Lady Heather's GPS Disciplined Oscillator Control Program
(now works with many different receiver types and even without a GPS receiver)

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Lady Heather is a monitoring and control program for GPS receivers and
GPS Disciplined Oscillators. It is oriented more towards the time keeping
funtionality of GPS and less towards positioning. It supports numerous GPS
(and Glonass, Beidou, Galileo, etc) devices.

Win32 port by John Miles, KE5FX (john@miles.io)
Help with Mac OS X port by Jeff Dionne and Jay Grizzard
  (note: OS/X version uses the XQuartz package for X11 display support)

Temperature and oscillator control algorithms by Warren Sarkison

Original adev code adapted from Tom Van Baak's adev1.c and adev3.c
Incremental adev code based upon John Miles' TI.CPP

Easter and moon illumination phase code from voidware.com

moon_info() derived from code in John Walker's moontool.c

Equation of time code adapted from code by Mike Chirico and NOAA

Sun position code is Grena's Algorithm 5

Moon position from code by Paul Schlyter at
  http://hotel04.ausys.se/pausch/comp/ppcomp.html

Heliocentric Julian Date code adapted from code by Richard Ogley.

Nutation and obliquity code derived from code by Jay Tanner and JPL

Equinox/Solstice equations derived from Jan Meeus "Astronomical Algorithms"
   via Simon Cassidy.

Time of perihelion derived from table by Fred Espenak, www.Astropixels.com

New moon table derived from table by Fred Espenak, www.Astropixels.com

Moon image code derived from code by Mostafa Kaisoun.

Nortel NTGS55A recever wakeup research by Sam Sergi

Linux IPv6 support by Kasper Pedersen

The LZW .GIF encoder used in this file was derived from code written by Gershon
Elber and Eric S. Raymond as part of the GifLib package. And by Lachlan
Patrick as part of the GraphApp cross-platform graphics library.

This file (HEATHER.CPP) contains most of the operating system dependent
routines, initialization routines, serial port I/O, and the screen I/O
and plotting routines.

-PROGRAM CONFIGURATION AND HELP INFORMATION

   Heather has two types of user commands. The first is the command line
   options. You can get a list of command line options by starting Heather
   with an invalid command line option such as "/?". This will bring up
   a scroll box of commands on Windows and several pages of commands on
   other operating systems. You can also enter "?" from the keyboard to
   bring up the command line help information.

   Command line options can begin with either a '/' (Windows standard)
   or a '-' (Linux / macOS standard). Either is acceptable no matter what
   operating system you are using. Options must be separated by a space.
   Note that file names may not contain spaces and quoted options are not
   supported!

   Once Heather has started, you can enter command line options from the
   keyboard using the "/" keyboard command. There are a few command line
   options that cannot be changed from the keyboard once Heather has started.

   The second set of commands are the keyboard commands. You can get a list
   of the primary keyboard commands and menus by pressing SPACE. Note that
   not all receivers support all of the keyboard commands. Keyboard menu
   commands are shown in this documentation in upper case characters, but
   either upper case or lower case are acceptable.

   Pressing the first key of a command menu will show a sub-menu of commands
   available under that menu. Pressing the second key of a menu command
   will either execute the command or, more commonly, prompt for a value
   to enter. The default value offered as the input is either the current
   setting or a common value to use. You can press ENTER to accept the
   offered value, ESC or ESC ESC to abort the command, enter a new value,
   or edit the offered value.

   LEFT and RIGHT arrows move the cursor within the string. INSERT
   toggles insert mode. HOME moves to the start of the string. END moves
   the end of the string. DEL deletes the character at the cursor. DOWN
   arrow deletes to the end of the line. UP arrow deletes to the start
   of the line. BACKSPACE deletes the character before the cursor.

   If a keyboard command suggests an input value and the first character
   that you enter is a not an editing character, the offered value is
   erased so that you don't have to backspace over it to enter a new value.

Heather's configuration comes from three places:

    First is a hard coded configuration in the program.
    Next is from the file "heather.cfg"
    Finally is from the command line that starts the program.

The location of "heather.cfg" depends upon the operating system and how
Heather was started (from a command line or from a desktop icon). You
can determine where to place the file by bringing up the command line
help information (described above) and scrolling down to the bottom of
the help information. There will be a line that says:
  "Put heather.cfg file in directory ..."

Note that if you rename the "heather" executable file, the .cfg and .cal
file names that Heather uses will also change to match the new executable
file name.

Note that this directory is also the default directory that Heather uses
for all of its support files (sound files, log files, screen dumps, etc).

If you launch Heather from a WINDOWS desktop icon, you can set the command
line options by right clicking on the icon and selecting PROPERTIES.
The TARGET field will show the command command line to use.

Windows users can also hit the 'n' key to edit the heather.cfg file
in Notepad. Heather will continue to run with the existing options;
any changes made to heather.cfg while the program is running will
take effect the next time Heather is started.

Note that in this file a lot of command line options are described as
"toggle" options. Toggle options are like on/off switches. For instance:
    /gw - will toggle the watch display between on and off and back on
           each time it is seen.

You can override this toggle action and explictly set the state.
For instance:
    /gw0 - forces the watch display OFF
    /gw1 - forces the watch display ON

LADY HEATHER'S CONFIGURATION FILE "heather.cfg" :

Place the command line options that you want to use in this file
with one command line option per line. Each option MUST start in column
one with a '/', '-', '@', or '$' otherwise the line will be treated as
a comment.

Lines that begin with '/' or '-' set command line option values.

Lines that begin with '$' send hex values to the receiver.

Lines that begin with '@' send keyboard commands (all '@' lines are copied
to temporary keyboard script file "heathtmp.scr" which is then processed
once heather has finished initializing the hardware, etc). See the
description of keyboard script files below.

You can also read in a ".cfg" file from the keyboard "R" menu or from
the command line:
    /h=file - reads a .cfg configuration file. These config files are
               processed after the default "heather.cfg" file has been
               processed. You should not include a "/h=" command in a .cfg
               file since reading config files do not nest.

At a minimum most users will want to configure the com port, receiver
type, and time zone in their default configuration.

If an error is detected in a command line option in the .cfg file,
processing of the file is stopped and the command line help screen is
shown. The offending option is listed at the end of the help info.

KEYBOARD SCRIPT FILES:

    Lady Heather has the ability to read keyboard script files. These
    file must have an extension of ".SCR" Script files mimic typing
    from the keyboard. Script file names must be less than 128 characters
    long.

    Commands that would normally suggest an input do not
    do it when read from a script file. They behave
    like you first entered ESC to erase the suggestion.

    Commands that normally toggle a flag may be followed
    by a "1" or "0" to set the flag value directly. e.g.
    you can use GW0 in a script file to force the watch display
    OFF. A few commands (like GS) do not toggle a specific value
    and cannot be used this way.

    You can put more than one command on a line (separated
    by spaces) until you do a command that expects a
    parameter value or string.

    A '~' in a script file pauses reading from the script
    and starts reading from the keyboard until a carriage
    return is seen. This is useful for entering a parameter
    value or string. e.g. GG~ will pause the script and
    prompt for a graph title.

    Any text following a ';' or a '#' in a script file
    is a comment and is ignored.

Script files abort upon the first error detected or any
        unrecognized command is seen.

        Script files can be nested up to 5 levels deep.
        Scripts can be stopped by pressing any key.

        You can cause processing of a keyboard script file to wait for a
        time interval or a specific time. See the section on ALARMS for
        a description of how to do this.

        To read a script file use the "R" keyboard command or "/r" command
        line option and specify a file name with an extension of ".scr"

  -CONFIGURING THE COM PORT:

    Lady Heather talks to the GPS device via a serial port (hardware or USB)
    or an internet TCP/IP connection. You need to tell Heather which
    communications device to use. For serial ports you use the "/#" command
    line option (where # is the com port number to use):
        /1 says to use COM1
        /2 says to use COM2, etc
        /0 says to not use a communications link. This can be useful if you
           are just reading a log file, etc and do not want to talk to a receiver.

    On Linux systems the # number you specify IS 1 MORE THAN THE SERIAL PORT
    NUMBER:
        /1 says to use /dev/ttyS0 on Linux
        /1 says to use /dev/ttys0 on macOS
        /2 says to use /dev/ttyS1 on Linux
        /2 says to use /dev/ttys1 on macOS
        /999 says to use /dev/heather

    Windows treats USB connected serial adapters as standard hardware serial
    ports. Most Linux and macOS users will be using USB serial converters.
    These operating systems treat the USB devices differently than hardware
    serial ports. For these system you can use the "/#u" command line option.
        /1u says to use /dev/ttyUSB0 on Linux systems and
        /1u says to use /dec/tty.usbserial on macOS.
        /2u says to use /dev/ttyUSB1 on Linux systems and
        /1u says to use /dec/tty.usbserial1 on macOS.

    If your system does not use these standard device names, you can specify
    the input device name to use with the "/id=" command line option:
        /id=/dev/your_device_name

    Heather also supports using a TCP/IP connection to talk to your receiver.
        /ip=addr:port
        addr can be be either a numeric address like 192.168.10.20 or a web
        address like ke5fx.dyndns.org

        If the :port number is not given Heather uses port 45000

    Note that if the specified IP address is not valid or cannot be reached
    Heather may appear to hang for quite a while until/if the connection
    attempt times out. This is particularly true for numeric IP addresses.

    On Linux and macOS Heather supports IPv6 addresses. If the specified
    IP address is a "bracketed" IP address [....] you can specify the port
    number to use like [....]:45000 otherwise you can force an IPv6
    connection by using a ';' before the port number.

For hardware serial port and USB serial connections you can specify the
serial port baud rate and data format with the "/br=" command line option:
    /br=9600:8:N:1   (9600 baud, 8 data bits, no parity, 1 stop bit)
    /br=19200:7:E:1 (19200 baud, 7 data bits even parity, one stop bit)
    /br=57600:8:O:2 (57600 baud, 8 data bits odd parity, two stop bits)
If a baud rate parameter is not given, Heather will use a default value
that is most commonly used for the receiver type it is using... which may
not be the same as what your receiver is configured for!

-CONFIGURING THE RECEIVER TYPE:

   Heather supports numerous receiver types. If you do not specify a receiver
   type Heather will attempt to automatically determine the receiver type.

   Auto-detection requires the receiver to be actively sending data that
   can be analyzed. Some receivers power up "mute" and do not automatically
   send data. You must "wake up" these receivers first by specifying the
   receiver type.

   If the receiver can work in both a NMEA and a native
   binary format, it probably powers up in NMEA. Use the
   proper /rx# command show below to put the receiver into native binary
   mode. Binary mode offers the user full control of the receiver
   and better monitoring options. The "!m" keyboard command can
   switch most receivers back to NMEA mode. On some receivers
   it swicthes the device to its alternate language.

   You can force the receiver type with the "/rx" command line option.
      /rx - auto-detect receiver type (default)
      /rxa - Acron Zeit WWVB receiver - 300:8:N:2
      /rxc - UCCM - Trimble / Symmetricom GPSDOs - 57600:8:N:1
      /rxd - DATUM STARLOC II GPSDO - inferior wannabe Thunderbolt
      /rxe - NEC GPSDO ... STAR-4 compatible at (115200:8:N:1)
      /rxg - GPSD interface (mainly a Linux thing - /ip=localhost:2947)
      /rxj - Jupiter-T (aka Zodiac)
      /rxk - Lucent KS24361 REF0/Z3811A (19200:8:N:1)
      /rxm - Motorola binary
      /rxn - NMEA
      /rxr - Trimble Resolution T family with odd parity
      /rxs - Sirf binary
      /rxt - Trimble TSIP binary,
      /rxu - Ublox UBX binary,
      /rxv - Venus mixed binary / NMEA (115200:8:N:1),
      /rxx - No receiver, uses system clock.
      /rxy - SCPI - Nortel telecom GPSDOs like NTWB and NTPX
      /rxz - SCPI (Z3801A style. 19200:7:O:1)
      /rx5 - SCPI (HP5xxxx style)
      /rx4 - Oscilloquartz STAR-4 GPSDO (9600:8:N:2)
      /rx8 - NVS binary (115200:8:N:1)

   /rx says to auto-detect the receiver type. This tries
   to find the receiver type at 9600:8:N:1, then
   115200:8:N:1, then 57600:8:N:1, then 19200:7:O:1 ...
   unless the user specified the com port parameters
   (with the /br=... command) before the /rx option.

   /rx (auto detect) is the default mode if no /rx? command
   is given on the command line.

   Note that the auto-detect routine is a bit simplistic
   and might occasionally mis-recognize the receiver type.

   You can force or set the UTC leapsecond offset with the /rx? commands
   like /rxx=17 (sets the leapsecond offset to 17 seconds)

   If you explicity specify the receiver type, Lady Heather
   defaults to the baud rate indicated above (or 9600:8:N:1 if
   not shown above). If your receiver is configured for

a different baud rate, specify the serial port settings
to use with the /br= command line option.

Special note for Lucent KS24361 units: the Z3811A
(REF1) unit talks SCPI at /br=19200:8:N:1 and the
Z3812A (REF0) unit talks at /br=9600:8:N:1 over the
DIAGNOSTIC ports. Lady Heather's auto detect routine
works with the REF0, but to talk to the REF1/Z3811A
you MUST force the baud rate with /br=19200:8:N:1
or it will try to use 19200:7:O:1. If you use the
/rxz command with these units you MUST first use the
/br= command to force the baud rate (since /rxz
defaults to 19200:7:O:1). For the Z3811A/REF1 you
should use the /rxk command to force SCPI at 19200:8:N:1

The Datum STARLOC II cannot be auto-detected. Firmware
bugs cause it to stop outputting time messages. Always
specify "/rxd" when running STARLOC II receivers. Also
note that the Datum STARLOC II has NUMEROUS firmware
bugs and generates lots of duplicate/missing time stamp
errors.

GPSD is a Linux service that provides a standardized
interface to numerous models of GPS receivers. It is
accessed via TCP/IP address "localhost:2947" GPSD cannot be
auto-detected. Use "/rxg" to force GPSD mode.

The Acron Zeit WWVB receiver cannot be auto-detected. Always use
the /rxa command. Support for this receiver is a hack. Heather shows
it as tracking sat PRN 1. You should manually enter your lat/lon/altitude
(/po=lat,lon,alt command line option or the SL keyboard command) and
the utc offset (like /rxa=17 or /uo=17 command line options). If you
don't enter your position, sat PRN 1 is shown at az=1, el=89.
Technically the Acron Zeit speaks at 300:7:O:2, but works with
300:8:N:2 if you strip off the received parity bit (which Heather does).
Also, it takes several seconds for Heather to startup and shutdown with
this device under Windows.

Special note for Trimble telecom GPSDOs like the NTWB and NTPX... these
devices can speak either TSIP binary (/rxt) or SCPI (/rxy). TSIP provides
much more information and a much more robust interface. Auto-detect will
find these units as TSIP devices.

