 1, 2, 4, and 8. For these cases, a maximum of 32, 16, 8, or 4 heads can be used at a time. `TPMODE=1` is appropriate for Mark III mode A, while `TPMODE=2` is used for Mark III mode B. Setups with different values of `TPMODE` may be specified for a station during an experiment, but SCHED will determine the lowest value specified for the station for the whole experiment and use that for all scans. Thus during the times when the setup calls for fewer heads than could be used with the minimum `TPMODE`, some tracks will be left blank. This wastes tape, but saves a great deal of complexity in keeping track of where data should be recorded on the tape. It is strongly advised that all setup files for a project use the same `TPMODE`. Note, however, that different stations can use different `TPMODES` without wasting tape.

The correct TPMODE can be determined from the `FORMAT`, the number of bits per sample (`BITS`), and the number of channels (`NCHAN`. Those parameters tell how many tracks are needed per channel and, multiplied by the number of channels, how many tracks are needed per pass. For VLBA formats, that total number of tracks is divided into 32 to get `TPMODE`. For Mark III, observations, the total number of heads available is normally 28, although the VLBA systems can record 32 tracks in Mark III format.

For S2 recorders `TPMODE` denotes the number of groups the S2 recorder can use in the desired recording mode. In other words it is the total number of recorders divided by the number of recorders implied by the mode. It must be consistent with the S2 mode implied by the number of channels and bandwidth to be record.

Argument: An integer.

Options: `1`, `2`, `4`, or `8`

Default: `0` - needed except for Mark II or pointing.

Usage: Defaults to previous station.

Example: `TPMODE=2`

17.4.41 TPSPEED

`TPSPEED` is an obsolete form that has been replaced by `TPSPEEDH` and `TPSPEEDL`. It will cause an error message to be written. The value given will be used for `TPSPEEDL`.

17.4.42 TPSPEEDH

`TPSPEEDH` tells SCHED the recording speed of the tape in inches per second when recording at high density. The low density record speed is specified with `TPSPEEDL`. SCHED uses this information to calculate where on the tape each scan is located, when to reverse direction, switch head assignments etc. The density at which the recording should be made is set by the `DENSITY` parameter in the tape initialization inputs.

TPSPEEDH and TPSPEEDL will default to the correct values for tapes written on VLBA, Mark III, Mark IV and S2 systems. It should not be necessary to specify them and it is probably safer not to do so. For S2, specify a number for the tape length that is the number of seconds of playing time. For TPSPEEDH/L, use 12 ips, which is the default.

The speeds currently in use are:

67.5 ips for low density Mark III/IV at 2 Msamp/s per track.

135 ips for low density Mark III/IV at 4 Msamp/s per track — the "normal" speed.

270 ips for low density Mark III/IV at 8 Msamp/s per track — the "double" speed.

66.665 ips for low density VLBA format at 2 Mbits/s per track (with fan out etc, this may not be the sample rate).

133.33 ips for low density VLBA format at 4 Mbits/s per track.

266.66 ips for low density VLBA format at 8 Mbits/s per track.

40 ips for high density Mark III/IV and VLBA format at 2 Mbits/s per track (with fan out etc, this may not be the sample rate).

80 ips for high density Mark III/IV and VLBA format at 4 Mbits/s per track.

160 ips for high density Mark III/IV and VLBA format at 8 Mbits/s per track.

320 ips for high density Mark IV format at 16 Mbits/s per track — the "double–double" speed. This is not yet supported.

4.2 ips for S2 format on high density recordings. The S2 speeds are fictitious values that make the times come out right.

6.3 ips for S2 format on low density recordings.

The VLBA and VLA start using high density on all thin tapes on about 1 May 1996.

Note that the recording speed determines the speed up factor on playback. All playback on the VLBA correlator is done at the higher speed (160, 266.66 or 270 ips). Projects recorded at less than the highest speed will play back in less than real time. It is important that a reasonable fraction of projects have a speed up factor of more than unity or the correlator will not be able to keep up with observing.

The VLBA control file only specifies STOP, +RUN, -RUN, +REWIND, or -REWIND, and the on-line system deduces the speed to use from the format and samplerate. If SCHED has the values different from what the on-line system chooses to use, the direction and head position commands, along with tape changes, will be wrong and the project will be messed up.

Argument: A real number that is the tape speed in inches per second.

Options: Any of those listed above.

Default: Defaults to values listed above depending on recording mode.

Usage: Defaults to previous station.

Example: TPSPEED=80

17.4.43 TPSPEEDL

TPSPEEDL tells SCHED the recording speed of the tape in inches per second when recording at low density. See the discussion of TPSPEEDH for details.

> **Argument:** A real number that is the tape speed in inches per second.
>
> **Options:** Any of those listed in under TPSPEEDH.
>
> **Default:** Defaults as in list under TPSPEEDH — depends on recording mode
>
> **Usage:** Defaults to previous station.
>
> **Example:** TPSPEED=135

17.4.44 TRACK1, TRACK2, ... , TRACK7, and TRACK8

The TRACKn parameters are arrays of track specifications for use during the nth pass at a head position. One track is given for each baseband channel. For Mark III, there is a one-to-one correspondence between baseband channels and tracks so this makes sense. For Mark III observations, the VLBA track for a channel is just the Mark III track plus 3. For many VLBA modes, several tracks are used for each channel. In these cases, the first track used for the baseband channel is specified and the on-line system determines the rest. A fanned out channel uses adjacent tracks within the odd or even groups and the lowest VLBA track used for data is 2. For example, a 1:4 fan out channel uses tracks 2, 4, 6, and 8 for the low order bit. If 2-bit samples are used, tracks 10, 12, 14, and 16 would be used for those bits. In such a case, the only track mentioned in a TRACKn parameter is 2. If a fan-in mode is used, more than one channel should be given the same track specification. Fan-in modes are not yet tested or in use.

For modes VLBA1:1, VLBA1:2, VLBA1:4, Mark III mode B with ascending frequency order (alternating sidebands), and Mark III mode E, TRACK1 can be left out. All of the TRACKn commands will default to reasonable values. This is the recommended action for most users since track assignment is an easy area in which to make mistakes. SCHED will complain and stop if it does not know how to set the tracks for the requested mode. For the Mark III modes, extra baseband channels (2 for Mode B and 1 for Mode E) can be specified and will be put on the edge tracks that are not normally used for Mark III. For Mode B, they should follow the same alternating sideband pattern as the rest of the channels.

> **Argument:** One integer track specifications per channel.
>
> **Options:** Any integer between 2 and 33.
>
> **Default:** 0 which will trigger automatic assignments for many modes.
>
> **Usage:** Defaults to previous station.
>
> **Example:** TRACK1=4,18,6,20,8,22,10,24,12,26,14,28,16,30
> TRACK2=5,19,7,21,9,23,11,25,13,27,15,29,17,31
> This example is Mark III Mode B.

17.4.45 VLABAND

`VLABAND` is the band code for VLA projects, whether VLBI or VLA-only. For complete information on the standard bands, see the VLA Standard Bands section.

Here is a brief list bands not including those involving 75 MHz. One of the standard bands must be listed even if the frequency will be modified with other control parameters. This helps insure that all VLA setup files etc are correctly specified.

Argument: Text of 2 characters.

Options: `'VP'` - 90cm VLBI. `'VL'` - 18cm VLBI. `'VC'` - 6cm VLBI. `'VX'` - 4cm VLBI. `'VU'` - 2cm VLBI. `'VK'` - 1cm VLBI. `'VQ'` - 7mm VLBI. `'PP'` - 90cm VLA-only. `'LL'`, `'HH'`, `'18'` - "20cm" VLA-only. `'LP'` - Mixed 20cm and 90cm. `'CC'` - 6cm VLA-only. `'XX'` - 4cm VLA-only. `'UU'` - 2cm VLA-only. `'KK'` - 1cm VLA-only. `'QQ'` - 7mm VLA-only.

Default: None - required for VLA.