Special note for Trimble Resolution-T devices:
These are commonly available configured for ODD parity. Heather attempts
to detect this when it thinks it sees a Resolution-T by issuing commands
and if it does not see expected responses, it toggles the parity mode and
tries again. This repeats every 30 seconds or so.
The "/rxr" command sets parity to ODD.
Also Resolution-T devices can have firmware that makes identifying the
exact model number impossible. If you have problems, you can force the
model type:
    /rxr=1 - original Resolution-T
    /rxr=2 - Resolution-T-SMT
    /rxr=3 - Resolution-T-RES
    /rxr=4 - Resolution-T-360

The Trimble Resolution-T TEP model is configured to speak Motorola binary
(rather poorly). The !M keyboard command will switch it to TSIP mode.
A factor reset (!H) will do a factory reset back to Motorola mode.

If no recognizable device is auto-detected,
Heather assumes that no receiver is connected and
defaults to a time-only mode using the system clock.
This will also happen if you specify the wrong com device or
it is in use by another program.

/rxx system clock mode does not need a GPS receiver, it uses
the system clock to drive Lady Heather as a time display.
Use /rxx=17, etc to set the UTC/GPS leap second offset
(needed only for some of the astronomical time formats)

Also Heather needs to know your location so that the
sun and moon info and the astronomical time formats will work.
To set your lat/lon/alt use:
    SL   - from the keyboard
    /po=lat,lon,alt - from the command line

The lat/lon values can either be decimal values or degrees/minutes/seconds
format like: 30d40m50.2s   Negative values are west longitude, southern
latitude.

The altitude value is normally in meters, but can be in feet if the value
is followed by an "f" or "'" like 500f or 500'

In "/rxx" receiver-less mode most of the keyboard commands are
meaningless (mostly the the "T" and "G" menus have relevant options)

-CONFIGURING THE TIME ZONE:

   You should tell Heather what time zone you are in so that the
   proper local time can be displayed. You can set the time zone
   with the command line option:
       "/tz=#sssss/ddddd" where # is the standard
   time zone offset in hours from GMT and "sssss" is up to 5
   characters of standard time zone ID and "ddddd"
   is the daylight savings time zone id.

   Fractional time zone offsets can be specified
   like "/tz=9:30ACST". NOTE THAT WESTERN HEMISPHERE
   TIME ZONES ARE NEGATIVE NUMBERS! (i.e. /tz=-6CDT/CST)

   The time zone ID strings can be up to 5 characters
   long (default=LOCAL). If no "ddddd" daylight savings
   time zone ID is given, the program does not do
   any daylight savings time conversions.

   If a standard time zone in use, the time shows in
   BLUE. If a daylight savings time is in use, it shows
   in CYAN. If no local time zone is in use, it shows
   in WHITE.

   The time zone string can also be specified in the standard
   Linux time zone format like CST6CDT (note: western
   hemisphere time zone offset values are POSITIVE values in
   this format)

   Time zones can also be set from the keyboard with
   the TZ command

If the user does not specify a time zone on the command line or in the
"heather.cfg" file, Heather attempts to get the time zone from the "TZ="
environment variable. Heather only checks the "TZ=" environment variable
when starting up. If you change it while Heather is running, the change
will not be seen.

Many of Lady Heather's time calculations depend upon having the correct
"UTC offset". This is a count of the number of leap seconds that that have
accumulated since the GPS system was first implemented. It is the number
of seconds of difference between GPS time and UTC time. Lady Heather
normally automatically gets this value from the GPS receiver. It is part
of the GPS almanac data which can take over 15 minutes to arrive from the
GPS satellites. Until the UTC offset is received, Heather will display
a "NO UTC OFFSET" warning.

Some receiver data formats (like NMEA) do not provide the UTC offset value.
You can specify the value to use with the "/uo=" command line option. You
can also force the UTC offset value with the "/rx#=offset" command line
option. For instance with a NMEA receiver use "/rxn=17" User specified
UTC offset values are shown in YELLOW.

If no UTC offset value has been set, Heather attempts to guess an
approximate value. Guessed values will be shown in RED.

Heather uses the availability of the UTC offset value from the GPS
receiver as an indicator that the date/time values reported are valid.
Until the UTC offset has been received, the date/time and other info
is assumed to be incorrect. When the UTC offset value has been received,
the plot data queue is flushed and normal operation is started.

There are several special time zone names. These special time zones
only affect the displayed time unless you specify OT from the keyboard.
Note that there can be multiple names for the same special time zone.

    GPS   - GPS time
    GPST   - GPS time
    UTC   - UTC time
    UT1   - UT1 time
    UT   - UT1 time

    LOR   - Loran time (9 seconds ahead of GPS)
    LORAN   - Loran time (9 seconds ahead of GPS)

    SST/SDT - Solar time
    SOL   - Solar time
    SOLAR   - Solar time

    GMST   - Greenwich Mean Sidereal Time
    GAST   - Greenwich Apparent Sidereal Time
    LMST   - Local Mean Sidereal Time
    LAST   - Local Apparent Sidereal Time

    TAI   - TAI time (19 seconds ahead of UTC)
    TT   - Terrestrial time
    TDT   - same as Terrestrial time
    TCG   - Geocentric Terrestrial Time
    TCB   - Barycentric Coordinate Time
    TDB   - Barycentric Dynamical Time
    BES   - Besselian time

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    MAR      - Mars date and time (official)
    MARS     - Mars date and time (official)
    MSD        Mars date and time (official)
    MTC        Mars date and time (official)
    AMT        Mars date and time (official)

    VEN      - Venus date and time (referenced to J1900 epoch, GPS time scale)
    MER      - Mercury date and time (referenced to J1900 epoch, GPS time scale)
    PLU      - Pluto date and time (referenced to J1900 epoch, GPS time scale)
```

Note that when setting one of these astronomical time
scales you should still specify your local time zone
offset (e.g. /tz=-6LAST/LAST) so that the various
features (like the audible clocks and alarms) that work
with local time will know the correct local time.
You can use the (rather obscure) OT keyboard command
to cause Heather to use the displayed time for these
features. See the description of the audible clocks for more details.

You can also start up in Solar Time mode with the "/bs" command line
option.

The astronomical time scales UT1/TT/TCG/TDB/TCB/MARS,etc
depend upon the current utc "delta-T" value. This
is normally derived +/- 0.5 seconds from the receiver
UTC time using the current leap second offset:
   delta-T = UTC offset + 51.184 seconds.

Delta-T actually changes constantly in an unpredictable manner
and if a more precise value is desired, you can specify it
with the "/uc=" command line option or TE keyboard command.
Heather can also read the delta-T value from the file
"deltat.dat". It tries to do this on startup and at
00:00:16 UTC every day.

You can set up a operating system chron job or script to fetch
the current delta-T value from the net and write it to
the file "deltat.dat". On startup or at 00:00:16 UTC every day
Heather will try to read the current delta-T value from the file.

The special time zone name "UT1" can only be set
using the "-6UT1/UT1" format... the Linux format cannot
be used (since the "1" int "UT1" looks like a time zone offset).
Use the equivalent time zone name "UT" instead.

Also supported are various planetary times: Mars ("MAR" or "MSD"),
Venus ("VEN"), Mercury ("MER"), and Pluto ("PLU"). Mars time is based
upon the NASA definition of Mars time. Mercury, Venus, and Pluto time
are based upon the number of revolutions of the planet around the sun
since 1 Jan 1900 (J1900).

Sorry, no time for Uranus... or Jupiter or Saturn...
these are big blobs of smelly gasses with no
fixed rotation time.

Besides specifying your time zone you should also specify your
Daylight Savings Time (aka Summer Time) calculation method.
The default daylight savings time switching dates are
the US standard. The "/b=" command line option lets you specify
your daylight savings time calculation.

Use "/b=1" for USA, "/b=2" for UK/Europe, "/b=3" for
Australia or "/b=4" for New Zealand. "/b=0" turns off
daylight savings time conversions.

If the rules change or you live in a backwater, you can
specify a custom daylight saving time rule:
    /b=nth1,start_dow,start_month,nth2,end_dow,end_month,hour

    nth1 = start DST on nth occurance of the day-of-week
        if nth1 > 0, count day-of-week from start of month
        if nth1 < 0, count from end of month

    start_dow - start DST day-of-week (0=Sunday, 1=Monday, ... 6=Saturday)

    start_month - 1..12 = January .. December

    nth2 = end DST on nth occurance of the day-of-week
        if nth2 > 0, count day-of-week from start of month
        if nth2 < 0, count from end of month

    end_dow - end DST day-of-week (0=Sunday, 1=Monday, ... 6=Saturday)

    end_month - 1..12 = January..December

    hour - local time hour of switchover (default = 2)

  Example: /b=-1,0,9,2,3,4,6 says to start daylight
            savings time on the last Sunday in September
            and return to standard time on the second
            Wednesday in April at 6:00 local time.

-CONFIGURING THE VIDEO SCREEN SIZE:

   Lady Heather works best with a screen size of at least 1024x768 pixels.
   This is the default screen mode. You can specify other fixed screen modes
   or a custom screen size with the "/v#" command line option or via the '$'
   keyboard menu. The keyboard menu also allows you to tweak the size of the
   text font (Tiny=8x8 Small=8x12 Medium=8x14 Large=8x16).

   WARNING: under Windows the F11 key is used to maximize the display
            true full screen mode (no title bar or edge decoration).
            This will ONLY work if your MONITOR size is supported by
            old-style DirectDraw (i.e. 640x480, 800x600,1024x768,1280x1024).

            If your system does not support DirectDraw and/or your monitor
            size is not supported, HEATHER WILL CRASH. If this happens,
            Use CTRL-ALT_DEL to bring up the Windows Task Manager and
            kill the heather.exe process. If your system does support it,
            you can start Heather in true full-screen mode with the /fu
            command line option. The MAXIMIZE button on the Windows title
            bar is only enabled in "/fu" mode.

            Pressing F11 in maximized true full screen mode will restore
            the screen size.

   WARNING: The macOS version of Lady Heather using XQuartz for the display
            manager does not let you restore the window size to its previous
            size if you maximize the window size. You must manually resize
            the window by dragging the lower right corner of the window.

   Linux can use the F11 key to toggle to/from full screen mode. Under
   macOS, F11 will switch to full screen mode (but may not be able to
   restore the previous screen size).

      /vt   - Text only Video screen
      /vu   - Undersized (640x480) Video screen
      /vs   - Small (800x600) Video screen
      /vm   - Medium (1024x768) Video screen (default)
      /vn   - Netbook (1000x540) Video screen
      /vl   - Large (1280x1024) Video screen
      /vv   - Very large (1440x900) Video screen
      /vx   - eXtra large (1680x1050) Video screen
      /vh   - Huge (1920x1080) Video screen
      /vc=colsXrows - custom screen size (e.g. /vc=1200x800)
      /vf   - startup in (nearly) full screen window mode - this
                        should not be confused with true full screen mode.

      /vi   - invert black and white on screen

   The "$" keyboard menu also lets you change the screen resolution. The
   command letters are the same as used with the "/v" commands. Note that
   under Windows if you select a display size that is larger than your
   screen, Heather will down-scale the screen by dropping pixels/lines...
   which usually looks awful.

   Changing the screen size from the keyboard may cause Heather to drop / add
   items from the display depending upon if it can find space to show them.

   The "/vi" command line option and "$i" keyboard commands swap WHITE and
   BLACK on the screen. It looks horrible, but can be useful for doing
   screen dumps that will be printed on paper... you remember paper, don't you?

The "G~" keyboard command lets you configure the global screen color
palette. Heather uses a palette of 14 colors plus BLACK and WHITE.

The color palette entry assigned to each of the the various plots can be
changed on a plot-by-plot basis. See the PLOTTING section for details...

-CONFIGURING DATA CAPTURE SIZES:

   Lady Heather records several data values from the GPS receiver into
   a circular buffer (called the "plot queue"). Once the plot queue
   fills up, the oldest values are replaced with the newest values.
   The default value for the plot queue size is 3 days of data (at one
   second per point).

   You can change the plot queue size with the "/q=" command line option.
      /q=100000   - 100,000 second queue size
      /q=2000m   - 2000 minute queue size
      /q=300h   - 300 hour queue size
      /q=40d   - 40 day queue size
      /q=5w   - 5 week queue size

   Normally the plot queue is updated once a second. You can change the
   queue update interval with the "/i=" command line option. For queue
   update intervals longer than 1 second, the GPS receiver data values are
   averaged over the queue update interval and the averaged value is stored.
      /i=60   - averages 60 GPS device readings and stores the result
                    in the plot queue.

   These values assume that your GPS receiver outputs data once per second.
   If your GPS device outputs data faster than once per second (see the "!r"
   keyboard command), then these values must be scaled. For instance, if
   your receiver is sending 10 updates per second, "/q=100000" would hold
   10000 seconds of data and "/i=60" would update every six seconds.

   If you change the queue size from the keyboard (using the "/"
   keyboard command) the queue data will be erased. Changing the plot queue
   update interval does not automatically erase the queue data, but the
   plot time horizontal scale factor indication (like VIEW: 5 min/div) will
   not be correct for data that was captured before the update interval was
   changed.

   You can clear the plot queue via the "C" keyboard menu.

   You can disable updating of the plot queue with new data:
      U - from the keyboard toggles plot queue updating
      /u - from the command line toggles plot queue updating

-GPS WEEK ROLLOVER ISSUES

   The GPS system does not actually broadcast a date. It does broadcast the
   number of weeks that have elapsed since the GPS system was first activated.
   However this week counter is only 1024 weeks (around 19 years) long. Once
   the week counter passes 1024 weeks, the date sent by the GPS receiver will
   be wrong (like 20 years in the past wrong).

   Modern GPS receivers attempt to get around this limitation in various ways
   which may delay when the rollover error occurs, but it will eventually
   happen. If Lady Heather sees a date before 2016 from the receiver, it will
   attempt to fix it by adding 1024 weeks to the GPS date/time until the date
   appears to be reasonable. If Lady Heather has "fixed" the GPS date, the
   letters "ro" appear after the date in the upper left corner of the string
   and the date will be shown in YELLOW. Before Heather will attempt to
   automatically adjust the date for rollover errors, the bogus date must
   persist for at least 15 seconds AND the GPS receiver must have the
   "UTC offset" value from the GPS receiver.

   You can force a rollover compensation value with the "/ro=" command line
   option. The rollover correction value can be either the number of 1024
   week cycles to add to the date, or the number of SECONDS to add to
   the date.

         /ro   - apply 1 1024 week rollover to the date
         /ro=1*   - apply 1 1024 week rollover to the date
         /ro=2*   - apply 2 1024 week rollovers to the date
         /ro=12345 - add 12345 seconds to the date
         /ro=0   - disable automatic GPS date rollover correction

-CONFIGURING FILTERS:

   Many GPS receivers have options for filtering their position data in
   various ways and optimizing them for the expected movement environment.

   These command line options allow configuration of the
   various receiver filters from the command line. Note that not all
   receivers support all of these filters.

     /fa - toggle altitude filter
     /fi - toggle ionospheric filter (Motorola)
     /fk - toggle Kalman filter
     /fp - toggle PV filter (position/velocity filter)
     /fs - toggle static filter
     /ft - toggle tropospheric filter (Motorola)

     /fd=# - display filter - the display filter averages # consecutive plot
             queue values to produce a plot point. This display filter does
             not change the raw values stored in the plot queue so can be
             changed freely.

             If the display filter is turned on, the values shown
             at the mouse cursor are the filtered values.

             Be careful when using large display filter values
             with long view time displays. It can take a lot
             of time to process the data on slower machines.

If the filter count is a negative value (including -0
              or 0-) then the PPS and TEMPerature plots are inverted.
              If the display filter value includes a "+" the PPS
              and TEMPerature plots are shown in their regular polarity.
              If no "+" or "-" sign is included the plot polarities are
              not altered. Inverting the PPS and TEMPerature plots makes
              all the Thunderbolt plots track in the same direction.
              You can also do this with the MI keyboard command.
              Also, you can append the '-' or '+' to the filter count
              value (i.e. -10 and 10- are treated the same).

There are also some filter settings only changeable via keyboard commands
in the "F" menu. If the receiver does not support one of these filters
it will not appear in the "F" menu. The "/f" filters listed above are also
accessible from the "F" keyboard menu.

   FC - coordinate filter
   FE - satellite elevation mask angle - satellites below this angle above
        the horizon will not be tracked
   FF - foliage filter
   FI - set Motorola ionosphere filter
   FJ - jamming mode filter
   FL - satellite signal level mask - satellites with signals below this
        setting will not be used
   FM - movement / marine filter
   FT - set Motorola troposphere filter
   FX - PDOP mask / switch setting

Many of the filter settings are shown in the system status column of
the screen display. You can disable showing the filters:
   GY - toggle filter display on/off
   /gy - toggle filter display from the command line

   GX - toggle the DOP (dilution of precision) value display in the
         receiver status information column.
   /gx - toggle DOP display from the command line

The Thunderbolt GPSDO firmware smooths the output of the
temperature sensor with a filtering algorithm. This
filtering can mask and prolong the occasional single
point glitches that the temperature sensor produces. Lady
Heather's default action is to reverse the filtering
that the Thunderbolt firmware does.
Removal of the temperature sensor filter makes the sensor
glitches much more obvious in the temperature plots and
minimizes their effect in the active temperature
control mode. It also makes the temperature display
a little less smooth since you now see the raw sensor
readings that have around 0.01C increments (0.16C on receivers
that have the newer, but lower resolution, temperature sensors).
The "/tj" command line option toggles the temperature sensor
un-filtering mode and the smoothed temperature data is used.

On Thunderbolts and other Trimble receivers you can save the filter
configuration into EEPROM using the "EE" keyboard command.
This will write the complete current receiver configuration into EEPROM.

-LOG FILES

   Lady Heather can write log files of the receiver data and program status.
   The log files can be written in real-time as the data comes in from
   the receiver or from data saved in the plot queue.

   Log files are automatically closed and re-opened once per hour. This
   provides some protection from data loss if your system crashes or loses
   power.

   The contents of the log files depends upon the receiver type.

   Lady Heather supports several different log file formats. The file format
   is determined by .EXTension of the log file name:
      .log - a simple ASCII format log
      .xml - a GPX 1.1 format file that supports extended / user defined
               data types.
      .gpx - a standard GPX 1.0 format file (a standardized XML file oriented
               towards time and location data.
      .kml - a Google KML format location file (only stores time and
               lat/lon/alt)

   Note that .gpx / .xml / .kml files are larger than the .log ASCII files.
   The .xml (GPX 1.1) log format contains the most comprehensive data
   including pretty much the compete receiver configuration.

   To start logging data from the keyboard:
      WLW or LW - write a new log file from real-time data
      WLA or LA - append real-time data to a log file
      WLS or LS - stop logging real-time data

   From the command line:
      /w=file   - set log file name to Write to
      /wa=file - set log file name to Append to

   You can write a log file from data in the plot queue:
      WA - writes ALL data in the plot queue to a log file
      WP - writes the data from the area of the plot queue that is
             being displayed on the screen.

             Note that the *tow* time-of-week field in logs generated from
             queue data is not the official GPS time-of-week, but is just
             a sequential number.

             If writing the plot window queue data to a log file
             AND the plot queue is full and warping AND the queue
             updates are not paused AND the plot window covers
             all of the queue data, then there may be a glitch
             at the beginning of the log output file. Several
             seconds of the latest data can appear at the start
             of the log data.

   You can delete files:
      WD - deletes a file

   Normally Heather updates the log file every second (or every time a
   new receiver data point come in). You can configure the log update
   interval.

```
   WLI or LI     - set the log update interval  -or-
   /l[=seconds]  - from the command line


Normally Heather does not write the satellite constellation data (sat PRN,
azimuth, elevation, signal level) to the log file.  You can enable logging
of the satellite constellation data:
   WLC or LC - toggle logging of satellite constellation data
   /ld       - from the command line
               Note that the sun is logged as satellite PRN 256 and
               the moon as PRN 257.


Normally Heather writes unfiltered data to log files.  If the display
filter is enabled (FD keyboard command) you can toggle the writing of
filtered data to the log file:
   WF  - toggle writing of filtered data to the log file.


Besides data logs, Heather also supports writing a debug log file:
   WX  - write debug log file  -or-
   /dl[=file]  - from the command line (if a file name is not given
                 "debug.log" is used.


Heather also supports writing a raw receiver data capture file:
   WY          - write debug log file from the keyboard
   /dr[=file]  - from the command line (if a file name is not given
                 "heather.raw" is used.


In ASCII format logs, the data separator can be changed from a TAB to
a comma with the command line option:
   /ls  - toggle log file value separator between TABs and COMMAs


You can disable comments in log files from with the command line option:
   /lc - toggle writing any comments to the log file
         Note that disabling log comments means Heather cannot
         calculate the date of a log entry or the log data interval
         because these values are stored as special comments.

         ALSO: to read a log file that was written without comments,
         the /lc command must be in effect,  otherwise the file will not
         be recognized as a log file because Heather uses the "#" comment
         line on the first line of the file to help it recognize the file
         as a potential log file.  XML/GPX logs don't have this limitation.



You can disable logging of detected errors with:
   /e   - toggle logging of detected errors in the log file


Lady Heather can read in log files and show the data in the plot area.
Reading in a log file first erases the plot queue the pauses the plot
queue updates from live incoming data.  You can then scroll around the
the logged data using the normal plot viewing commands.  You can resume
processing of receiver data using the "U" keyboard command.,, you might
want to first clear the plot queue data ("C" keyboard menu).

   R       - read a file (with .log .xml .gpx file extension)
   /r=file - from the command line
```

Note that If you read in a log file, Heather should first
be configured ("/rx#" command line option) for the receiver
type that created the log file.

Heather can also write a raw receiver data log file... every byte from
the receiver is written to the raw data file:
    WY - write raw incoming receiver data to a file -or-
    /dr[=file] - from the command line (if a file name is not given
                    "heather.raw" is used.

The "/rs=filename" command line option can be used to read data from
a simulation file (a raw receiver data capture image). For simulation
mode to work there MUST be a GPS receiver connected to the computer.
The receiver data is ignored, but the data stream is needed to provide
pacing to Lady Heather. The receiver can be a different type than the
simulation file as long as it is providing some sort of data stream and
the baud rate has been set to match the connected receiver.
Simulation mode may not work correctly with some receiver type (mainly
SCPI devices that require two-way polling to get data from the receiver)

For instance you have a Venus receiver connected at 115200 baud and want
to process a Ublox simulation file. Try the command line:
    heather /rxu /br=115200 /rs=ublox.raw

Log file can be automatically dump on a scheduled basis. See the help
section on AUDIBLE CLOCKS for details.

-TIME DISPLAYS

    Lady Heather has three main time displays:
        1) The date/time block in the upper left hand corner of the screen
        2) A digital clock display
        3) An analog watch display.

    The date/time block is always shown. It contains the time / time zone,
    the date, the GPS week number, the GPS time-of-week, and the "UTC offset"
    leap second count. It also indicates whether the GPS receiver is running
    in GPS time mode or UTC time mode and the validity of the receiver time.

    If a GPS week rollover condition has been detected and is being
    compensated for, the date is shown in YELLOW and is followed by " ro".

    The time in the time block is normally shown if BLUE if daylight savings
    time is not being applied, CYAN if daylight savings time is in effect,

    The time can be shown in a few different formats:
      /tp - shows time as fraction of a day
      /tq - shows time as total seconds of the day

    The digital clock display is located between the satellite information
    data and the plot area, It is normally CYAN in color. If the GPS
    receiver reports invalid time, it shows in RED. If not UTC leapsecond
    offset is available, it shows in YELLOW.

```
   GZ  - from the keyboard toggles the digital clock on/off
   /gz - from the command line

Clicking on the digital clock display (or just under the satellite
information display) will zoom the digital clock display to full screen.
Cicking again will restore the screen to its previous state.
Note that short clicks might be ignored... particularly on devices like
UCCM receivers that only output time updates every two seconds.  It can
help to hold down the mouse button until the screen changes.


You can control the format of the digital clock:
   TM   - toggles between a seconds resolution clock or a millisecond clock
   /tsz - from the command line

   TW   - toggles between a 24 hour clock and a 12 hour AM/PM clock
   /ti  - from the command line

   TJ   - toggles between a Julian date.time clock and a normal clock
   /tsz - from the command line



The watch display is located either in the upper right hand corner of
the screen or to the right of the plot area.  The watch outline is
normally shown in WHITE.  It is drawn in RED if the GPS reports that the
time is not valid,  and in YELLOW if no UTC leapsecond offset is available.

   GW  - from the keyboard toggles the watch on/off
   /gw - from the command line

Clicking on the watch display on the screen will zoom it to full
screen.  Clicking again will restore the screen to its previous state.
Note that short clicks might be ignored... particularly on devices like
UCCM receivers that only output time updates every two seconds.  It can
help to hold down the mouse button until the screen changes.


You can label the watch face with a "brand name".  On small screens there
might not be room to show the brand name:
   /tb       - toggles labeling of the watch face
   /tb=name - sets a brand name on the watch face. Any "_" in the brand
               name is converted into a space.  The brand name can be two
               lines long.  Separate the lines with a "/".  A two line
               watch name does not show the date in the clock face.
   /tb=      - sets the watch "brand name" to the day of the week


You can specify the watch face style with the "O" keyboard command.
Enter "O" from the keyboard and then, on the edit line, enter:
  W0 - normal Roman numeral clock
  W1 - decimal hours clock
  W2 - "*" hour markers
  W3 - 24-hour Roman numeral clock
  W4 - 24-hour decimal hours clock
  W5 - 24-hours "*" hour markers
```

The watch display includes a representation of the moon at its current
location in the sky and with its current phase. The moon is shown in
YELLOW if it is visible and GREY if it is below the horizon. The sun
is shown in a similar manner. The watch display also flags when the
moon is new, quarter, or full. Also "blue" and "black" moons are shown.

You can disable the sun/moon images in the satellite map and watch
displays using the command line options:
    /kj   - toggle sun/moon drawing
    /kj=0 - disable sun/moon drawing
    /kj=1 - disable sun drawing
    /kj=2 - disable moon drawing
    /kj=3 - disable sun and moon drawing

Note that the watch display is not updated while a keyboard command
menu is being displayed and the "GB" option is in effect that allows
maps and/or the watch to be displayed in the plot area.

The ZC keyboard command will zoom the clock display to full screen.
The ZW keyboard command will zoom the watch display to full screen.
    Clicking the mouse will toggle between the zoomed watch and digital
    clock displays.
    Clicking in the upper left hand corner of the screen will restore
    the screen to normal mode.
    Note that short clicks might be ignored... particularly on devices
    like UCCM receivers that only output time updates every two seconds.
    It can help to hold down the mouse button until the screen changes.

The ZB keyboard command will zoom the watch and satellite map displays
to full screen overlayed on each other.
    Clicking the mouse will switch to the ZV display where you can then
    click again to select another display to zoom to full screen.
    Clicking in the upper left hand corner of the screen will restore
    the screen to normal mode.
    Note that short clicks might be ignored... particularly on devices
    like UCCM receivers that only output time updates every two seconds.
    It can help to hold down the mouse button until the screen changes.

Note that the watch or clock do not have to be enabled on the main
screen for the zoomed displays to work. Pressing any key (except '\')
will restore the main display screen if it has been zoomed. '\' will
dump a .GIF image of the zoomed screen to the file "xxxx.gif" where xxxx
is the receiver type (if you press SPACE to bring up the keyboard help
screen, the file name used will show up by the '\' entry)

The "/ta" toggle command line option shows dates in the European
          the European dd.mm.yyyy format instead of the normal 12 Oct 2016
          format.

--PENDING LEAPSECOND DISPLAY

   Many GPS devices report when a leapsecond adjustment has been announced.
   Heather shows this in the receiver status column. Leapsecond announcements
   are generally made 6 months in advance.

      If the receiver supports leapsecond announcements but no leapsecond
      is pending it shows "No leap pend" in GREEN. If a leapsecond
      adjustment has been announced it shows "Leap pending" in YELLOW.

      Many receivers send enough enough information to determine the date of
      the leapsecond event. If this information is available the leapsecond
      status shows a countdown clock like "Leap 45 days". If the receiver
      does not report the exact date of the leapsecond, Heather assumes it
      will be on the last day of June or December and indicates this guess
      by "Leap 45 days?".

      As the time of the leapsecond nears, the countdown clock starts showing
      hours, then minutes, then seconds until the leapsecond. When showing
      hours, any fractional hour count is rounded up, so the countdown
      clock will show 2 hours then 59 minutes.

      Some receivers (like the Z3801A and Z3812A have firmware bugs that
      expect a leapsecond announcement no more than 3 months in advance.
      These receivers will display an invalid leapsecond date while the
      pending leapsecond is more than three months in the future and may
      take several days to figure out the proper leapsecond date once the
      erroneous date has passed.

--DATE AND CALENDAR DISPLAYS

   Lady Heather can display the date in various calendar formats. The
   calendar type is selected by a command line option:
      /d - default Gregorian calendar
      /da - Afghan calendar
      /db - Mayan Haab calendar
      /dc - Chinese calendar
      /dd - Druid calendar
      /dh - Hebrew calendar
      /di - Islamic calendar
      /dj - Julian date
      /dk - Kurdish calendar
      /dm - Modified Julian Date (MJD)
      /di - Indian civil calendar
      /dp - Persian calendar
      /ds - ISO date
      /dt - Tzolkin calendar
      /dv - Bolivian calendar
      /dx - Xiuhpohualli (Aztec Haab) calendar
      /dy - Mayan calendar
      /dz - Aztec Tonalpohualli calendar
      /dyyyymmdd - force date to year yyyy, month mm, day dd for testing

   For several of the calendars you can specify an epoch correction factor
   for the date calculations. The correction factor is the number of days
   (+ or -) to add to the default date calculation. This is to compensate
   for various interpretations of when the calendar should begin.