Usage: Defaults to previous scan.

Example: `VLABAND='VC'`

17.4.46 VLABW

`VLABW` specifies the bandwidth of each of the VLA's 4 IFs (ABCD). This is done with coded digits such that the bandwidth is `50/2**n` MHz where `n` is the digit used. For example, `VLABW='0202'` specifies that the AC IFs are at 50 MHz bandwidth and the BD IFs are at 12.5 MHz bandwidth. The digits are specified in a 4-character text which is copied to the VLA observe file. The default of `'0000'` is appropriate for most VLBI observations. The final baseband filters for VLBI at the VLA are in the VLBA DAS and not controlled by the VLA on-line computers.

Argument: Text of 4 characters, each of shich is a decimal digit.

Options: Each digit can be between `0` and `9`.

Default: Takes the VLA default for the specified band.

Usage: Defaults to previous scan.

Example: `VLABW='1414'`

17.4.47 VLAFEAB and VLAFECD

`VLAFEAB` is the VLA front end synthesizer for the A and B IFs (RCP). `VLAFECD` is the VLA front end synthesizer for the C and D IFs (LCP). See the discussion of the parameter `FIRSTLO` for more details. If specified, a "//LO" card will be written, and `VLAFECD`, `VLASYNA`, and `VLASYNB` will also be required. Note that, except at 7mm, `VLAFEAB` must be the same as `VLAFECD` — there is really only one synthesizer.

Allowed values for the front end synthesizer are (in GHz):

```
For 90 cm:       0.0
```

```
For 18-20 cm:   -3.2
For 6 cm:        0.0
For 4 cm         11.8, 12.2, 12.4, 12.8, 13.0, 13.4,
                 13.6, 14.0, 14.2, 14.6, 14.8, 15.2

For 1 and 2 cm:  16.7, 16.9, 17.0, 17.2, 17.3, 17.5, 17.6,
                 17.8, 17.9, 18.1, 18.2, 18.4, 18.5, 18.7,
                 18.8, 19.0, 19.1, 19.3, 19.4, 19.6, 19.7,
                 19.9, 20.0, 20.2, 20.3, 20.5, 20.6
```

Note that many of the above settings will not produce usable signals.

After conversion by one of the above frequencies, the upper sideband is kept at 90, 18-20, 6, 1.3 cm bands and the lower sideband is kept for the 3.6 and 2 cm bands. The resulting IF should fit within the 6 cm receiver band of 4500–5000 MHz (actually a 4355 to 5145 MHz filter). See `VLASYNA` and `VLASYNB` for more frequency constraints based on allowed values of the L6 synthesizer.

At 7 mm, `VLBFEAB` should be 3 times a valid value for the 1/2 cm synthesizer. `VLAFECD` should be a valid 4 cm value. The first value (51.6 is a typical one) will produce a lower sideband IF in the 4 cm part of the spectrum which is then fed to the 4 cm frequency conversion system.

Note that, if any of `FLUKEA`, `FLUKEB`, `VLAFEAB`, `VLAFECD`, `VLASYNA`, `VLASYNB`, `VLAIF`, `FEFILTER`, or `VLAROT` are specified, both LO and FI cards will be made. In such cases, any other parameters allowed to default will be set to the standard value for the specified `VLABAND`.

Argument: A frequency in GHz.

Options: See VLA documentation for details.

Default: Takes the VLA default for the specified band.

Usage: Defaults to previous station.

Example: `VLAFEAB=-3.2 VLAFECD=-3.2`

17.4.48 VLAIF

`VLAIF` gives the name of the VLA IF file that contains gain calibration and efficiency information.

Note that, if any of `FLUKEA`, `FLUKEB`, `VLAFEAB`, `VLAFECD`, `VLASYNA`, `VLASYNB`, `VLAIF`, `FEFILTER`, or `VLAROT` are specified, both LO and FI cards will be made. In such cases, any other parameters allowed to default will be set to the standard value for the specified `VLABAND`.

Argument: Up to 10 character file name.

Options: Any string.

Default: Uses VLA default for the specified band.

Usage: Defaults to previous station.

Example: `VLAIF = 'SYSLIF'`

17.4.49 VLAROT

`VLAROT` gives the name of the VLA ROT file that contains such things as control information for subreflector focus and rotation, collimation errors and control parameters for each frontend.

Note that, if any of `FLUKEA`, `FLUKEB`, `VLAFEAB`, `VLAFECD`, `VLASYNA`, `VLASYNB`, `VLAIF`, `FEFILTER`, or `VLAROT` are specified, both LO and FI cards will be made. In such cases, any other parameters allowed to default will be set to the standard value for the specified `VLABAND`.

Argument: Up to 10 character file name.

Options: Any string.

Default: Uses VLA default for the specified band.

Usage: Defaults to previous station.

Example: `VLAROT = 'VLBLROT'`

17.4.50 VLASYNA and VLASYNB

`VLASYNA` and `VLASYNB` give the VLA F6 synthesizer settings for the A and C IFs `VLASYNA` and for the B and D IFs `VLASYNB`. The value will be near 3900 MHz and must be N*50 +- 10.1 MHz. It will be rounded to the nearest MHz for the "//LO" card but should be given to full precision here to facilitate frequency calculations. The LO is passed through a filter that has the range 3435 - 4065 MHz. Allowed settings, some of which will not pass through this filter, are:

```
3310.1, 3339.9, 3360.1, 3389.9,   3410.1, 3439.9, 3460.1, 3489.9,
3510.1, 3539.9, 3560.1, 3589.9,   3610.1, 3639.9, 3660.1, 3689.9,
3710.1, 3739.9, 3760.1, 3789.9,   3810.1, 3839.9, 3860.1, 3889.9,
3910.1, 3939.9, 3960.1, 3989.9,   4010.1, 4039.9, 4060.1
```

There are actually even more allowed values at the low end, but it is not clear that it is possible to use them.

Note that, if any of `FLUKEA`, `FLUKEB`, `VLAFEAB`, `VLAFECD`, `VLASYNA`, `VLASYNB`, `VLAIF`, `FEFILTER`, or `VLAROT` are specified, both LO and FI cards will be made. In such cases, any other parameters allowed to default will be set to the standard value for the specified `VLABAND`.

Argument: A frequency in MHz.

Options: N*50+-10.1

Default: Uses the VLA default for the specified band.

Usage: Defaults to previous station.

Example: `VLASYNA = 3889.9`

18 INSTALLING SCHED

Each login under which SCHED is run should be set up so that the program can be run easily. On unix systems, this means adding the location of the executable to the PATH. It is also convenient to add an environment variable `SCHED` that points to the base location where SCHED related files are kept. In Socorro, it is best to do both by adding `setup_vlba` to your *.tcshrc.SunOS5* (or equivalent file for other shells). Of course, the addition to PATH is not needed if the user gives the full path of the executable. And the SCHED environment variable is not need if it is not used in SCHED input file names. This precludes the use of the default file names.

Of course, it is also necessary to have access to an executable version of SCHED. It is possible to install SCHED on a wide variety of computers. It is written in FORTRAN 77 using only a few common extensions from the standard. Development has occurred on a variety of machines including VAXes, PCs, and SUNs. Current development is done on a SUN Sparc Station under Solaris. The export version has been tested on SUN (Solaris), PCs under Linux using both f2c (fort77) and g77, Hp, SGI, IBM (AIX), and DEC Alpha. A big "thank you" to Franco Tinarelli at Bologna for performing many of these tests. Machine dependent code has been isolated in special subdirectories under the *src/Cit* code directory. All other FORTRAN files should compile without changes on a wide variety of machines. Note, however, that all current testing is under one or another flavor of unix. There has been no recent testing under other operating systems. This will only change if there is pressure to do so. Please inform Craig Walker at cwalker@nrao.edu if you install it on something else, including VMS or DOS/Windows - it's been many years since the last port to VMS or DOS, although both have served as the primary development environment for SCHED in the past.