```
     /db=days   -  AZTEC_HAAB
     /dc=days   -  CHINESE
     /dd=days   -  DRUID
     /dt=days   -  TZOLKIN
     /dv=days   -  Bolivian
     /dx=days   -  Xiuhpohualli
     /dy=days   -  MAYAN
     /dz=days   -  AZTEC Tonalpohualli
```

Heather has a "greetings" calendar function. This displays a message
at the bottom of the plot area whenever a special event or day occurs.
The greetings calendar is read from the file "heather.cal". If no
calendar file is seen, Heather uses an default internal calendar file.

You can disable the greeting calendar with:
   /gn - toggles the greetings calendar from the command line

The calendar file should be placed in the same directory as the
"heather.cfg" file. The proper directory is shown when you do a
"HEATHER /?" command line or enter ? from the keyboard.

When a calendar file date is matched to the current date, the message is
displayed at the bottom of the plot window until erased (G G command)
or the start of the next day. If multiple calendar entries match the
current date, only the first match is shown.

Fields on each line in "heather.cal" are:
   nth   - event happens on the n'th occurance of DAY in the month
           (negative values are from the end of the month)
           (positive values are from the start of the month)
           (zero means the event occurs on a fixed day number)
           Values >= 100 are codes for holidays that must be specially
           calculated.

   day   - The DAY of the month if nth is 0
           The DAY of the week if n'th is not zero
           (0=Sunday, 1=Monday, ... 6=Saturday)

   month - (1=January ... 12=December 0=ignore this entry)

           If DAY < 0 then MONTH is the day-of week code.
           This allows for doing days like Friday the 13th (0, -13, 5)

   text - The text to display when the event occurs.

Comment lines can start with # * / or ; in column 1

-AUDIBLE CLOCKS, ALARMS, and SCHEDULED EVENTS

   Lady Heather has several audible clock modes that signal the time via
   the computer's sound system.

   The singing clock:
     The singing clock signals the time by playing .WAV files at fixed
     intervals throughout the hour. It is activated via:
        TH #S   - from the keyboard
        /th=#s - from the command line

     The number (#) is the number of times per hour to play the files.
     For instance /th=4s says to play a sound file 4 times per hour (every
     15 minutes).   The files to play should be placed in the default
     heather directory are named:
        "heather_songxx.wav" where xx indicates the minutes.

     if # is 0 or not given, the singing clock is disabled.

     If the singing clock is activated a double musical note symbol is
     shown near the upper left hand corner of the screen.

   The cuckoo chime clock:
     The cuckoo chime clock signals the time by playing .WAV files at the
     hours and at intervals throughout the hour. It is activated via:
        TH #H   - from the keyboard
        /th=#h - from the command line

     The "heather_chime.wav" file is played x times on the hour (where x is
     the current hour). In addition the file is played once (#-1) times
     during hour. For instance /th=4h says to play the file x times at the
     hour and 3 more times times during the hour (every 15 minutes). The
     file "heather_chime.wav" should be less than once second long.

     If # is 0 or not given, the chime clock is disabled.

     If the cuckoo chime clock is activated a single musical note symbol is
     shown near the upper left hand corner of the screen.

   The ships bell clock:
     The ships bell clock signals the time in ships bells format. Ships bells
     sound on the hour and half hour. Ships bells mode is activated by:
        TH 1B   - from the keyboard enables ships bell mode
        /th=1b - from the command line enables ships bell mode
     The bell sound is from the file "heather_bell.wav" This file should be
     less than two seconds long.

     if 0B is used instead of 1B, the ships bell clock is disabled.

     If the ships bell clock is activated a '#' symbol is shown near
     the upper left hand corner of the screen.

    Note that the Windows versions of Heather plays sound files via the
    PlaySound() system call, the Linux versions use system() to spawn a
    /bin/sh command to the "aplay" program, and macOs spawns a /bin/sh
    command to the "afplay" program. If your system does not support these
    sound file player programs, modify the function "play_tune()"
    in file heather.cpp

```
EGG TIMER ALARMS

Heather supports two types of alarms:
  An "egg timer" mode where a countdown timer is started and when it
  reaches 0, the file "heather_alarm.wav" is played. The alarm sound is
  usually played continuously (and the screen flashes) until a key
  is pressed which cancels the alarm.  You can set the timer to only
  play the sound file once by following the time interval with the
  letter "o".  You can set the timer to automatically repeat by following
  the time interval with the letter "r"


  To start the timer from the keyboard:
    TA 5S    - sound the alarm continuously after 5 seconds
    TA 10M   - sound the alarm continuously after 10 minutes
    TA 3H    - sound the alarm continuously after 3 hours
    TA 2D    - sound the alarm continuously after 2 days
    TA 10MO  - sound the alarm once after 10 minutes
    TA 20MR  - sound the alarm continously every 20 minutes
    TA 30MOR - sound the alarm once every 30 minutes

  You also set the timer from the command line with the "/na=" command
  line option:
    /na=5s  - (see the keyboard commands listed above for the various
               timer modes)

  If a countdown timer is enabled and the watch display is enabled, a
  YELLOW tick mark is shown at the edge of the watch face.


ALARM CLOCK MODE:
  Heather has an alarm clock mode where you specify a time (and optional
  date) for the alarm to sound. The commands are the same as for the egg
  timer, but you specify a specific time (and optional date) for the
  alarm instead of an interval.  Alarm clocks always a repeating alarm
  amd must be manually canceled.

  TA 14:15:16   - sound the alarm continuously every day at 14:15:16
  TA 14:15:16o  - sound the alarm once every day at 14:15:16
  TA 8:0:12 2016/12/25  - sound the alarm at 8:00:12 on 25 December 2016
  TA 8:0:12 12/25/2016  - sound the alarm at 8:00:12 on 25 December 2016

  You also set the alarm from the command line with the "/na=" command
  line option:
    /na=14:15:16
    /na=14:15:16,2016/12/15 (note non-space char between time and date
    /na=14:15:16o2016/12/15  is needed on command line alarms)

  Dates can be of the form yyyy/mm/dd, dd/mm/yy, or dd/mm/yyyyy.
  If only a date is given, the time is assumed to be 00:00:00 on that date.

  If an alarm clock is enabled and the watch display is shown, a
  RED tick mark is shown at the edge of the watch face.

  Note that if you have one of the astronomical time zones set (such
  as GMST) alarms are normally based upon your LOCAL time zone time and
  NOT the displayed astronomical time.  You can force the alarms to be
  triggered based upon the displayed astronomical time with the "OT"
  keyboard command. This is the reason you should include your time zone
  hour offset when using an astronomical time scale. e.g.  /tz=GMST6GMST
```

KEYBOARD SCRIPT FILE WAITS
  If, in a keyboard script file, you follow and egg timer or alarm clock
  time with the letter "W", the processing of the script file will
  be paused until the alarm triggers.

AUTOMATIC PROGRAM EXIT

  You can configure Heather to automatically quit at a given time or after
  a given time interval. This works just like the egg timer mode or alarm
  clock mode. The commands to do this are:
     TX - from the keyboard - see TA command for details
     /nx - from the command line - see /na command for details

AUTOMATIC LOG FILE DUMPS

  You can configure Heather to automatically write the plot queue data
  to a log file at a given time or after given time interval. This works
  just like the egg timer mode or alarm clock mode. The commands to do
  this are:
     TL - from the keyboard - see TA command for details
     /nl - from the command line - see /na command for details

  The format for the scheduled log dump files defaults to ASCII. You
  can change this with command line options:
     /fg - toggle .GPX format for scheduled log file dumps
     /fx - toggle .XML format for scheduled log file dumps

  If the command setting contains the 'o' character
  the file "tblog.log" is re-written each time a dump
  occurs. Without the 'o' character, the file
  "tbyyyy-mm-dd-#.log" is written (where #) is an incrementing
  sequence number. See the /fg and /fx commands for using .gpx and .xml
  log formats.

  Example: to write the log dump to the file "tblog.log" every 30 minutes
  use the command line option "/nl=30mor" or "TL 30mor" from the keyboard.
  (the 30m says do it every 30 minutes, the "o" says to do it to
   one file, the "r" says to do it on a repeating basis).

AUTOMATIC SCREEN IMAGE FILE DUMPS

  You can configure Heather to automatically write a screen dump image
  to a .GIF file at a given time or after given time interval. This works
  just like the egg timer mode or alarm clock mode. The commands to do
  this are:
     TD - from the keyboard - see TA command for details
     /nd - from the command line - see /na command for details

  If the command setting contains the 'o' character
  the file "tbdump.gif" is re-written each time a dump
  occurs. Without the 'o' character, the file
  "tbyyyy-mm-dd-#.gif" is written (where #) is an incrementing
  sequence number.

  Example: to write the screen image to the
  file "tbdump.gif" every 30 minutes use the command
  line option "/nd=30mor" or "TD 30mor" from the keyboard.
  (the 30m says do it every 30 minutes, the "o" says to do it to
   one file, the "r" says to do it on a repeating basis).

  Screen dump mode is indicated on the screen by a '!'
  or !! next to the time mode indicator on the first
  line of the screen.

If a leap-second is observed (seconds value = 60) then Heather
automatically does a screen dump to the file "leap_sec.gif" On some
receivers this might capture the previous second (xx:xx:59)... such is life.

Note that when a screen or log dump happens, Heather first creates the
the file "tblock", next the image/log file is written, and then the
"tblock" file is deleted. This can be used by external scripts to
minimize (but not totally eliminate) the chances of an external
script/program accessing the dump file while it is being written.

Note that alarm and dump times are matched to the GPS receiver time down
to the second. If the receiver skips the time stamp of the alarm/dump
event it will NOT be triggered.

-SETTING THE SYSTEM TIME FROM GPS

   By far the best way to keep your system time accurate is to use an
   Internet time protocol like NTP. This can keep the system clock highly
   accurate and monotonic (i.e. it does not jump back and forth, it smoothly
   increments at a rate to keep the system time accurate.

   However, if you do not have an internet connection available, Heather can
   set the system time from data available from the GPS receiver. Heather
   can set the system clock on demand, every minute, every hour, every day,
   or whenever the system clock diverges from the GPS time by more than "x"
   milliseconds.

      TS - from the keyboard - set the system clock once
      /tso - from the command line - set the system clock once when Heather
             starts up and has valid time from the GPS receiver.
      /tsm - from the command line - set the system clock once a minute
             (the time is set at hh:mm:06 local time)
      /tsh - from the command line - set the system clock once an hour
             (the time is set at xx:00:06 local time)
      /tsd - from the command line - set the system clock once a day
             (the time is set at 04:05:06 local time)
      /tsa - from the command line - set the system clock anytime the system
             clock differs from the GPS time by over 40 milliseconds (Windows)
             or 10 milliseconds (Linux, macOS)
      /tsa=msecs - from the command line - set the system clock anytime the
             system clock differs from the GPS time by over "msecs"
             milliseconds

   Most operating systems require program that manipulate the system clock
   to have administrator / root permissions. You can check if Heather can
   can the system clock by issuing a "TS" command from the keyboard. Within
   a few seconds you should hear a BEEP if the time set command was accepted.

   Heather sets the system clock by "jamming" the time into the system. It
   makes no attempt to keep the clock monotonically increasing. This can
   be a bad thing for some systems, but, well, beggars can't be choosers.

   GPS receivers typically send out a message once per second that contains
   the time. Heather uses when the last character of this message arrives
   to set the system clock. One problem is that different receivers send the
   the time message at different offsets from the true time. Also variations
   in the computer, operating system, receiver configuration, etc used can
   affect when the message actually arrives.

   You can set the message offset time (in milliseconds) with the command
   line option:

      /tsx=milliseconds

   Milliseconds can be positive (message arrives AFTER the true time value
   encoded in the receiver time message) or negative (message arrives BEFORE
   the true time)

   If you do not set a message offset value, Heather uses a default value
   for a typical model of that receiver. For maximum accuracy you
   you should set the message timing offset adjustment factor for your
   particular system and receiver configuration. Heather can help determine
   the message offset adjustment to use.

   For this to work, your system time must be set accurately. If you are

using a network time protocol like NTP, you should be good to go.
Otherwise let Heather set the system time with a "TS" command from the
keyboard.

Then issue the "TK" keyboard command. This starts measuring the
difference between the system clock and the receiver timing message times.
It builds a histogram table and also calculates an average value of the
message offset time. For the histogram to work, the system and GPS time
need to be within two seconds of each other.

When measuring the message timing the timing jitter is plotted in the G0
plot and the message offset time is shown in the G9 plot. Also ADEV
(Allan variance) tables are shown for the message offset time and jitter.
The G0 and G9 plots do not show up as options in the "G" keyboard menu,
but are available...

Let the system run for a minute or so. Then issue the "TK" command
again. This should print a message at the bottom of the plot area like:

    # msg offset time: /tsx=246.00 msec   max hits:10 points:34   avg:254.35
sdev:10.16

   There are two values of interest in this message:
     /tsx=246.00   and   avg:254.35

These values should be close to each other. The "/tsx" value is the
most common value in the histogram and the "avg:" value is the average
value seen. Some receivers do not send the timing message in a consistent
manner. If the "/tsx" value and the "avg:" value are not close or the
"SDEV:" (standard deviation) value is large then using the receiver for
setting the time may give optimum performance. The "TK" measurement
mode also writes a ".jit" file with the histogram values and measurement
results.

With some receivers, Lady Heather's periodic polling
of the receiver for status info, etc can put spikes in
the timing measurements. If this is a problem use the
"/it" command line option to disable the sending of commands
to the receiver. The spikes should not affect the
message offset time measurements but can affect the
message jitter standard deviation measurements. Issue
the "/it" command again to re-enable status polling.

Tell Heather what your system message offset is with the command line
option:
   /tsx=msecs - msecs is the value shown the the measurement results
                   described above.

Note that the "TK" timing measurement mode flogs the system CPU rather
hard. You can see CPU usage stats approaching 100% in this mode. This can
produce heating that can affect the system clock rate after a while.
Ideally you should do the timing measurement test when the system has
been running normally (for you) for a while to let it settle down at your
typical operating temperature. The difference is probably not much, but
in the world of precision timing, every little bit helps.

-SETTING THE GPS RECEIVER POSITION and DOING ANTENNA LOCATION SURVEYS

   First a word about ALL the various values that Lady Heather reports...
   The various values shown by Lady Heather are reported to a decimal
   point precision represented by the data fields that the receiver
   messages contain. Just because your receiver says the altitude is
   123.4567890 meters does NOT mean the altitude is actually ACCURATE to
   that many decimal places... Heather just shows what the receiver is
   sending out... garbage in, garbage out.

   Lady Heather shows the latitude/longitude/altitude position that the
   receiver is currently reporting. It can show the position in various
   formats. From the keyboard:

      GLD - decimal format
      GLS - degrees/minutes/seconds format
      GLR - decimal radians
      GLG - decimal grads (400 grads in a circle)
      GLI - decimal mils (6400 mils in a circle)
      GLE - ECEF (Earth Centered Earth Fixed) coordinates
      GLH - Maidenhead grid square (ham radio)
      GLU - UTM (Universal Transverse Mercator)
      GLN - NATO MGRS (Military Grid Reference System)

      GLF - show altitude in feet
      GLM - show altitude in meters

      GLP - private location - latitude and longitude are not displayed.
              (so you can publish screen shots without revealing the location
               of your evil mad scientist volcano lair to the world)

      /gld , etc - set the location format from the command line. The
              command line option to use is the same as the keyboard commands
              listed above with a leading "/" or "-".

      /t" - toggle between degrees.minutes.seconds / decimal location format
              (this is a legacy command for compatibility with earlier
               version of Lady Heather).

   Heather also records the lat / lon / alt data in the plot queue and
   can display the location data in the plot area or as an X-Y "scattergram"
   of distance from a reference point. The plot queue locations are saved
   as single precision floating point numbers are limited to a resolution
   of around 5-10 feet.

      G1 - from the keyboard - toggle the latitude plot on and off
      G2 - from the keyboard - toggle the longitude plot on and off
      G3 - from the keyboard - toggle the altitude plot on and off
      GV - from the keyboard - toggle the lat/lon/alt (G1 / G2 /G3) plots
             on and off

THE LOCATION FIX SCATTERGRAM

  Heather can plot a "scattergram" of the location fix data relative to
  a fixed reference point. The reference point is the point that was
  active when the scattergram was activated. The scattergram is
  automatically enabled if a position survey is started. Every hour the
  color of the dots in the scattergram changes (14 colors are used).

  The scattergram grid defaults to a resolution 3 meters or 10 feet
  per division (with +/- 5 divisions from the center reference point.
  You can change the scattergram grid scale factor with a command
  line option:
     /tm=meters_per_division
     /t'=feet_per_division

  Normally the scattergram image is created from the double precision
  location data as it comes in from the receiver. If you change the
  resolution scale factor of the scattergram then the scattergram is image
  is re-created from the single precision plot queue data. The resulting
  scattergram image will be very "sparse" because the plot queue locations
  have a resolution of 5-10 feet per point.

  GI   - toggle the lat/lon "scattergram" on and off.
  /gi - toggle the lat/lon "scattergram" on and off.
  ZL   - zoom the scattergram to full screen (ok, it doesn't actually
         fill the screen... needs some work)

Clicking the left mouse button on the lat/lon/alt information display
of the scattergram will zoom the lat/lon scattergram to full screen.
Clicking again will restore the normal screen display,
Note that short clicks might be ignored... particularly on devices
like UCCM receivers that only output time updates every two seconds.
It can help to hold down the mouse button until the screen changes.

ANTENNA LOCATION SURVEYS

  Most GPS timing receivers and disciplined oscillators require a fixed
  location for the antenna and its position must be known to very high
  accuracy for optimum operations. These devices can usually operate
  in a "position hold" mode or a "3D fix / navigation" mode. Position
  hold mode is also called "overdetermined clock" mode.

  The accurate fixed location can be input manually by the user or the
  receiver can automatically determine it by doing a "self-survey" where
  it collects data for a period of time and averages/filters the readings
  to come up with an accurate location. Most receiver self-surveys last
  for at least 20 minutes and may take hours. Some devices let you
  specify the time interval to survey for.

  Lady Heather can also do a precision median survey to determine the
  location. This collects data for several hours (48 hours is the default)
  and statically processed the data using medians and averages over
  several time intervals to come up with a precise location that is usually
  better than the standard receiver position survey. The GPS satellite
  orbits repeat on a roughly 12 hour basis (with 6 hours of visibility
  for each orbit). A 48 hour survey allows for 4 repeats of the complete
  satellite constellation and allows the precision survey to mitigate
  a lot of signal problems such as multi-path distortion. If you cannot
  wait for 48 hours, 24 hours works well, and 12 hours is OK.

  If a precision survey is done, Heather logs the readings and results in

a ".lla" file. Precision surveys can be done on receivers that do not
support a "position hold" mode. After the survey completes you can
check the ".lla" file for the results. The calculated position will be
shown at the end of the file.

Trimble Thunderbolt receivers do not have a command for entering the
position using double precision numbers. Heather tries to write the
calculated precision location or the manually set location to the
device by doing single point self-surveys until one is within a foot
of the desired location. This process takes an indeterminate amount
of time!

Interrupting a standard survey or precise position survey save
will save the current location using the lower precision
TSIP command. So will exiting the program while a survey is
in progress.

Some GPSDO devices (mainly telecom surplus devices) do not have a
"navigation" mode that lets them output 3D fixes. You cannot do a
precision survey on these devices.

To enter a location manually and set position hold mode:
    SL   - from the keyboard. The latitude and longitude can be in
           decimal or degrees/minutes/seconds format like 30d40m50.60s

To start a native receiver self survey:
    SS   - from the keyboard. It will request a value for the length
           of the survey. Depending upon the receiver type the length
           will be in samples, seconds, minutes, or hours. A few
           receivers can only perform a fixed length survey. If a survey
           is in progress, issuing SS again tries to stop the survey.
   /ss[=length] - from the command line. If a length is not specified
           the survey length is device dependent (maybe 20 minutes or 1-3
           hours). If a survey is in progress and Heather is started with
           /ss=0, Heather attempts to stop the survey.

To start a precision survey:
   /sp[=hours] - from the command line - do a precision survey,
    SP   - from the keyboard. It will request the length of the survey
           in hours (up to 96 hours long)... the longer the better. If a
           survey is in progress, issuing SP again will stop the survey.

To force position hold mode:
    SH   - from the keyboard - Some receivers remember their set position
           hold locations and use that when position hold mode is
           selected Other receivers will use the current position as
           the hold position.

To force 3D navigation mode mode:
    SN   - from the keyboard

Trimble Thunderbolt and related devices support several other positioning
modes. See the device manual for more information (0xBB packet).

    S0   - automatic 2D/3D navigation mode selection
    S1   - single satellite mode
    S2   - 2D mode (S2 actually sets receiver mode 3)
    S3   - 3D mode (S3 actually sets receiver mode 4)
    S4   - undocumented (3D?) mode (S4 actually sets receiver mode 2)
    S5   - DGPS reference mode (disables timing functionality)

```
        S6   - 2D clock hold mode
        S7   - overdetermined clock mode (same as SH)
```

INCLUDING and EXCLUDING SATELLITES

  Several receivers let the user exclude certain satellites from being
  tracked, force or restore the inclusion of satellites, or operating
  the receiver in a single satellite mode.

    SO   - from the keyboard controls single satellite mode. Trimble
           receivers can be configured to track a specific satellite or
           automatically select the highest elevation satellite. For
           other receivers Heather offers to track the highest satellite
           or the use can select a particular satellite... eventually
           that satellite will fall below the horizon and the receiver
           won't be tracking anything... Non-timing receivers are not able
           to work in a single-satellite mode.

    SX   - from the keyboard controls excluding/including of satellites.

CONFIGURING THE SATELLITE CONSTELLATION TYPES TO USE

  Many modern GPS receiver are actually GNSS receivers... they can work
  with more than one satellite system: GPS/GLONASS/BEIDOU/GALILEO/SBAS/
  QZSS/IMES, etc. Heather lets you control which satellite systems to
  track. Note that most GNSS receivers have limits on which systems can
  be enabled at the same time. Consult your receiver manual for
  information on what it can do.

    SG   - from the keyboard controls the GNSS satellite system configuration.
           You will be prompted to input a string of characters that
           indicate which systems to use. The currently enabled systems
           will be offered as the default entry.

-THE SATELLITE INFORMATION DISPLAYS

    Heather has three main satellite information displays:
       1) The satellite information table
       2) The satellite position map
       3) The satellite signal maps

    The satellite information table lists the currently visible and tracked
    tracked satellites and various information about them:
       Satellite PRN (that identifies the satellite)
       Satellite azimuth angle
       Satellite elevation angle
       Satellite signal level

    Depending upon the receiver type the information table can also show
    extra things like: doppler shift, tracking state, carrier phase, code
    phase, clock bias, URA (range accuracy).

    A normal GPS receiver may be able to track around 14 satellites at once.
    More modern receiver that can also track GLONASS, GALILEO, BEIDOU, SBAS
    and other satellites might be tracking over 32 satellites at once.
    Normally Heather expects to show up to around 14 satellites, and
    displaying 32 satellites at once can cause problems fitting all that data
    on the screen. You can control the size and format of the satellite
    information table display:

       SI   - from the keyboard
       GCT   - from the keyboard
       /si=# - from the command line.

    Clicking the left mouse button on the satellite information display
    will zoom the sat info it to full screen.
    Clicking again will restore the normal screen display,
    Note that short clicks might be ignored... particularly on devices
    like UCCM receivers that only output time updates every two seconds.
    It can help to hold down the mouse button until the screen changes.

    If you don't use the SI commands to specify the maximum number of
    satellites to show information for, Heather will show up to 14 satellites.
    The satellite information display size automatically adjusts as more
    satellites are seen. If you set a value, Heather forces the display size
    to that value.

    If you input a number without a +/- sign, Heather displays all the
    information it has for up to the specified number of satellites.

    If you input a negative number, Heather shows the short form of the
    info for up to that number of satellites. The short form display frees
    up enough space to the right of the satellite info display to show
    the sun / moon information display. If the receiver type in use does
    not report any extended information, the sun/moon info display is
    automatically enabled.

    If you input a number with a "+" sign, Heather shows the short form
    information in two columns (but does not leave room for the sun / moon
    information). This helps with displaying information for receivers that
    can track multiple satellite systems.

    If you follow the number with a "t", only satellites that are being
    actively TRACKED are shown in the satellite information table and
    satellite map display.

The more rows of satellite information being displayed, the less space
there is for the plot area. Combine lots of rows of satellite info
with the digital clock display on a small screen and you can wind up with
an unusable plot display or unreadable keyboard menus. Turning off the
digital clock display (GZ) can help with the screen formatting.

If more satellites are visible that you have allocated space for, the
info for the excess satellites is not shown.

Satellites that are being actively tracked are shown in GREEN
Satellites that are visible, but not being tracked are YELLOW
Excluded/disabled/blocked satellites are shown in BLUE
Unhealthy satellites are shown in RED (if the receiver reports satellite
health)

Heather graphs the number of actively tracked satellites in the plot
window:

    GCG - toggles the tracked satellite count plot ON and OFF.
           The satellite count plot is shown in CYAN at the bottom of
           the plot window. Each minor division equals one satellite.
           For screen resolutions less than 800x600, each minor division
           represents two satellites.

You can sort the satellite information table using the following
keyboard commands. You can sort in descending order by including
"-" character. Ascending sort is the default.
If you sort by one of the values, the header of that column is shown
in GREEN. If you don't specify a sort, the table is sorted by PRN
number in ascending order.

    GCA - sort by azimuth
    GCD - sort by doppler
    GCE - sort by elevation
    GCP - sort by PRN (default)
    GCS - sort by signal level

Besides the satellite information table, Heather has two other satellite
information displays... the satellite map and the signal level map:

```
THE SATELLITE POSITION MAP:

The satellite map shows a map of the currently visible / tracked
satellites. It is enabled by:
    GM   - from the keyboard
    /gm  - from the command line
    ZM   - zoom the satellite map to full-screen
    ZB   - zoom the satellite map and watch to full-screen

Clicking on the map/watch display on the screen will zoom it to full
screen.  Clicking again will restore the screen to its previous state.
Note that short clicks might be ignored... particularly on devices
like UCCM receivers that only output time updates every two seconds.
It can help to hold down the mouse button until the screen changes.

The satellite map shows the satellites as circles on an azimuth/elevation
grid.  The size of the circles depends upon the current signal level.
Satellites that are currently being tracked are shown as filled in
colored circles.  Satellites that are visible are shown as hollow circles.

The position history of each satellite is shown as a "trail" behind the
satellite.  The trail has small time marker circles drawn on it.  Solid
circles indicate hours and hollow circles indicate half hours. The trail
shows the last 6 hours of the satellite position.  The drawing of satellite
position trails can be toggled with:
    /st - from the command line - toggle display of satellite trails
    /sd - from the command line - toggle display of time markers on the
          satellite trails


The satellite position map includes a representation of the sun at its
current location in the sky.  The sun is shown in solid YELLOW if it is
visible and as a hollow yellow circle if it is below the horizon. The sun
symbol is shown surrounded by sun rays in order to distinguish it from
satellites.

If both the satellite position map and the watch display are enabled they
will overlay each other on the screen if there are not two places
available to draw them (the GB and /gb commands allow one of the displays
to be drawn to the right of the plot area).

The GB command is labeled "Both map and adev tables" in the keyboard menu
but is more properly "allow map displays in the plot area."