The export version of SCHED is available from anonymous ftp at *ftp.aoc.nrao.edu* in subdirectory *pub/sched*. All required files for installing and running SCHED are contained in the compressed (gzip) tar file *sched.tar.gz*. Additional copies of the setups files are in the subdirectory *pub/sched/setups* for those who only need a few. In addition, the executable for SUN/SOLARIS is in the ftp area. Note that this executable may not be portable. It is our hope to eventually provide executables for many types of computers.

To install SCHED, the following steps can be followed:

environment and PATH: Set the environment variable SCHED to the base directory under which SCHED will be installed. Add the bin subdirectory to your PATH. This is an optional step, but will save effort and confusion later.

ftp the tar file: Use anonymous ftp to ftp.aoc.nrao.edu (user "anonymous", password should be your full email address). `cd` to pub/sched. Tell ftp to do a binary file transfer (type `binary`). Get *sched.tar.gz*. This file is very roughly 1.5 Mbytes so it will take a while to get with a slow modem. The tar file should be transfered to the base directory under which you wish to install SCHED. It is best if this is an otherwise empty subdirectory.

Uncompress: You will need the GNU zip utility to uncompress the tar file. This should be available on most systems. Type `gunzip sched.tar.gz` or `unzip sched.tar.gz`. GNU software is available by ftp from prep.ai.mit.edu.

Unpack the tar file: Type `tar -xvf sched.tar` .. This will unload all files from the tar file, creating the necessary subdirectory structure in the process. A *README* file will appear in the top level directory which contains useful information on the directory structure and on installing SCHED.

Compiling the programs: Follow the instructions in the *README* file. The current versions of the Makefile require the use of GNU make (often invoked with `gmake`), available by ftp from prep.ai.mit.edu), although this may change eventually. Check for GNU make on your system, it is installed on many. Note that you will need PGPLOT installed on your system to get the plotting capabilities of SCHED (see below for more information on getting PGPLOT). However there are stubs that can be used to bypass PGPLOT if necessary. SCHED will still be able to make schedules if the stubs are used, but it will not be able to make any plots. There are also stubs for the routines related to the JPL emphemeris and the VEX output, in case that code causes problems (observations of planets are probably only of interest for single-dish testing by the VLBA by staff). Using the stubs requires changing some comments in the *Makefile*.

Environment variable: It is useful under unix systems, and simplifies running the examples and running SCHED itself, if an environment variable `SCHED` is defined to point to the base directory under which SCHED was installed. The examples and the file name defaults use this environment variables to point to any catalogs etc that they need. If an example is used as a template for a user schedule written in some other directory, it will still find the catalogs.

Testing: The examples in the *examples* subdirectory can be used to test the code once it has been installed. A few outputs from each examples are stored in the *Stdout* subdirectory. For unix systems, the routine *Verify* can be used to run all the examples and compare results with those in *Stdout*. The output from *verify* will be in the file *testruns.out*. Any differences are in the output from diff. It is common to have differences in items such as source positions in the last significant figure. Different machines handle rounding differently. Such differences can be ignored.

Some VAX FORTRAN features that are commonly supported by other FORTRAN compilers remain in the code. Some of these can be removed using the (very old) program *vaxms* (contact cwalker@nrao.edu) or with "fct" on a CONVEX or "f77cvt" on a SUN (beware of bugs in f77cvt!). Preprocessing is not required on any of the machines under which SCHED is currently being tested. *vaxms* has not been exercized in a very long time.

Some non-standard features, including long variable names, remain in the program after processing with *vaxms*. All of the compilers used so far allow these features but they might cause trouble for other ports. Considerable use was made of the SLALIB (STARLINK) routines for precession, etc. These routines use long variable names so removing this non-standard feature would not be easy. (email permission to use the FORTRAN SLALIB routines has been obtained from P. Wallace).

If the code or any other files are moved from a unix or VMS machine to a machine using DOS, beware that the end of line characters are different. At least on a SUN (others?), a pair of utilities unix2dos and dos2unix can be used to fix the files. If DOS format input files or catalogs are given to a unix SCHED, it will abort.

As noted above, SCHED has plotting capabilities that utilize the PGPLOT graphics subroutine library. PGPLOT is not distributed with SCHED and will have to be obtained independently by anyone wanting to do plotting. There is extensive information on PGPLOT available from the WWW page at http://astro.caltech.edu/~tjp/pgplot/. PGPLOT is in common enough use at astronomy sites that it is likely to be installed somewhere at many institutions. If PGPLOT is not available, the stubs can be used for SCHED as described above.

We are always interested in hearing about people's experiences installing sched on various machines. If you have problems, or even success on machines other than those listed earlier, please let us know (email to cwalker@nrao.edu).

19 RUNNING SCHED

SCHED is currently being developed and tested exclusively on SUN SPARC stations. However, it was once supported on VAX, CONVEX and MS-DOS PC's. The coding style has not changed and FORTRAN is almost, but not quite, standard FORTRAN 77. It should work on a wide variety of machines.

19.1 Running SCHED on a VAX

To run SCHED on a VAX, make a VMS command file, called `INPUT.COM` for example, which begins with a VMS command that causes SCHED to be executed. For systems with a fully installed Caltech package, the command "$ SCHED" should work. Otherwise use a command of the form "$ RUN UMA3:[VPGM.CIT.VLB]SCHED", where you will need to substitute the correct directory specification. The command file should end with "$ EXIT", although this is not necessary. The SCHED command file is run by typing, for example,

```
@INPUT.COM
```

The files output by SCHED will appear in the default directory.

19.2 Running SCHED under UNIX

To run SCHED on a UNIX machine such as a SUN or a PC under LINUX, prepare the keyin file without system level commands. Then type, for example,

```
sched < input.key
```

Alternatively, if plotting is wanted, for example, type:

```
sched
* plot schedule=input.key /
```

where the SCHED executable file is assumed to be in the default directory or path and the SCHED input commands are in *input.key* in the default directory. The "<" pipes the information in *input.key* to SCHED. The "*" is the prompt from SCHED. Remember that, in UNIX, file names and commands are case sensitive. Also, there is a complication for users of the tc shell for versions after mid 1995: there is a built-in shell command "sched" that the shell takes instead of running SCHED. So to use SCHED, either alias "sched" to mean this program or else specify the full path name of the execute module. The files output by SCHED will appear in the default directory.

19.3 Running SCHED on an MS-DOS PC

To run SCHED on a PC (MS DOS), prepare the input file without system level commands. Then type, for example,

```
\CODE\SCHED\ < INPUT.KEY
```

where the SCHED.EXE executable file is assumed to be in the CODE directory (substitute whatever is correct for your system) and the SCHED input commands are in INPUT.KEY in the default directory. The "<" pipes the information in INPUT.KEY to the program (note the similarity to UNIX). The files output by SCHED will appear in the default directory.

20 DISTRIBUTION OF SCHEDULE FILES

Once SCHED has been used to make schedules for an observation, those files need to be sent to the stations, usually by way of a distribution center at NRAO or in Europe. When time for a project is allocated, instructions for how to accomplish this will be provided.

21 RELATED PROGRAMS

This section briefly describes other programs that may be of use when using SCHED.

UPTIME: Used to determine when sources will be visible from stations of interest. The plotting capabilities in SCHED partially duplicate the function of UPTIME, but, until they become more sophisticated, are not a complete replacement. UPTIME also does coordinate epoch conversions and Doppler calculations. For the latter, a velocity needs to be provided in the source catalog and a line frequency in the program input. The Doppler values will be for the center of the Earth, which is within 1 km/s for any station and is an appropriate value for VLBI observing.

SKEDCONV: Used to convert a SKED or drg file from a Mark III scheduling program into a SCHED keyin file. The resulting SCHED keyin file should be complete if all of the questions are answered properly. However a setup file will need to be provided. Special attention should be paid to the frequencies and track assignments when making the setup file.