Note that on SCPI, UCCM, STAR, and ACRON receivers the message that sends
the satellite position and signal data takes a long time for the receiver
to send.  Heather only requests it once per minute at hh:mm:33.  These
satellite information messages block the sending of time code messages
and causes time code skip errors... Heather automatically ignores any
time code errors caused by these messages.  Heather also adjusts any
alarm times so that they will not occur during the interval where the
receiver may not be sending time codes.
```

THE SIGNAL LEVEL MAPS:

The signal level maps show a map of the satellite signal levels as a
function of satellite azimuth/elevation. The values used are the AVERAGE
value of the signal level of all satellites seen a given position in
the sky. The signal level map can be shown in several different formats.

signal level map   - shows a color coded display of the average signal
                     level seen across the sky. Data is interpolated
                     to fill in spaces between observed positions.

data   - this is similar to the signal level map, but the map
                     is not interpolated between missing points.

azimuth   - shows a map of the relative signal level seen at
                     each azimuth angle.

elevation weighted - shows a map of the relative signal level seen at
                     each azimuth angle weighted by 1.0/elevation.
                     Weighting the signal levels by the inverse of the
                     satellite elevation compensates for the normal
                     behavior of satellite signals being better at
                     higher angles and better shows the effects of
                     antenna obstructions.

elevation   - shows a map of the relative signal level seen at
                     each elevation angle. Note that a YELLOW tick mark
                     appears at the edge of this map. This is the
                     elevation angle where satellite signal levels begin
                     to rapidly drop off. A BLUE tick mark indicates the
                     satellite elevation mask setting.

From the keyboard:
    GQ - toggle signal level map on and off
    SAS - toggle signal level map on and off
    SAW - toggle signal level elevation weighted data map on and off
    SAE - toggle signal vs elevation map on and off
    SAA - toggle signal level vs azimuth map on and off
    SAD - toggle raw signal level data map on and off

From the command line
    /gq - toggle signal level map on and off
    /gqs - toggle signal level map on and off
    /gqq - toggle signal level map on and off
    /gqw - toggle signal elevation weighted level map on and off
    /gqa - toggle signal level vs azimuth map on and off
    /gqe - toggle signal vs elevation map on and off
    /gqd - toggle raw signal level data map on and off

 SAA - displays relative signal level seen at each
       azimuth angle
 SAW - displays relative signal level seen at each
       azimuth angle, with the signal strength
       weighted inversely with elevation angle. This
       highlights low elevation antenna blockages and
       low orbit angles that have no satellites.
 SAE - displays relative signal level seen at each
       elevation angle
 SAS - displays color coded map of the absolute signal
       level seen at each azimuth/elevation point.
 SAD - shows raw satellite signal level data points
       (much like the GM satellite position map)
 SAC - clears the old signal level data and starts

collecting new data. You can also do this with
        the CM keyboard command

You can zoom the various satellite maps to full screen from the "Z"
keyboard menu. Any keypress (except '\') will exit the zoom screen mode.
A '\' will dump the screen image to a .gif file.

    ZX - zoom the watch, satellite, and signal quality maps to full screen
         overlayed on each other
    ZY - zoom the satellite map and signal quality map to full screen
         overlayed on each other

    ZS - zoom the Signal quality map to full screen
    ZQ - zoom the signal Quality map to full screen
    ZA - zoom the elevation weighted Azimuth map to full screen
    ZR - zoom the Relative signal level map to full screen
    ZE - zoom the signal level vs Elevation map to full screen
    ZD - zoom the raw signal level Data map to full screen
         If once of the signal quality maps is shown you can click the
         mouse to show all the signal quality maps (ZU command)

    ZU - zoom the all signal level maps to full screen
    ZV - zoom the watch, sat map, signals full screen
         If the ZU or ZV screen is showing you can click the mouse
         on one of the displayed items to zoom it to full screen.

Note that it can take several hours for the map to fill in. The more
satellites that your receiver can track, the faster the map fills in.

Note that the satellite position and signal level maps are affected
by the settings of the elevation mask and signal level mask filters.
If you want a complete view of your antenna system performance then first
set those filters to their lowest settings.

The signal level maps show the current setting of the satellite elevation
mask filter with a dotted circle at the elevation mask angle. You can
disable the display of the elevation mask angle circle:
    GJ - from the keyboard
    /gj - from the command line

You can reset the satellite map and signal data with the keyboard command:
     CM   - clear out the satellite map data

You can write the current signal level information to a ".sig" file.
The signal level file contains some comments and a list of az/el/snr
values.
     WZ   - writes the signal level data to a file.

You can read a ".sig" file from the "R" keyboard command. Note that
reading a ".sig" file pauses updating the plot queue with new values.
You can resume plot queue updates with the "U" keyboard command.

```
-SUN and MOON INFORMATION DISPLAY

   Besides displaying information about the GPS satellites, Lady Heather
   calculates the position of and other relevant information about the sun
   and moon:

     Sun azimuth and elevation in the sky
     Moon azimuth and elevation and phase (illumination percentage)
     Sun rise/transit/set times
     Moon rise/transit/set times
     Current solar equation of time.
     Current moon "age" from the start of the lunar month (new moon).

   The sun/moon information table is shown to the right of the satellite
   information table.  Enabling the sun/moon information automatically
   selects the short form of the satellite information display.

   The sun rise and set times are based upon the sun's position above the
   horizon. There are several definitions of sun rise/set:
       Physical - when the top edge of the sun crosses the horizon
       Official - when the sun crosses 0.833 degrees below the horizon
                   (this angle is for atmospheric refraction effects)
       Civil    - when the sun crosses 6 degrees below the horizon
       Nautical - when the sun crosses 12 degrees below the horizon
       Astronomical - when the sun crosses 18 degrees below the horizon
       Islamic  - when the sun crosses 18 degrees below the horizon at sunrise
                   or 17 degrees below the horizon at sunset
       User defined - you can specify any angle above (positive) or
                       below (negative) the horizon.


   Sun/moon times are shown as local time zone times for the current date.


   To display the sun (or moon) rise/set times use:
       TR    - from the keyboard

       TR P  - display "Physical" sunrise/sunset times
       TR O  - display "Official" sunrise/sunset times
       TR C  - display "Civil" sunrise/sunset times
       TR N  - display "Nautical" sunrise/sunset times
       TR A  - display "Astronomical" sunrise/sunset times
       TR I  - display "Islamic" sunrise/sunset times
       TR #  - (where # is the user defined solar horizon angle[s]
               negative values are for angles below the horizon, positive
               values are for angles above the horizon)
               You can specify independent solar rise/set horizons like:
                   TR -18,-17

       TR M  - display moon rise/transit/set times

       /sr=# - from the command line where # is the sunrise type selection
               character shown above.  For example
                   /sr=c says to show civil sunrise/sunset times.

   Heather can also play sound files at rise/set or transit (solar noon):
       Include an "*" after the command:
           TR O*
           /sr=o*

   Heather plays the file "heather_sunrise.wav" at sunrise/sunset.
   Heather plays the file "heather_noon.wav" at solar noon or moon transit.
```

If the sun/moon files are enabled a double musical note appears next to
the rise/noon times. Otherwise, the horizon type letter is used. The
horizon type always appears next to the set time.

The standard rise/set sound is a rooster crowing and the noon sound is
a church bell.

If moon rise/set times are selected (TRM) the sound files are played at
moon rise/transit/set and not sun rise/noon/set. They are the same files
used for sun times... there are not separate moon files.

Normally Heather assumes that the GPS receiver is at a fixed position
and the sun/moon rise/set times are only recalculated when Heather
starts up or once per hour at xx:00:26 local time. If you are
working with a moving receiver you can cause Heather to continuously
recalculate the times:
    Include an "!" after the command.
        TR C!
        /sr=c!

You can use both "*" and "!" on the same command.

-THE PLOT WINDOW

   The receiver data gathered by Heather and stored in the plot queue
   is shown in the plot window at the bottom of the screen. The data
   that is stored and shown is dependent upon the receiver type.

   The plot area is divided into a header area at the top and a plot
   grid below it. The header shows the various plot scale factors and
   reference (center line) values along with a statistical value for each
   plot.

   Clicking on the plot header area will zoom the plot display to full
   screen Cicking on the zoomed plot header area will restore the screen
   to its previous state.
   Note that short clicks might be ignored... particularly on devices
   like UCCM receivers that only output time updates every two seconds.
   It can help to hold down the mouse button until the screen changes.

   Moving the mouse cursor into the plot area will show the values of
   the data points at the cursor and the time that the value was acquired.
   Also the time interval from the first point shown in the plot area
   to the mouse cursor is shown.

   If a plot has not been enabled, its header entry will not be shown.

   You can put a title string at the bottom of the plot window with the
   keyboard command:
      GG - label the plot window with a title.
      Titles are also saved to/loaded from log file comments.

      If a plot title contains an '&&' then the '&&' is replaced
      with the current oscillator disciplining parameters.

      If a plot title contains an '&t' then the '&t' is replaced
      with the current time

      If a plot title contains an '&d' then the '&d' is replaced
      with the current date

   Heather also uses the plot title feature for displaying things like
   calendar events, errors, and certain status information. Setting a user
   defined title usually inhibits these automatic titles.

   Heather usually only updates the parts of the screen that have changed.
   You can force Heather to fully redraw the screen from the keyboard:
      GR - redraw the screen

   You can zoom the plot window display to full screen:
      ZP   - zoom the plot window to full screen

   Data plots can be individually configured for either fixed scale factors
   or can be automatically scaled. Most plots default to be automatically
   scaled and centered to fit the plot window.

   If a plot has a fixed scale factor, the plot is labeled like:
       DAC=(25 uV/div)

   An automatically scaled plot is labeled like:
       DAC~(25 uV/div)

The "reference" value for a plot is the value at the horizontal center
line of the plot area (indicated by small '<' and '>' marks at the left
and right edges of the plot area.

Plots can be individually configured for either fixed reference
values or can have a "floating" reference value where the plot is
automatically centered in the plot area.

If a plot has a fixed reference value, the plot is labeled like:
    ref=<100 uV)

A plot with a floating (auto centered) reference value is labeled like:
    ref~<100 uV>

The plot grid is divided into horizonal and vertical major divisions
which are further divided into minor divisions. Time is represented by
the horizontal axis and data values by the vertical axis.

The "V" (view) keyboard command controls the view window into the plot
data queue. This sets how much data is shown in the plots. The
view value can be either in minutes per (major) division or the time
interval to be shown. Note that the specified view interval is
automatically tweaked/rounded to fit a multiple of the plot grid size.

If the selected plot view interval is larger than one plot queue sample
per pixel, the plot queue data is down-scaled by dropping values.
Note that if down-scaling is in use the display of time skip markers, etc
may not be accurate / complete. Markers or other events that do not
happen on a displayed sample may not always be shown because all
non-displayed samples are skipped over while processing the plot queue
data for display.

    VA - shows all data currently in the plot queue. The plot horizontal
          scale factor (time per division) is adjusted to fit the data
          onto the screen. The data is down-scaled by dropping values.

    VT - auto scale the time axis as data comes in. The plot view
          interval is automatically adjusted as data come in. Once the
          plot window fills, it is scrolled left a few major divisions
          and a new scale factor is calculated.

    V# - set the plot time to # minutes per horizonal major division

    V#S - set the plot horizontal scale factor so that # seconds of
          data are shown

    V#M - set the plot horizontal scale factor so that # minutes of
          data are shown

    V#H - set the plot horizontal scale factor so that # hours of
          data are shown

    V#D - set the plot horizontal scale factor so that # days of
          data are shown

```
    V#W - set the plot horizontal scale factor so that # weeks of
          data are shown

    X   - set the plot scale factor to 1 hour per division

    Y   - set the plot scale factor so around 24 hours of data are shown
          If the plot area is being shared with a map display (GB command)
          this "day" plot view time may be reduced to less than 24 hours.


    You can also set the plot view time with the /y command line option:
       /y=3  - set view to 3 minutes per division
       /y=3h - set view to 3 hours (can also use #S, #M, #D, #W as
               described above for seconds, minutes, days, and weeks)
       /y     - set the view interval to 24 hour mode


Normally the plots show the last data acquired and scroll to the left
as new data comes in.  You can "review" older data using keyboard commands
to change the starting point in the plot.  When you are in plot review
mode the plot header shows:
    "Review (DEL to stop):"  or "All (DEL to stop):"
and scrolling of the plot data is inhibited.


    HOME  - move to the start (oldest) of the plot queue data
    END   - move to the end (newest) of the plot queue data
    LEFT  - move the plot forward one horizontal division
    RIGHT - move the plot back one horizontal division
    PG UP - move the plot forward one screen
    PG DN - move the plot back one screen
    UP    - move the plot forward one hour
    DN    - move the plot back one hour
    >     - move the plot forward one day
    <     - move the plot back one day
    ]     - move the plot forward one pixel
    [     - move the plot back one pixel
    DEL   - exit plot review mode and return to normal scrolling


If you are in VIEW ALL mode and click the LEFT mouse button at a point in
the plot, the plot will be centered at that point and the view interval
will be set to 1 minute per division.  The clicked point will be marked
with a "v" at the top of the plot area and a '^' at the bottom.  You can
return to the marked point by pressing '0' or '@'.

When in "auto" or "all" mode, clicking on the plot to zoom in to a point
on the plot will cancel that mode and set normal PLOT REVIEW mode.

If you (QUICKLY) right click on the graph it will mark the point
and center the display on it (without zooming).  You
can return to the mark with the '@' or '0' keyboard command.

You can hold the RIGHT mouse button to scroll around in the plot.  Move
the mouse cursor to the horizontal center of the plot and HOLD the right
button down.  Moving the mouse cursor to the left or right of the plot
center scrolls the plot in that direction.  The further you move the mouse
from the center of the plot, the faster the plot will scroll.


You can disable the mouse from the command line:
    /km  - toggle the mouse functionality
```

You can disable the keyboard from the command line. The only way to
exit Heather when the keyboard is disabled is to click the CLOSE button
on the operating system title bar (or using the "kill process" command
of your operating system)
```
    /kq  - toggle the keyboard enable  (earlier version of Heather used
           /kk for this, but that conflicted with the temperature control
           PID commands)
```


PLOT MARKERS

   If you see something interesting a a plot, you can set a marker at that
   point. Move the mouse cursor to that point and press "=". A numeric
   marker (from 1 to 9) will show at the top of the plot area.

   To center the plot on a marker, press that number on the keyboard.
   Pressing '0' or '@' centers the plot on the last place you
   left-clicked in the plot area.

   If you have just gone to a marker, pressing '+' will center the plot
   where where the cursor was previously located.

   To delete a marker, select that marker from the keyboard and press '-'
   The GU keyboard command will clear all markers.

   Note that the "+" and "-" keyboard commands have a different meaning
   if you have not just selected a marker... they move the last selected
   plot up or down and lock the plot scale factors and reference line
   value (see the description below).

   Plot markers are also saved in and reloaded from log files.

TIME SEQUENCE and HOLDOVER ERRORS

   Heather expects to see a time message from the GPS device every
   second. The time code in the message should always increment
   by one second. If an error is detected in the time code sequence
   (like skipped or duplicated time codes) these are flagged by a
   RED tick mark at the top of the plot. If you place the mouse cursor
   in the plot area and press '%' the plot will jump to the next time
   sequence error.
```
      GE  - toggles display and finding of time skip markers
      /ge - toggles display and finding of time skip markers
```

   If a GPSDO enters a holdover state that is indicated by a solid RED
   line at the top of the plot area. The '%' key will also move the plot
   display to the next holdover event.
```
      GH  - toggles display and finding holdover events
      /gh - toggles display and finding holdover events
```

CONTROLLING THE DISPLAYED PLOTS

   The "G" keyboard menu controls the plots that are displayed and their
   configuration.

      GP - usually a "PPS" (Pulse Per Second) output related value
      GO - usually an oscillator frequency output related value
      GO - usually an EFC DAC or PPS sawtooth correction related value
      GT - usually a temperature related value

      G1 - receiver latitude
      G2 - receiver longitude
      G3 - receiver altitude
      G4 - receiver speed or TFOM (time figure of merit)
      G5 - receiver course or FFOM (frequency figure of merit)

      G6 - average DOP (dilution of precision) value
      G7 - (currently unused)
      G8 - (currently unused)

      G9 - message timing offset
      G0 - message timing jitter

      GA - ADEV plots (see the section of ADEVs)

Selecting one of the plots listed above brings up a sub-menu of options
for controlling that plot. The descriptions listed below use the "GP"
plot, but can be used with any of the plots. Replace the lower-case "p"
shown below with the letter of the plot you want to manipulate.

      Gp<cr> - toggles the plot display ON or OFF
      GpP   - toggles the plot display ON or OFF
      /gP   - from the command line - toggles plot "P" ON or OFF

      If the previous key was not a plot marker command (where
      a following + or - key will undo a marker) you can
      use the '+' or '-' keys to move the last selected
      graph up or down 0.1 divisions.   That graph's scale
      factor and center reference values will be "fixed".

         +   move the last selected plot up 0.1 major divisions
         -     move the last selected plot down 0.1 major divisions

      GpI   - toggles inversion of the plots' display ON or OFF. Inverting
               a plot can make it easier to compare how one parameter (like
               temperature) affects another one (like DAC voltage)
      /mi   - invert PPS and TEMPerature plots

      Gp/ - select plot statistic selection menu. Heather can calculate
            various statistics of the plot data shown in the plot window:
        GP/A   - average value
        GP/R   - RMS value
        GP/S   - standard deviation
        GP/V   - variation
        GP/N   - minimum value
        GP/X   - maximum value
        GP/P   - span - difference between maximum and minimum values
        GP<cr> - turns off the plots' statistic display

      G/p - you can set the statistic to show for ALL enabled plots
             with this command

```
GpA  - toggles auto-scaling mode for ALL plots
/ma  - from the command line

GpC  - select the color to display the plot in

GpL  - toggles a linear regression trend line for the plot.  The
         trend line is drawn and it's equation (as a function of time)
         is shown as the plot title.