PC-SCHED A program, written at Haystack Observatory, for scheduling Mark III projects. It is advertized to read a simple SCHED keyin file if that has already been made, but that is not its normal mode of operation. PC-SCHED writes a SKED or drg file that can be used by `DRUDG` to produce snap files for the Mark III stations. The SKED or drg file can also be converted with SKEDCONV to a SCHED keyin file for scheduling VLBA stations. DRUDG can produce VLBA control files and this ability is used by the geodetic community, but rarely by astronomers. The VLBA control files from PC-SCHED should not be used since that part of the program is out-of-date.

SKED The traditional scheduling program for Mark III. It produces SKED or drg files that are converted to snap files by DRUDG, but that can also be used, via SKEDCONV and SCHED or DRUDG, to schedule the VLBA. It has sophisticated automatic scheduling capabilities, well beyond what is available in the optimization modes of SCHED, for geodetic projects.

A SCHEDULING MARK II OBSERVATIONS

SCHED was originally written in about 1978 as the Caltech Package scheduling program for Mark II VLBI. Most Mark II observations done since then were scheduled with it. Now it seems that the program will outlast the system that it was designed to support. Mark II recording systems have been removed from most active VLBI stations and the main Mark II correlators are no longer operating. However, the system is not completely gone. An old Caltech correlator is being supported at Medicina and Mark II recording systems are being supported at a few places. For these reasons, the Mark II specific features of SCHED have not yet been removed.

Mark II observations typically use one of the Mark III or VLBA data aquisition system baseband converters (called video converters in the Mark III world). Therefore much of the setup information required for the wide band systems is also required for Mark II, although only for a single channel. A very few parameters are available that are only for Mark II and the descriptions of those parameters should be consulted. In the main program input, the only such parameter is `TPREF` which helps get the tape changes synchronized. In the tape initialization parameters, parameter `TPTIME` serves a similar purpose. The main schedule parameter `AUTOTAPE` has special meaning for Mark II observations. Other than these special cases, the parameters used for a Mark II project are essentially the same as for a wide band experiment. Of course, parameters related to control of the wide band tape systems are not needed.

Tape management for Mark II observations is simpler than for wide band observations. Normally the tapes are run continuously for 4 hours per tape and then changed, usually by hand. Correlator operators normally prefer is all tapes are changed at the same time, which can be arranged using `TPREF` or `TPTIME`. The schedule should have scan breaks at the tape change times (this will be forced by SCHED, so tape changes might be requested at odd times if scan breaks don't occur at the nominal 4 hour intervals.

Below is an example of a simple Mark II schedule. Be warned that this aspect of SCHED is not being maintained because Mark 2 is no longer available at most stations. Also, this example is not being tested with each release.

```
SIMPLE EXAMPLE
--------------------------------------------------------------------
    !   Cover information:
EXPT = 'Mark II, 3C345, May 1986'  ! Any description.
EXPCODE = 'C85G'                   ! Project code.
VERSION = 1                        ! Version 1 of schedule
PINAME = 'Craig Walker'            ! Principal Investigator's name.
ADDRESS1 = 'National Radio Astronomy Observatory'  ! Address
ADDRESS2 = 'P. O. Box O'                           ! Up to 4 lines.
ADDRESS3 = 'Socorro, New Mexico, 87801'
ADDRESS4 = ' U.S.A. '
PHONE    = '505 835 7247 '         ! Telephone number
OBSPHONE = '505 835 7247 '         ! Phone number during observations.
EMAIL    = 'Internet: cwalker@nrao.edu'   ! Electronic mail address.
FAX      = '505 835 7027 '         ! Phone number for FAX.
TELEX    = '910-988-1710 '         ! Telex number.
OBSMODE  = '6cm  Mark~II Standard Setup'  ! Observing mode.
CORREL   = 'Caltech'               ! Correlator to ship tapes to.
NOTE1    = 'You can put any comments you want to in these four lines.'
NOTE2    = ' More comments '
NOTE3    = ' More comments '
NOTE4    = ' Last of the comments'

!         Now the actual schedule information.
SRCFILE = sources.obs              ! Source catalog.
STAFILE = stations.dat             ! Station catalog.
SETUP   = nug6cm.set               ! Setup file.
YEAR = 1986  MONTH=5  DAY=11       ! Date of first stop time.
STATIONS=BONN,BOLOGNA,HSTK,NRAO,
         VLA,VLBA_PT,OVRO          ! Stations list
VLAMODE='VS'                       ! Required information for VLA
START = 02:00:00                   ! Start time in UT.
TPREF = 1::                        ! Control tape change times.
SOURCE = '3C345'                   ! Source name.
DUR = 30:00   REP = 8              ! 8 scans of 30 minutes each
/                                  ! End of first group of scans.
SOURCE='NRA0512'  DUR=30:00  /     ! One scan on another source.
SOURCE='3C345'  DUR=30:00 REP 9 /  ! 9 more scans on main source.
--------------------------------------------------------------------
```

Below is an example setup file for Mark II observations. This is the standard setup file *nug6cm.set* and contains the correct information for the VLBA and VLA, which no longer have Mark II recording equipment. For a real Mark II observations, the stations involved would have to be added.

```
---------------------------------------------------------------------
 EXAMPLE:   Setup file for Mark~II observations (1 channel) at 6cm.
 --------------------------------------------------------------------
! nug6cm.set
!      Setup file produced by MAKESETUP.
!      Modifications will be lost next time MAKESETUP is run.

nchan = 1  bbfilter = 2.0 format = MARKII
bbc = 1 netside = U
ifchan = L
!    Radio Astronomy allocation: 4990-5000
!    Radio Astnomomy footnote:   4950-4990
!    VLA 50MHz 4960.1 to 5010.1 with VC mode.
!        VLA 6cm receiver falling off at high end.
freqref  = 4990.99  !  Mark II network standard.
fe(1) = '6cm'   fe(3) = '6cm'   synth(2) = 4.1
firstlo  = 4100.00
station  = VLBA   rchan = A  lchan = C   /
firstlo  = 4360.10
station  = VLA1   rchan = B  lchan = D   /
station  = VLA27  rchan = A  lchan = C   /
firstlo  = 4260.0
station  = GB_VLBA  rchan = A  lchan = C  /
station = 'EB_VLBA'
fe(1)='6cm' fe(3)='6cm'
firstlo = 4100.0  rchan=A lchan=C  /
```

B HEAD POSITIONS and TRACK ASSIGNMENTS

This appendix describes the default track and head assignments used on the VLBA for projects scheduled using SCHED. These are *gory* details that most users should not need to be concerned about. Just let SCHED use its defaults and the observations should be ok.

The VLBA uses 14 head positions. Both the positions and the order in which they are used are the same for all projects. The head position for each index number are in the following table in microns.

```
            HEAD POSITIONS
--------------------------------------------
     Forward Passes      Reverse Passes
     Index   Offset      Index   Offset
--------------------------------------------
       1     -319          2       31
       3     -271          4       79
       5     -223          6      127
       7     -175          8      175
       9     -127         10      223
      11      -79         12      271
      13      -31         14      319
-------------------------------------------
```

All forward passes are to be written in the negative offset positions and all reverse passes are to be written in the positive offset passes. This ensures that nearly all adjacent tracks are in the same direction and minimizes the required guard bands.

The following tables give the head index position and the and the set of heads that are used for each pass for experiments using 1, 2, 4, and 8 passes per head position: Number: 1 2 3 4 5 6 7 8 9 10 11 12 13 14

```
            HEAD INDEX and HEAD SET for each PASS
---------------------------------------------------------------
 For 1 Pass Per Head Position:
   Passes 1 - 14
     Head Index    1  2  3  4  5  6  7  8  9 10 11 12 13 14
     Head Set      1  1  1  1  1  1  1  1  1  1  1  1  1  1
---------------------------------------------------------------
 For 2 Passes Per Head Position:
   Passes 1 - 14
     Head Index    1  2  1  2  3  4  3  4  5  6  5  6  7  8
     Head Set      1  1  2  2  1  1  2  2  1  1  2  2  1  1
   Passes 15 - 28
     Head Index    7  8  9 10  9 10 11 12 11 12 13 14 13 14
     Head Set      2  2  1  1  2  2  1  1  2  2  1  1  2  2
---------------------------------------------------------------
```

```
For 4 Passes Per Head Position
  Passes 1 - 14
    Head Index    1  2  1  2  1  2  1  2  3  4  3  4  3  4
    Head Set      1  1  2  2  3  3  4  4  1  1  2  2  3  3
  Passes 15 - 28
    Head Index    3  4  5  6  5  6  5  6  5  6  7  8  7  8
    Head Set      4  4  1  1  2  2  3  3  4  4  1  1  2  2
  Passes 29 - 42
    Head Index    7  8  7  8  9 10  9 10  9 10  9 10 11 12
    Head Set      3  3  4  4  1  1  2  2  3  3  4  4  1  1
  Passes 43 - 56
    Head Index   11 12 11 12 11 12 13 14 13 14 13 14 13 14
    Head Set      2  2  3  3  4  4  1  1  2  2  3  3  4  4

---------------------------------------------------------------
For 8 Passes Per Head Position
  Passes  1 - 14
    Head Index    1  2  1  2  1  2  1  2  1  2  1  2  1  2
    Head Set      1  1  2  2  3  3  4  4  5  5  6  6  7  7
  Passes 15 - 28
    Head Index    1  2  3  4  3  4  3  4  3  4  3  4  3  4
    Head Set      8  8  1  1  2  2  3  3  4  4  5  5  6  6
  Passes 29 - 42
    Head Index    3  4  3  4  5  6  5  6  5  6  5  6  5  6
    Head Set      7  7  8  8  1  1  2  2  3  3  4  4  5  5
  Passes 43 - 56
    Head Index    5  6  5  6  5  6  7  8  7  8  7  8  7  8
    Head Set      6  6  7  7  8  8  1  1  2  2  3  3  4  4
  Passes 57 - 70
    Head Index    7  8  7  8  7  8  7  8  9 10  9 10  9 10
    Head Set      5  5  6  6  7  7  8  8  1  1  2  2  3  3
  Passes 71 - 84
    Head Index    9 10  9 10  9 10  9 10  9 10 11 12 11 12
    Head Set      4  4  5  5  6  6  7  7  8  8  1  1  2  2
  Passes 85 - 98
    Head Index   11 12 11 12 11 12 11 12 11 12 11 12 13 14
    Head Set      3  3  4  4  5  5  6  6  7  7  8  8  1  1
  Passes 99 - 112
    Head Index   13 14 13 14 13 14 13 14 13 14 13 14 13 14
    Head Set      2  2  3  3  4  4  5  5  6  6  7  7  8  8
---------------------------------------------------------------
```

The following give the lists of the first track (head) for each channel for experiments using all heads in a pass. Channels using multiple tracks because of fan out and/or 2 bit mode use the listed track plus successive even or odd tracks. For the multiple pass per head position modes, the listed tracks are divided into groups and successive passes (at a head position) use the successive groups.

```
              FIRST HEAD per CHANNEL
----------------------------------------------------------------
    Tracks Per Channel:    8
    Modes:                 (VLBA1:4, 2 bit)
    First Heads:           2 18 3  19
----------------------------------------------------------------
    Tracks Per Channel:    4
    Modes:                 (VLBA1:4, 1 bit), (VLBA1:2, 2 bit)
    First Heads:           2 10 18 26 3 11 19 27
----------------------------------------------------------------
    Tracks Per Channel:    2
    Modes:                 (VLBA1:2, 1 bit), (VLBA1:1, 2 bit)
    First Heads:           2 6 10 14 18 22 26 30
                           3 7 11 15 19 23 27 31
----------------------------------------------------------------
    Tracks Per Channel:    1
    Modes:                 (VLBA1:1, 1 bit)
    First Heads:           2  4  6  8 10 12 14 16
                          18 20 22 24 26 28 30 32
                           3  5  7  9 11 13 15 17
                          19 21 23 25 27 29 31 33
----------------------------------------------------------------
    Mark~III Mode B with channels in ascending frequency order.
    Sidebands should alternate.
    First Heads:  18  4 20  6 22  8 24 10 26 12 28 14 30 16 32 2
                  19  5 21  7 23  9 25 11 27 13 29 15 31 17 33 3
----------------------------------------------------------------
    Mark~III mode E with channels in ascending frequency order.
    First Heads:  4   6   8  10  12  14  16   2
                 18  20  22  24  26  28  30  32
                  5   7   9  11  13  15  17   3
                 19  21  23  25  27  29  31  33
----------------------------------------------------------------
```

Mark III mode A is not normally used with VLBA systems because the gain of only 2 tracks over mode A is not worth the extra tape usage. When it is used, the assignments are special because a decision has to be made about what subset of tracks to use.

Perhaps an example will help clarify all of this. Consider an experiment that uses 2 passes per head position and 4 tracks per channel. There will be 4 channels and the following pattern is used for the first few passes.

```
Pass Head  Dir             Heads.
      pos        Chan 1       Chan 2        Chan 3       Chan 4
 1    -319  For | 2 4 6 8 | 10 12 14 16 | 18 20 22 24 | 26 28 30 32 |
```

```
2     31  Rev | 2 4 6 8 | 10 12 14 16 | 18 20 22 24 | 26 28 30 32 |
3   -319  For | 3 5 7 9 | 11 13 15 17 | 19 21 23 25 | 27 29 31 33 |
4     31  Rev | 3 5 7 9 | 11 13 15 17 | 19 21 23 25 | 27 29 31 33 |
5   -271  For | 2 4 6 8 | 10 12 14 16 | 18 20 22 24 | 26 28 30 32 |
6     79  Rev | 2 4 6 8 | 10 12 14 16 | 18 20 22 24 | 26 28 30 32 |
7   -271  For | 3 5 7 9 | 11 13 15 17 | 19 21 23 25 | 27 29 31 33 |
8     79  Rev | 3 5 7 9 | 11 13 15 17 | 19 21 23 25 | 27 29 31 33 |
etc.
```

Note that when there is both fan out and 2 bits per sample, the "sign" bits are fanned out over the first n tracks (eg 4 for VLBA1:4), and then the "magnitude" bits are fanned out over the next n tracks.

C STATION CODES

The following is the list of station codes used in VLBA and Global Network scheduling as of the end of 1995.

```
Suggested 2-letter Observatory codes
-------------------------------------------------------
Aq      Algonquin, Canada            GEO
Ar      Arecibo, USA                 VLBA+
As      Alice Springs, Australia     Sheve
Ba      Bangalore, India             mm
Bl      Bear Lakes, Russia
Br      Brewster, USA                VLBA
Cb      Cambridge, UK                Ryle telescope
Ce      Cebreros, Spain              GEO
Ch      Chilbolton, UK
Cm      Cambridge, UK                MERLIN
Cu      Culgoora, Australia          AT
Da      Darnhall, UK                 MERLIN
De      Defford, UK                  MERLIN
Dw      Dwingeloo, Netherlands
Eb      Effelsberg, FRG (VLBA)       EVN, VLBA+
Ef      Effelsberg, FRG (Mark IV)    EVN
Ev      Evpatoriya, Ukraine
Fd      Fort Davis, USA              VLBA
Gb      Green Bank, USA              VLBA+
Gc      Gilcreek, USA                GEO
Gn      Green Bank, USA              NAVY
Go      Goldstone, USA               DSN
Hc      Hat Creek, USA               mm
Hn      Hancock, USA                 VLBA
Ho      Hobart, Australia            Sheve
```