Gp=  - removes drift from a plot by subtracting the linear regression
         trend line slope from the plot

GpS  - set the plot scale factor in units per division  -or-
        enable auto scaling of the plot.
/mP      - from command line doubles plot P scale factor
/mP=val - sets plot P scale factor from the command line (0 = auto)
/m       - doubles all plot scale factors from the command line
/m=val  - multiplies all plot scale factors by "val"

GpX  - toggles auto-scale mode for the selected plot

GpZ  - set the plot zero reference value (the value at the horizontal
        center line of the plot) to a fixed value  -or=  enable auto
        centering of the plot.
/zP       - toggles plot P auto-centering from the command line
/zP=val  - sets plot P zero reference line value the command line
            (0 = auto center)

GCG  - toggles the tracked satellite count plot ON and OFF.
        The satellite count plot is shown in CYAN at the bottom of
        the plot window (each minor division equals one satellite)

GpF  - calculate an FFT (Fast Fourier Transform) of the selected
        plots' data.

           The data to be analyzed starts at the beginning of
           the plot window and end when the max fft size points
           or the end of the plot data are reached.  The
           data is sampled from the plot data at the viewing
           interval (seconds/pixel).

           The calculated FFT bins are shown as seconds with the
           lowest frequencies to the left and highest to the right.
           Moving the mouse cursor within the plot area shows the
           various FFT bin values.

           The max FFT size is set by the /qf[=#] command line option.
           (1024 points if not given,  /qf is 4096 points,
           otherwise it is whatever is set (must be a power of 2). If
           the number of data points in the plot queue to less than
           the FFT size, the FFT size is reduced accordingly.

           Note that a FFT requires the input data to be bandwidth
           limited to below the sample frequency or else you will.
           get spurious values due to aliasing.  Set the display
           display filter count to at least the value shown as
           the "view interval" in minutes/division.

           The FFT plot option defaults to doing a single
           FFT of the selected plots' data when the FFT command was
           given.  The O L keyboard command can be used
           to enable a "live" FFT that gets recalculated
           every time a new point is added to the plot.
```

The O D keyboard option toggles the FFT display value
format between raw values (default) and dB's.

Whenever an FFT is calculated, the first point of the plot
queue data analyzed by the FFT is marked with MARKER 1 and
the last point is marked with MARKER 2.

You can apply an averaging filter to the displayed plots (see the
section on FILTERS for more details.
   FD - set the display filter count.

Normally Heather displays the OSC related parameter values in ppb
(parts-per-billion) or ppt (parts-per-trillion) which can cause
Europeans to wander off in a daze of confusion and angst.
You can display the OSC related value with an exponent using:
   /tx - toggle OSC value displays with eXponent

TEMPERATURE DISPLAYS

Lady Heather can display the temperature readings in several
different temperature scales (I bet you didn't know there are
so many!) by using one of the following command line options:

      /tc   - show Celcius temperatures (default)
      /td   - show DeLisle temperatures
      /te   - show Reaumur temperatures
      /tf   - show Fahrenheit temperatures
      /tk   - show Kelvin temperatures
      /tn   - show Newton temperatures
      /to   - show Romer temperatures
      /tr   - show Rankine temperatures
      /ty=# - show temperatures to # decimal places

-WRITING SCREEN DUMPS

   Heather can write .GIF or .BMP image files of either the entire screen
   or just the plot area. Dumps can be either as the screen appears or
   in "reverse video" where BLACK and WHITE are swapped. Reverse video
   dumps are useful for printing.

     WS - write screen to image file
     WR - write reverse video screen to image file

     WG - write plot (graph) area of the screen to image file
     WI - write reverse video plot (graph) area of the screen to image file

   You get a beep at the start and end of the dump.

   The '\' keyboard command can be used to do a quick full screen .GIF dump
   with a single keystroke. It does not bring up a menu that prompts for a
   file name. This can be useful because redrawing of the plot area after
   entering the file name from the normal screen dump menu can cause
   problems with some parts of the screen not being updated before the
   screen dump happens. The "quick" screen dump is done to file
     "xxxxx.gif"
   where "xxxxx" is dependent upon the receiver type.

   If you start to select a reverse video screen dump (even if you do not
   complete it by using the ESC key) the reverse video attribute will
   will be used for any following '\' initiated screen dumps. The same
   applies to normal polarity screen dumps.

   If the mouse cursor is in the plot area when a screen dump is done, an
   "X" will be drawn in the plot area of the dump.

-GPSDO and HOLDOVER CONFIGURATION

   GPS Disciplined Oscillators (GPSDOs) use the GPS satellite signals to
   steer a precision oscillator to a precise frequency (usually 10.0 MHz)
   over long periods of time. This "disciping" process corrects for normal
   oscillator frequency drift, aging, and temperature effects.

   The steering of the oscillator frequency is usually done by a phase locked
   loop (PLL) circuit in the GPSDO that compares the current frequency to
   the GPS timing signals. A GPSDO controls the oscillator frequency by
   using a digital to analog converter (DAC) to drive the oscillator's
   electronic frequency control (EFC) signal.

   If a GPSDO loses lock on the GPS satellites it can enter a HOLDOVER mode
   where it attempts to guess the compensation that it needs to apply to the
   oscillator in order to keep it on frequency. Many GPSDOs can be
   forced into HOLDOVER mode manually by the user for testing, etc.

   Heather has some keyboard commands for controlling holdover mode and
   oscillator disciplining:

     HE - enable manual holdover
     HX - exit manual holdover
     HH - toggle holdover mode on/off

Besides HOLDOVER mode, some GPSDOs let the user manually control the
oscillator EFC signal.

    DD - completely disable oscillator disciplining
    DE - re-enable oscillator disciplining
    DS - set the oscillator EFC DAC to a given value.

The plot area normally shows when the device is in holdover by a RED
line at the top of the plot. You can turn this off with:
    GH - from the keyboard toggles the holdover plot display
    /gh - command line option toggles display of holdover events
          in the plot area.

Heather shows the amount of time of the current ot last holdover event.
The value is shown in GREEN if the holdover event ended before Heather
was started. It is shown in YELLOW if a holdover event occured after
Heather was started. It is shown in RED if holdover mode is currently
active.

GPSDO DISCIPLINING CONFIGURATION PARAMETERS:

    Some GPSDOs let the user configure various parameters of the oscillator
    disciplining PLL system.

    GPSDO control parameters are accessible from the "&" keyboard menu.
    Not all GPSDOs support all of these settings.

    The "&" keyboard command brings up the oscillator parameter
    and satellite max signal level display screens.
    To return to normal display mode you can press SPACE
    or ESC or "&" again.

    The "&" display screen shows the current GPSDO parameters and also
    a table of the maximum signal level seen from each satellite.

      &d - sets the PLL damping factor
      &t - sets the PLL time constant
      &g - sets the PLL gain (i.e. Hz change per volt of EFC)
      &p - sets the pullin range (for UCCM devices)

      &i - sets the DAC initial voltage
      &n - sets the DAC minimum voltage
      &x - sets the DAC maximum voltage

      &h - sets the DAC allowable range high value
      &l - sets the DAC allowable range low value

      &f - sets the max frequency offset threshold
      &j - sets the jam sync threshold

      &a - autotune Thunderbolt oscillator parameters

    Some GPSDOs (like the Nortel/Trimble NTBW and NTPx devices) let the user
    control the GPSDO settings, but do not save them in EEPROM. You can cause
    Heather to configure the GPSDO at startup with these command line options:

```
   /ud=val - set oscillator disciplining damping value
   /ut=val - set oscillator disciplining time constant value
   /ug=val - set oscillator disciplining gain value
   /up=val - set pull-in range value (for UCCM devices)
   /ui=val - set oscillator disciplining initial dac value
   /un=val - set oscillator disciplining minimum dac value
   /ux=val - set oscillator disciplining maximum dac value
   /uh=val - sets the DAC allowable range high value
   /ul=val - sets the DAC allowable range low value

   The &L (/ul) and &H (/uh) commands use an undocumented TSIP command
   for reading and setting the what appears to be the allowable EFC DAC.
   range.  You can alter the low and high values with the UNDOCUMENTED
   &L and &H keyboard commands.  These values might just be for reporting
   the allowable DAC range to the software or they might do something
   else!  Also, /ul and /uh on the command line may not always work...
   it seem to work from the keyboard, though.

                CAVEAT EMPTOR IF YOU USE/CHANGE THEM!


 When you write a log file an OSC_GAIN comment is written to the log
 file.  This allows the computation of osc drift and tempco from logged
 data acquired on a unit that does not have the same osc gain (or that
 is not connected to a tbolt).  If the osc gain has been loaded from a
 log file,  it is shown in YELLOW.
```

OSCILLATOR DRIFT RATE and TEMPERATURE COEFFICIENT VALUES

```
   For Trimble GPSDO devices, the '&' screen display shows an oscillator
   drift rate and temperature coefficient value.  These are calculated
   from the data points shown in the plot window.

   For the best results,  select a plot display interval
   that covers a fairly long time interval with well
   behaved DAC and/or TEMP values.

   You should be able to get a decent value for the drift rate
   with 24 hours of data. The oscillator drift rate value makes the most
   sense if the temperature is stable so that temperature effects on the
   oscillator frequency are minimized.

   The oscillator temperature coefficient value makes the most sense if
   the temperature is allowed to change in a linear ramp.  This is
   easy to achieve with Heather's active temperature control mechanism.
```

AUTOMATICALLY SETTING GPSDO OSCILLATOR PARAMETERS:

```
   Heather can automatically configure Thunderbolt style GPSDO parameters
   to values better suited for precision time and frequency applications
   that their default "telecom" values.

   The "&a" keyboard command sequence starts the "auto-tune" process.

   Before running auto-tune you should:
     1) Wait for the unit to stabilize with (relatively)
      steady DAC, OSC, and PPS values.
```

2) Set your antenna elevation mask angle (F E keyboard command)
    to 0 and signal level mask (F L keyboard command) to 1. This allows
    collection of signal level data across the full sky.

    3) Clear your signal level history (C M keyboard command)

    4) Let Heather run for at least 6-12 hours to build
    up a new satellite signal level map.

    5) Issue the "&a" auto-tune command and wait for it to
    complete

Heather will spend a couple of minutes tickling
your oscillator and determine good values for the
osc gain and initial dac voltage. The time constant
will be set to 500 seconds, and the damping to 1.0
Also the AMU (signal level) mask will be set to 1.0
and the satellite elevation mask to midway between the horizon
and where your average signal level begins to fall off.

The values will be written to the configuration EEPROM.
You can then manually change any of the parameters
that may not suit your needs.

Note that non-Thunderbolt GPSDOs (such as the NTBW and NTPx telecom
devices) do not all support saving disciplining parameters to EEPROM
and some do not allow users to change the disciplining parameters.
You can use "/d" command line options for setting the PLL parameters
from the command line.

If you run the auto-tune command on non-Thunderbolt devices then
only the satellite elevation mask (and perhaps the signal level mask)
values will be set.

ACTIVE GPSDO TEMPERATURE CONTROL

GPS Disciplined Oscillators are very precise devices and their
precise oscillators and circuity can be sensitive to temperature,
other environmental conditions (air pressure, humidity, etc), and
power. You can maximize a GPSDOs performance by minimizing changes
in these values.

Heather has the ability to actively control the environmental
temperature of GPSDO devices that regularly (like every second) report
their temperature to a high level of resolution (like less than 0.1C).
The Trimble Thunderbolt series of devices is particularly good at this.
Early models have a temperature sensor with a resolution of around
0.01C and later models used an inferior version of the sensor with
around 0.1C resolution.

Heather uses a PID control algorithm driven by the GPSDO temperature
sensor readings to PWM (pulse width modulate) a temperature control
device (such as a fan or a peltier device).

You specify the desired control temperature in degrees C. A value
of 0 says to turn off temperature control.
    TT   - from the keyboard
    /tt=degrees - from the command line

When temperature control is activated an DOWN_ARROW, EQUAL_SIGN, or
UP_ARROW is shown next to the temperature reading at the top of the

screen. They mean that the temperature control PID is calling for
cooling, holding temperature, or heating.

Heather uses the RTS and DTR serial port modem control lines to control
the fan or peltier (there is some legacy code in there that could
be activated to work with a parallel port).

RTS is the temperature controller enable (+12=off, -12=on)
DTR is the heat (-12V) / cool (+12V) line.
(note that some serial ports may have different voltage ranges like
 +/- 6V)

The DTR line is updated once a second with a pulse whose width is
proportional to how hard to drive the fan/peltier. Use the line to
control a transistor or solid state relay. The RTS line can be
used to enable the temperature control device. RTS and DTR will be
set to +12V when Heather exits.

Simple implementation:
   Isolate the Thunderbolt in a box (I use a corrugated cardboard box),
   set the control temperature below the typical unit operating temp
   but above normal room temp. When Heather signals COOL turn
   send power to a fan to move room air into the box. You want the
   fan to move enough air to cool the unit, but not so
   much air that the temperature drops by more than 0.01C
   per second. The indicator of too much airflow is a
   temperature curve that spikes down around 0.1C several
   times per minute. Too little airflow shows up as a
   curve that oscillates around 0.25C about set point over
   a couple of minutes. Good airflow should show a
   temperature curve stable to with 0.01C with a period of
   between 1 and 3 minutes.   Generally you do not want
   the fan to blow directly on the unit (mine is surrounded
   by foam). You want to gently move air through the
   box. It can help to include a large thermal mass in
   the box (I use a 2kg scale weight, other people use water).

   Placing the GPSDO power supply in the same controlled environment
   as the GPSDO can improve system performance. BE AWARE OF WHAT
   MIGHT HAPPEN IF A POWER SUPPLY OR CONTROL SYSTEM FAULT CAUSES
   OVERHEATING OR A FIRE!

   One thing to try is to disable the fan and closely monitor the
   temperature see how warm the device becomes in the event of a fan
   failure. Try and use an enclosure that keeps the maximum device
   temperature to safe levels. An enclosure with too much insulation
   is not a good thing here...

TUNING THE TEMPERATURE CONTROL PID

  The temperature control PID is adjusted via the "K" keyboard menu or
  "/k" command line options. The "K" keyboard menu works a bit
  differently than the other keyboard menus! It does not bring up any
  sub-menus. It brings up an edit line where you enter a command letter
  optionally followed by command values. Commands that expect a value
  (or values) are shown with an "=" sign here. You do not type the "="
  sign, just the letter and the value(s) separated by a space or comma.

  From the command line you DO enter the "=" to set a value. For instance
  you would set the PID parameters with:
     K 1.5 45 2 100   from the keyboard "K" menu or

```
      /kk=1.5,25,2,100    from the command line


    A= Autotune temperature PID
      A 0  - abort autotune
      A 1  - full autotune with all settling delays
      A 2  - don't wait for temp to get near the control setpoint
      A 3  - don't wait for PID to stabilize

    P= PID Proportional (gain) term
    I= PID Integral control term
    D= OID Derivative control term
    F= PID Filter time constant
    K= P D F I   (sets all foure major PID "K" terms)

    W  config PID with canned slow time constant PID values (default)
    X  config PID with canned fast time constant PID values
    Y  config PID with canned very fast time constant PID values
    N  config PID with canned medium time constant PID values

    G= Scale factor (loop gain correction)
    H  show PID debug info
    L= Load disturbance test value
    O= filter Offset term
    R= Reset integrator value
    S= Scale factor (loop gain correction)
       (use /kg= from command line for this since /ks controls sounds!)
    T= Test PWM output  (cool_msecs, heat_msecs)
    Z  reset and restart temperature PID control loop
    9= set auto-tune step size
    0  test with crude temperature values




  EXPERIMENTAL OSCILLATOR CONTROL PID

    The Thunderbolt GPSDO is a very versatile device that offers the
    user great flexibility and control.  You can manually control the
    oscillator EFC DAC and measure the oscillator frequency and PPS error.
    This provides the ability to implement a user-defined GPSDO control
    loop.  Lady Heather has an implementation of such a control PID. It
    is activated from the "B" keyboard command or /x command line options.