Hs	Haystack, USA	VLBA+, GEO
Hh	Hartebeesthoek, S.Africa	
Hy	Hyderabad, India	
It	Itapetinga, Brazil	
Jb	Jodrell Bank, UK	EVN, MERLIN
Ka	Kashima, Japan	GEO
Kn	Knockin, UK	MERLIN
Kp	Kitt Peak, USA	VLBA
Kr	Kiruna, Sweden	
Kt	Kitt Peak, USA	12m
Ku	Kauai, USA	GEO
Kw	Kwajalein, USA	GEO
La	Los Alamos, USA	VLBA
Ls	La Silla, Chile	SEST
Mc	Medicina, Italy	EVN, VLBA+, GEO
Md	Maryland Point, USA	
Mg	Mount Graham, USA	
Mh	Metsaehovi, Finland	EVN+
Mk	Mauna Kea, USA	VLBA
Mm	Mauna Kea, USA	JCMT
Mo	Mojave, USA	GEO
Mr	Matera, Italy	GEO
Ms	Mauna Kea, USA	CSO
Na	Nancay, France	EVN+
Nb	Nobeyama, Japan	mm
Ng	Narayan Gaon, India	GMRT
Nl	North Liberty, USA	VLBA
Nt	Noto, Italy	EVN, VLBA+, GEO
Oc	Owens Valley, USA	CIT
Oh	O'Higgins, Chile	GEO
On	Onsala, Sweden	EVN, GEO
Oo	Ooty, India	
Ov	Owens Valley, USA	VLBA
Pa	Parkes, Australia	AT
Pb	Plateau de Bure, France	
Pe	Penticton, Canada	GEO
Pt	Pie Town, USA	VLBA
Pu	Puschino, Russia	EVN+
Pv	Pico Veleta, Spain	mm
Qb	Quabbin, USA	mm
Ri	Richmond, USA	GEO
Ro	Robledo, Spain	DSN
Sc	Saint Croix, USA	VLBA
Sa	Santiago, Chile	GEO
Sh	Sheshan (Shanghai), China	EVN+

```
Sm      Simeiz (Crimea), Ukraine     EVN+
Ss      Siding Spring, Australia     AT
Su      Suffa, Kazachstan ?
Ta      Tabley, UK                   MERLIN
Ti      Tidbinbilla, Australia       DSN
Tr      Torun, Poland                EVN+
Ud      Usuda,Japan
Ur      Urumuqi, China               EVN+
Us      Ussuriisk, Russia
Uu      Ulan-Ude, Russia
Wa      Wardle, UK                   MERLIN
Wb      Westerbork, Netherlands      EVN
Wf      Westford, USA                GEO
Wh      Weilheim, FRG
Wz      Wettzell, FRG                EVN+, GEO
Y1      VLA, USA                     VLBA+
Yb      Yebes, Spain                 mm, EVN+
----------------------------------------------------------------
Y27 indicates phased VLA, VLBA indicates ScHnNlFdLaPtKpOvBrMk
for Mk III and VLBA mode observations, ScHnNlPtOvBrMk for Mk II.
```

D CHANGES TO SCHED

This appendix lists the changes made to SCHED at various releases. Consult the old *sched.hlp* file for changes before 1995. It can be obtained from Craig Walker.

D.1 Release of 16 May 1995

- `TAVLBA` mode, make second on-source qual 20 and add final off. (1994 December 21)
- Bug fix: if one velocity was given in the source catalog, it was not used for other baseband channels. (1994 December 30)
- Add tape summary to summary file. (1995 January 24)
- Add setup name to summary listing. (1995 January 24)
- Add third pcal tone when there are enough detectors. (1995 January 25)
- Fix source name in error message when there are imbedded blanks. (1995 April 24)
- Add to summary file a list of sources in format for transfer to the correlator data base. (1995 May 15)
- Turn on `UNLOAD` between tapes at 1-drive stations. (1995 May 16)

- Fix problem with tape summary for stations excluded by `DOSTA`. (1995 May 16)
- Don't print the ".set" in the summary file if the setup file name is too long to fit. (1995 May 16)
- Adding commands to control the 50cm filter.
- Improved the reliability of writing the `EXTLO` parameter. (1995 May 16)

D.2 Release of 22 Feb 1996

This is a slightly modified version of the SCHED that was released within NRAO in December 1995.

This version included a number of evolutionary changes made up to November 1995. In that month, the VLBA OBSERVE (GNOMES) project was cancelled and it became clear that SCHED had much more of a future than expected. Many changes, including addition of plotting and dwell time scheduling, along with massive changes in internal structure for both maintainability and for eventual Mark IV support, were made. Also the help file was renamed the manual, formated for LaTeX and html, and to a large degree, rewritten. It is now this document.

The evolutionary changes before November 1995 were:

- Add `REMARK` to valid parameters in source catalog. Someday, print it in the summary file. (1995 May 31)
- First parallactic angle was PA2, not PA1, in PRTSCH. Fixed. (1995 June 4)
- Added horizons. (1995 June 17)
- Warn if automatic tape allocation requested. (1995 June 26)
- Rewrite optimization mode routines for easier modification. (1995 June)
- Increase maximum number of setup files to 50. (1995 June 25)
- Make cover-like info in VLA observe file look like what VLA OBSERVE observe makes so observe will read it. (1995 July)
- Fix rounding of F6 numbers for VLA, since did wrong thing when negative. (1995 October 3)
- Change reference pointing at VLA from `IA` to `IR` mode. Also, only put pointing request in VLBA control files if this is not a DAR-only station (1995 October 4)
- Update some bits of VLA info in help file. A major review of the help file should be done soon. Also put the help file in HTML. (1995 October 4)
- SCHIN had `FASTF` instead of `FASTFOR` as per the documentation. Change to `FASTFOR`. (1995 October 30)

The big rewrite included:

- Added plotting.
- Added dwell time scheduling.
- Added new subroutines for setting up and reading KEYIN variables. It is now much easier to add and remove parameters. Also, the number of inputs for arrays is now sensitive to the parameter statements.
- Much restructuring of code.
- Can now write telescope output files when optimization used. Optimization much better integrated into program.
- Help file made into a manual and formated for LaTeX.
- Manual made convertable to html by latex2html.
- Reduced maximum stations and scans parameters. Some variables with both dimensions were added so this keeps the size down.
- Convert many time parameters to fractional days from radians inside program. Not visible to user.
- Allow in-line setup files much like the source and station catalogs.
- Setup files are now required for all projects.
- Allow a "default" station in setup files (eg for Mark II or experiment planning).
- Relative order of "VLBA" default station and any specific stations in a setup file no longer matters.
- SCHED no longer takes the number of channels from the main input file. This is set only in the setup file.
- The bandwidth is no longer required in the main file for observations using Doppler calculations — it is obtained from the setup file. It can still be changed in the main file.
- The formats of the summary and sch files were changed somewhat.
- SUN proximity warnings no longer overwrite other comments.
- For dwell time scheduling, more general axis limits and slew rates were put in the station catalog. Parameter HALIM was removed.
- In the summary and sch files, scans below the horizon but above the slew limits are marked differently from scans below the slew limits
- Scan timing specification was enhanced. GAP was added to take the place of the usual use of PRESCAN. PRESCAN is now just a tape start offset. It can be negative for prestarting tapes. The changes are backward compatible

- SCHED internally calculates XYZ for stations if they are needed. Mainly used in u-v plotting.
- Put summary file output early enough in program that it is done and closed before plotting begins. It can then be examined during plotting.
- Now, when there is in-stream input such as tape initialization, source and station catalogs, line frequencies, or setup information, SCHED reads that input and then returns to reading input for the current scan. No scan initialization is done. Thus these in-stream inputs can go anywhere. The main use of this will probably be to put the cover information at the top of the file. Another use is to put in-stream setup information in the main file at the scan where it is first used. This is useful especially for test observations.
- Let OPMINANT and OPMINEL apply regardless of optimization. They are useful especially in planning.
- The TPRATE parameter was removed.
- Allow program restart from plotting input.
- Allow setups with different numbers of tracks. This can waste tape because the tape management will be done as if all scans used the maximum number of channels.
- Allow specification of schedule input file name from main input. This allows one-time inputs, such as the request to plot, to be made before sending SCHED off to get the schedule input.
- Add DEBUG which turns on some extra printing.
- VLABAND and VLABW were moved to the setup file.
- Added a toggle concept for many variables such as RECORD, TSYS, DOPPLER, etc. Now they are paired with a NO... (eg NORECORD) that turns them off.
- Added OPSTYPE=VLA for pure VLA observations. This helps tell SCHED not to worry about tape related stuff.
- Changed DOPCAL to DOPPLER to avoid the confusion with DO PCAL. Added NODOP to turn it off.
- Got latest SLALIB and updated a couple of places where there were changes. Also got email permission to use it.
- Add OVERWRIT to allow sched to overwrite old files if desired. This is not the default as a safety measure.
- Adding CSUB optimization mode. The optimizes sky coverage. It includes subarrays.
- Adding SUMITEM input to allow specification of what is in the summary file.

- Changed `XY` mount type to `XYNS`. Should add
tt XYEW.
- When the station catalog is read, the position both in geodetic longitude, latitude, and elevation and in geocentric X,Y,Z are determined from the information provided. The catalog should contain one or both of the above coordinates.
- Added Station XYZ to summary listing.
- Allow vlba and vla defaults in `TAPEINI` section.

D.3 Release of 13 Apr 1996

- Move test of OBSCODE for inline tapeini stuff out to SCHIN.
- Add TPSPEEDH and TPSPEEDL to setup files. Make tape speed default optimally so it doesn't need to be specified.
- Improve various error checks.
- Redo handling of DOSTA - don't read stations in first place.
- Put S instead of F or R for direction in sch filewhen not recording.
- Remove TPSPEED from setup files. Add comments giving tape speeds and times.

D.4 Release of 26 June 1996

- Some small format and manual changes 14apr96.
- Fix bug with FORMAT passed to CHKSPD - problem with mixed modes. 17apr96.
- Fix bug with obscode default when tapeini not specified 18apr96.
- Fix bug with SCANS optimization mode not going full time. 19apr96.
- Reverse sign of U in plots for normal convention. 23apr96.
- Put tapeini and pass times in summary file. 23apr96.
- Add TSETTLE to station catalog. 25apr96
- Add INDXHEAD and HEADPOS to simplify VEX additions. 25apr96
- Alter defaulting of FE to avoid need for 'OMIT'. 25apr96
- Remove all INTEGER*2 to prevent confusion and because nonstandard. 26apr96
- Add much checking of VLA parameters (CHKVLA and BADLO) 29apr96.
- Get rid of ALLVLBA option (produce VLBA type cards for all stations. 01 May 96

- Split STAFILES out of main routine. 01 May 96.
- Add calls to VEX routines, DOVEX input, and beginning Mark IV support. 01 May 96.
- Remove MARK3 and VLBATP logicals - add VLBITP. Make OBSTYP local to SCHIN. 02May96
- Add routine CHKVLBA with checks of FE, SYNTH etc. 3May96
- Set unused synthesizers to 10.9 GHz for 2 cm observations.
- Add EARLY and DWELL to SUMITEM options. 6May96.
- Add correlator parameters. 14 May 96.
- Add DAR, RECORDER, NBBC, NDRIVEs, NHEADs to station catalog 17 May 1996.
- Add much stuff about VLA defaults. Print to summary. 22May1996
- Add planets and JPL ephemeris. Bryan Butler and RCW 26 Jun 96

D.5 Release of 4 Dec. 1996

- Discourage picking successive scans on same source when using the subarrayed sky coverage optimizer (OPTCSUB). 11Sep96 RCW.
- No longer attempt to space to the end of tape between scans when there is going to be a turn-around. With speed-up on the correlator, this can put the correlator badly out of sync. 12Sep96 RCW
- Add TAPESYNC to try to force synchronized tape changes. This is especially useful in optimized schedules with subarraying. Sep 96 RCW.
- Made cosmetic changes to sched.inc and some clean up of source namehandling, including a bug fix in the planets code. 1 Oct 96 RCW
- Added new routine STMSG for startup messages. 1 Oct 96 RCW
- Added a new routine SHORTN for getting the short source name. 1 Oct 96 RCW
- Add ability to use station codes in place of station names for the input parameters STATIONS, REWIND, FASTFOR, TAPE, and REVERSE. This had the side effect of requiring that the station catalog be read by the time the first scan is processed. 4 Oct 1996 RCW
- Fix calls for planet positions. 4 Oct 1996
- Print 0 for dwell time if source is down. 4 Oct 96 RCW.

- Increase the maximum number of channels to 32. This required quite a bit of work as 16 was built in in several places. 9 Oct 96 RCW.
- Made various changes to help the Mark IV and VEX support. Set the default low density Mark IV tape speeds to the same as Mark III.
- Set the maximum correlator data rate to 350 kbps. 14Oct96 RCW.
- Don't allow BW to be specified in the main schedule if VEX output is to be written. This significantly simplifies the generation of setups in the VEX file. 15 Oct 96 RCW.
- Add DOPINCR to allow doppler frequency setting for systems with different frequency setting capabilities from VLBA and Mark III/IV. For example, VSOP only hits the nearest MHz. 15 Oct 96 RCW.
- Require that the user provide many of the cover and correlation parameters to give the observatories and correlators the information they need. Internally, put all parameters in variables to reduce dependence on the print format. Eliminate the parameter TELEX since as far as I know, this system is no longer used. 16 Oct 96 RCW.
- Add a mechanism, and a program, for easy including of examples in this manual. This should make keeping the examples up to date and tested easier. 17 Oct 96.
- Add SLEW to the allowed summary items (SUMITEM).
- Allow MKIV dar and S2 recorder at the same site.
- Add the ability to use environment variables in UNIX file names. This simplifies specification of catalogs names. Also adjust the default catalog names to work on a UNIX system with the standard SCHED directory substructure and with $SCHED defined to point to the SCHED base area. 21 Oct 96 RCW.
- Add FREQREF to schset.inc to make it easier for other routines to get the observing frequency. Set FREQREF in RDSET and/or SETFREQ.
- Add POL to schset.inc to make it easier to keep track of polarization. Add POL to setup input variables.
- Changed SPEEDUP in sched.inc to RSPEED and added SPEEDUP to schset.inc. This improved bookkeeping.
- Prohibit frequency switching when writing VEX. 24 Oct 96.
- Add MJD to summary output.
- Restructure writing of summary file and add number of passes, tapes, and readback tests. 24 Oct 1996.

- Extend the leveling scan for pointing observations to twice PTDUR to make it long enough to get pcx tests. 24 Oct 1996.

- Force the doppler calculations to give the same LO frequency for channels sharing a BBC. This is mainly for Upper/Lower sideband pairs. Added subroutine SBSIDE. 25 Oct 1996 RCW.

- Add consistency checks across channels and setup groups in a setup file in the area of frequency and sideband assignments. 25 Oct 1996.

- Protect against scans shorter than one second. 25 Oct 1996.

- Remove tape stuff from VLAONLY and NOTAPE observations. 28 Oct 96.

- Set up for defaulting many SETUP parameters based on input from a frequency catalog. This was a major change involving considerable additional code and a new input file which is called *freq.dat* in the catalogs subdirectory. If users are observing a frequency covered by the frequency catalog, they only need to specify generic information like observing frequency, polarization, number of bits per sample etc. SCHED can then fill in all the site dependent parameters like firstlo, synthesizer settings, channel names etc. This should greatly simplify the process of making setup files. See Section 16 for a lot more information. SCHED also uses the frequency catalog information to check any setups provided. If it does not recognize the setup, it will complain. For VLBA observations, this probably means there is a problem. For other sites with less complete information in the frequency catalog, it is just a flag to be careful with what you are doing.

  In the process of making these changes, it became possible to specify multiple stations for a setup group (SETSTA now has two indices). With only the generic parameters specified, this can be useful. Internally, SCHED expands such a case to have a separate group for each input station before adding all the LO values etc. After that, only the first station of the list is used. 29 Oct 96. RCW.

- Set up defaulting of parameters like NETSIDE and BBC in SETCHAN. This can be a bit risky since different defaults require different frequency settings, which aren't defaulted. 2 Nov 96. RCW.

- Did some cosmetic reformatting of the summary file. 4 Nov 96 RCW.

- Clarify VLA vs VLB IF's in sum file. Warn of special patching.

- Allow POL=DUAL in setup. Will cause R/L pairs to be specified.

- Adding FREQFILE and FREQLIST for frequency defaulting and display. FREQLIST can be used to get a list of possible frequency setups from the frequency catalog for a desired sky frequency. SCHED will generate the list, writing it to the screen and to a file called *frequencies.list*. 6 Nov 96 RCW.

- Put catalog of origen into summary file source list. Also move SRCFILE and STAFILE to sched.inc. 8Nov96 RCW.

- Allow the setup file to specify generic FORMAT=VLBA or FORMAT=MKIV. SCHED will figure out the appropriate fanout, usually trying to obtain a speed up factor on the VLBA correlator of two, if possible. 12Nov1996 RCW.
- Default TPMODE to the actual one so that the user does not need to specify it in the setup file.
- Put FE, SYNTH, and pcal stuff in the setup summary in the summary file for VLBA stations.
- Allow plotting without cover information. This helps keep schedules used for planning purposes simple. 18 Nov 1996.
- Fix bug that caused OPTMODE='SCANS' to start at input start time of first good source (perhaps involving big delay from the experiment start time). 18 Nov 1996 RCW.
- Increase number of scans and number of setup files allowed. The program size is now about 15 Mbytes. The size is sensitive to these two parameters which can be altered easily in the include files. 18 Nov 96.
- Allow VSOP control, dar, and recorder types. Add a stub for writing VSOP drudg files. 18 Nov. 96.
- Activate axis type XYEW (Hobart). Rewrite XYNS routines while at it. 19 Nov 1996. RCW.
- Modify all of the standard setup files for new defaulting capabilities. 20 Nov 1996
- Add FOCUS, ROTATION, AZCOLIM, and ELCOLIM as scan inputs. These are for VLBA testing only. 20 Nov 1996 RCW
- Add ROTPAT, FOCOFF, and ROTOFF for focus/rotation test patterns. Again these are for VLBA testing (the 3mm receiver has arrived at Pie Town!). 25 Nov 1996 RCW
- Add speedup factor to summary. 27 Nov 1996
- Add warnings if baseband channels overlap in frequency. 27 Nov 1996.
- Use the setup frequency for a source for which no velocity was specified even if DOPPLER was specified. 27 Nov 1996.
- Fix data set size calculation — data rate was ok, but it did not allow for the fact that processing happens faster with a speed up greater than 1. 3 Dec 1996.
- Tested and works under Linux. 4 Dec 1996.
- Added VLBI at the VLA example provided by Joan Wrobel. 4 Dec 1996.
- Allow norecord scans to count for readback tests and don't include them in the tape time calculation. 4 Dec 1996

D.6 Release of 14 Jan. 1997

- Fixed mistake in frequencies in v6cm-128-4-2-L.set. Put in 4 Dec release. 5Dec96
- Add source qualifier to qualifiers used in pointing pattern. This will be used to distinguish scans meant to be processed with on-off spectral line observations. For testers only. 6 Dec 96 RCW.
- Fix bug in SLEW that caused slew times to be wrong some of the time. This was introduced in the 4 Dec sched so old schedules are ok. 9 Dec 96 RCW.
- Rick Lively has been doing some clean up in the Makefile, especially for machines other than those we have. The 9 Dec release has several modifications relative to the 4 Dec release.
- I did a mini-release in the evening of 9-Dec-1996 RCW
- Franco Tinarelli sent information on a number of problems detected by his Dec Alpha compiler. Mostly these are non-serious problems with declares (although he is the one who flagged the SLEW problem above). These are fixed. 10 Dec 1996. RCW
- Block test for different speedups for S2 sites. 13 Dec 96 RCW
- Make RCHAN and LCHAN have 2 characters. 13 Dec 96 RCW
- Add setup information to the end of the sch files. 13 Dec 96 This and the above 2 items were requests from Huib.
- Alter TFORM so that it does not overflow a small input character string. RCW 18dec96.
- Start adding SAVE to routines and includes. Needed with g77. RCW 18dec96. First change in KEYPUT. 23dec96 — this turned into a mess. Putting variable specific SAVEs in many routines. In the process, a few initializations were cleaned up.
- Reinstate postpasses for VLBA format files. 23 dec 96. RCW.
- Write *verify* and *check_results* scripts for checking both new code and new installations. Put "standard" output files in the *examples/Stdout* subdirectory. 26 Dec 96. RCW.
- Do various programming cleanups to keep g77 with all warning switches turned on happy. These should make the program more robust.
- Fix several problems for RESTARTs from the plotting section. The fixes mainly had to do with the initialization of station and frequency catalog reads. 31 Dec 96.
- Allow single tape stations not to postpass if the tape doesn't stop during a pass. 31 Dec 96.

- Warn if tape change gaps are less than 15 minutes. 13 Jan 97 RCW.
- If a tape change is preceeded by norecord scans, move the tape change time back to as early as possible. 13 Jan 97 RCW.

D.7 Release of 10 Feb. 1997

- Fix a concatenation problem (Linux only?) in envir.f - related to the use of environment variables. RCW 15 Jan 1997. Moved to standard release (14 Jan version).
- Add some variables to SAVEs. Required by g77 to fix some problems. 21 Jan 1997.
- Change the order of the examples to try to get people to use the simpler one. 21 Jan 1997.
- Update Sla/dat.f for July 1, 1997 leap second. 27jan97 RCW.
- Add comment to crd files giving tape start times. 3feb97 RCW.
- Incorporate VEX output from Huib. Debugging and porting over next few days. 3feb97 RCW.
- Prevent mixing planets and VEX. 6feb97 RCW.
- Fix MST day for VLA obs files when the experiment starts between UT and local midnight. 7Feb97 RCW.
- This should be the most robust release yet in a portability sense because of testing on several platforms, much of it done by Franco Tinarelli of Bologna. Numerous small non-standard items in the code were corrected.

D.8 Development version

- Nothing yet.

E HISTORICAL NOTES

SCHED was written by R.C. Walker in the late 1970's for Mark II VLBI scheduling. It received a number of modifications over the following decade by the author and others, including Tim Pearson, John Benson, and Mark Hodges. During 1988 and early 1989, the program was extensively revised by RCW, mainly to accommodate VLBA scheduling (including Mark III observations on the VLBA systems). Much of the internal structure of the program was changed. Changes of interest to users are outlined in Section D. A history of changes prior to 1989 is available from RCW if it is needed. Another major release was prepared by 1990 October by RCW. Many enhancements, as described in Section D, were made, including VLBA tape handling, Doppler calculations, proper motions, setup file changes, and many more were provided. In 1991 May a significant release was made. Cover information, VLBA recording modes, and `TAVLBA` were added, along with other changes as detailed in the Section D. At about this time, a project to write VLBA OBSERVE was been begun by Wes Young. SCHED development was at a maintenance and only necessary enhancement level during this development project.

In the Fall of 1995, the VLBA OBSERVE project was cancelled. Then in an intensive session, plotting and many other features were added by about Christmas time. In the Spring of 1996, Huib van Langevelde began work on the VEX additions which became a significant part of the program. Also, at about that time, Brian Butler provided the code needed to add the planet capability. Rick Lively is providing systems support including makefiles and interactions with users trying to install the programs on other machines. Developments and enhancements are proceeding rapidly now that the program has a significant future. In fact, it has been chosen as the primary scheduling software for VSOP and the EVN, in addition to the VLBA.

In February 1997, Huib vanLangevelde delivered 7000 lines of new code to implement VEX output and give SCHED the ability to schedule Global VLBA/MarkIV/S2 observations. The first release with this code will probably be within days of the launch of VSOP.