    The experimental oscillator control PID commands work like the
    temperature control PID commands described above.

      K .1 0 100 100     from the keyboard "B" menu or
      /xk=.1,0,100,100   from the command line

      P= Proportional gain (P)
      I= Intergral time constant (I)
      D= Derivative time constant (D)
      F= Filter time constant (F)
      K= P D F I   (sets all four PID "B" terms (P D F I))

      N  use pre-configured PID #1 values
      W  use pre-configured PID #2 values
      X  use pre-configured PID #3 values
      Y  use pre-configured PID #4 values

      H  show PID debug info
      L= Load disturbance test value
```

```
          O= Filter offset
          Q= Post-filter depth
          R= Reset integrator
          S= Scale factor (loop gain compensation)
          Z  Reset and restart oscillator control PID
          0  Disable oscillator control PID
          1  Enable oscillator control PID
```

-GPSDO / TIMING RECEIVER PPS and FREQUENCY OUTPUT CONTROL

   GPS timing receivers and discipline oscillators usually have one
   or more timing output signals. Almost all have a 1 pulse-per-second
   (PPS) output signal. On many devices this can be programmed for
   other frequencies. Other devices also have other auxiliary output
   signals that can be controlled.

   The "P" keyboard menu provides commands for controlling these output
   signals.

   ANTENNA CABLE DELAY

     To precisely align the PPS output to GPS or UTC time, the receiver
     needs to know the delay of the GPS signal through the antenna cable
     (plus the delay through the PPS output cable). The cable delay
     adjustment can also be used to shift the PPS output relative to
     GPS/UTC time for other reasons.

     Note that some devices (like the Trimble Thunderbolt and the
     OSCILLOQUARTZ STAR) use a NEGATIVE number for compensating for cable
     delay compensation, other devices use a positive number. Consult
     the device manual for details (but good look finding them!)

        PC   - sets the cable delay
        /c=75   - sets the cable delay (in nanoseconds) from the command
                     line
        /c=50f   - sets the cable delay to 50 feet of 0.66 velocity factor
                     coaxial cable
        /c=70m   - sets the cable delay in 70 meters of 0.66 velocity
                     factor coaxial cable
        /c=50m,.8v - sets the cable delay to 50 meters of 0.80 velocity
                     factorcoaxial cable

   The "PC" keyboard command lets you specify the cable delay in
   nanoseconds or in cable length / velocity factor:
     PC 100   - 100 nanoseconds
     PC 50f   - 50 feet of 0.66 velocity factor coax
     PC 75m .77v - 75 meters of 0.77 velocity factor coax
```

```
PPS SIGNAL CONTROL and OUTPUT FREQUENCY CONTROL

   You can turn the PPS signal ON, OFF, or toggle its state:
     PD   - disable the PPS signal
     PE   - enable the PPS signal
     PS   - toggle the PPS signal ON or OFF
     /pd  - disable PPS output signal from the command line
     /pe  - enable PPS output signal from the command line
     /p   - toggle PPS output signal from the command line


   You can control the PPS signal polarity:
     PR   - select rising edge PPS signal
     PF   - select falling edge PPS signal
     PP   - toggle PPS polarity
     /-   - select rising edge PPS signal from the command line
     /+   - select falling edge PPS signal from the command line


   Some devices let you set the oscillator signal polarity referenced
   to the PPS signal:
     PO   - toggle the oscillator signal polarity from the keyboard
     /^f  - sync OSC signal falling edge to time
     /^r  - sync OSC signal rising edge to time
     /^   - toggle OSC signal edge


   Some devices let you configure the PPS output between a 1 PPS mode
   and a PP2S mode (telecom standard pulse per 2 seconds):
     P1   - select 1 PPS mode
     P2   - select PP2S mode

   On the Oscilloquartz Star-4 GPSDO:
     P1   - enable TOD (time of day) output
     P2   - disable TOD output


   Some devices let you adjust the PPS timing offset in relation to
   UTC/GPS time (much like the antenna cable delay parameter):
     PO   - set the PPS pulse timing offset in relation to UTC/GPS time
             (the times are in nanoseconds and can usually be positive or
              negative)


   Some devices let you reference the PPS pulse to either UTC time or
   GPS time (and usually this also changes the time reported by the
   receiver to GPS or UTC time).
     TG   - configure the receiver for GPS time
     /tg  - configure the receiver for GPS time from the command line

     TU   - configure the receiver for UTC time
     /tu  - configure the receiver for UTC time from the command line



   Some devices have one or pulse/frequency output signals that let
   you set the pulse rate/frequency and/or pulse duty cycle or width:
     PA   - configure pulse output A
     PB   - configure pulse output B

     You enter the pulse frequency in Hz and optionally a pulse
```

width or duty cycle (duty cycle values are between 0 and 0.99999,
pulse width values are a width in microseconds >= 1.0). If a pulse
width/duty cycle is not given, the default is 50% duty cycle.
Note that most devices have limits of the output frequency and
width/duty cycle that is available, and may be different for each
output... consult your device manual.

TRAIM CONTROL

Many GPS timing receivers support a feature called TRAIM - Time
Receiver Autonomous Integrity Monitoring. TRAIM mode monitors the
timings from the various satellites and if inconsistencies are
detected can drop suspect satellites from the timing solution, set
alarm conditions, etc. Consult your device manual.

   PT   - configure device TRAIM mode / threshold.

-NON-VOLATILE CONFIGURATION EEPROM/FLASH/SRAM memory

Some receivers support saving all or parts of the receiver configuration
into some form of nonvolatile memory (like EEPROM). Configuration
saves are currently supported on Trimble, Ublox, and Venus devices.

Whenever EEPROM is written Heather sounds a BEEP.
If you hear lots of unexpected beeps, something cold be
wrong and you may be wearing out the EEPROM. Note that SCPI
type devices also sound a BEEP when a receiver message response does
not seem to match what was expected (loss of message sync).

Jupiter receivers automatically write things like almanac data to EEPROM
and will periodically produce EEPROM write BEEPs. After a power-on there
will be quite a few during the first hour or so.

   /kc   - toggles disabling of writing configuration data into EEPROM
   /kc1   - disable writing into EEPROM
   /kc0   - enable writing into EEPROM

   EE   - from the keyboard, writes the complete current receiver
            configuration to EEPROM/BBRAM/FLASH.

            For Venus receivers this command toggles the enable of
            writing configuration changes to flash memory. If writing
            to flash is enabled, the receiver status column will
            show "FLASH: WRT" instead of "FLASH: OK". Writing to flash
            defaults to OFF for Venus receivers.

            Changing any of the PPS/OSC/Cable delay parameters
            from the keyboard stores the values in EEPROM unless EEPROM
            writes have been disabled. Changing them from the command
            line does not cause an EEPROM write.

-ADEV CALCULATIONS and DISPLAYS

   Lady Heather can calculate and display various ADEV (Allan Variance/
   Deviation) values from the receiver readings. ADEVs are a way of
   characterizing how stable a signal is over various time intervals.
   Heather supports ADEV, MDEV, HDEV, and TDEV calculation.

   ------------------------ WARNING -------------------------

   Heather calculates ADEVs based upon the PPS and OSCillator
   error values reported by the unit. These values are not
   derived from measurements made against an independent reference
   (other than the GPS signal) and may not agree with ADEVs calculated
   by measurements against an external reference signal. ADEVs calculated
   when the oscillator is undisciplined are more meaningful than when
   the oscillator is being disciplined. For proper ADEV values, you could
   modify the code to support reading time intervals from a proper external
   Time Interval Counter.

   Not all devices report values that are even suitable for ADEV
   calculations... Mostly the Trimble GPSDO devices are usable.

   SELECTING THE ADEV TYPE TO DISPLAY

   Heather maintains a separate circular data buffer of the values that
   it uses to calculates ADEVs from. The queue contains a PPS related
   value and an OSCillator related value. The size of the ADEV queue
   determines the maximum "tau" time interval that the ADEVs can show.
   The default is 33,000 points which is suitable for values of TAU out
   to around 10,000 seconds.

   You can set the size of the ADEV queue from the command line:
      /a=size - sets the number of points to save in the ADEV queue.
                A size of 0 will disable ADEV calculations.

   Normally Heather collects a new ADEV entry every second. You can adjust
   the ADEV interval with:
      /j=secs - sets the ADEV sample interval

   You can clear the ADEV queue from the keyboard:
      CA - clear the ADEV queue
      CB - clear the ADEV and plot queue

   You can clear the ADEV queue and reload it from the porttion of the
   plot queue currently being shown on the screen:
      CR - reload the ADEV queue from the plot queue data being shown

   Heather can also read ADEV information from files using the "R"
   keyboard command. ADEV files must have an extension of .ADV
   These files can have two independent values per line. The first value
   if the "PPS" value and the second one is the "OSC" value. These values
   don't have to be actual PPS and OSC values, but that is how Heather
   refers to them in the menus.

The .ADV files can also can contain:
    # text comments
    #title: title text (note that the ': ' is required)
    #period seconds_between_readings (default=1)
    #scale pps_scale_factor osc_scale_factor

The first line of an ADV file must be a '#' line.

The scale factor value multiplied by the data values should yield
nanoseconds.

Note that the #period command erases any data values that appeared
before it in the file.

Reading an ADEV file pauses the processing of data from the receiver.
THe "U" keyboard command can resume receiver updates.

ADEV INFORMATION DISPLAY

Heather displays ADEV info in two ways. First is a table of ADEV values.
Second is as graphs in the plot area.

    GA - from the keyboard toggles the ADEV plots on and off
    /ga - from the command line

If the ADEV plot is enabled, then the division markers in the plot area
that represent decades are highlighted in CYAN. Each highlighted
vertical division represents a power of 10. Each minor division marker
is a linear division of that decade. The decade value of the top line of
the plot area is determined from the largest ADEV value seen in any
of the ADEV tables. All ADEV types are scaled the same.

Each highlighted horizontal division represents TAU with divisions a power
of 10 seconds (TAU 1,10,100,1000,10000,,..) The horizontal major
divisions between the highlighted ones are a 1:2:5 division of
that time decade (like 1,2,5,10,20,50,100...).

For screen resolutions 800x600 and below, the ADEV plot decades
are scaled to single VERT_MAJOR divisions (not to every two major
divisions)

The ADEV table is always shown on the screen if there is space for it
(in the upper right corner of the screen). The "GB" keyboard command
allows for one of the satellite maps or the watch display to be shown
in the plot area.

If more than one of the map displays and/or watch display is enabled
they take precedence over the ADEV table display.

Clicking on the adev table display will switch the screen to the
"all adevs" mode. You should click on the upper adev table. The lower
adev table might be ignored in some screen configurations.
Cicking again will restore the screen to its previous state.
Note that short clicks might be ignored... particularly on devices
like UCCM receivers that only output time updates every two seconds.
It can help to hold down the mouse button until the screen changes.

Heather always calculates all four ADEV types for both the PPS and OSC
values. The "A" keyboard menu is used to configure the ADEV information
to display:
    AA - Show ADEVs for the OSC and PPS values
    AH - Show HDEVs for the OSC and PPS values
    AM - Show MDEVs for the OSC and PPS values
    AT - Show TDEVs for the OSC and PPS values
    AO - Show all ADEV types for the OSC value
    AP - Show all ADEV types for the PPS value

You can also select the ADEV type(S) from the command line:
    /oa - Show ADEVs for the OSC and PPS values
    /oh - Show HDEVs for the OSC and PPS values
    /om - Show MDEVs for the OSC and PPS values
    /ot - Show TDEVs for the OSC and PPS values
    /oo - Show all ADEV types for the OSC value
    /op - Show all ADEV types for the PPS value

    The "all adev" commands (AP and AO) lets you
    control what info to display. All four ADEV plots
    only, all four ADEV types and the graphs (can be a
    bit confusing since the same colors are used for
    two different things), or the two regular
    ADEV plots and graphs:
       AOA - show all four OSC ADEVs tables and all ADEV plots
       APA - show all four PPS ADEVs tables and all ADEV plots
       AOG - show all four OSC ADEVs tables and all plots
       APG - show all four PPS ADEVs tables and all plots
       AOR - show all four OSC ADEVs tables and regular ADEV plots
       APR - show all four PPS ADEVs tables and regular ADEV plots

-MISCELLANEOUS RECEIVER CONTROL COMMANDS

    RESTARTING and RESETTING the RECEIVER

       !W - warm start the receiver
       !C - cold start the receiver
       !H - hard reset the receiver to factory defaults

            Note that on many receivers doing warm/cold/factory resets may
            take a long time and Heather may take a long time to
            re-establish communications or Heather may not be able to
            re-establish communications, or may change the receiver language
            type. You may need to exit and restart Heather.

```
SERIAL PORT CONTROL
    !S  - re-initializes the serial port connection and receiver data
          parser

    !Z  - reset the receiver message data parser

    !P  - set operating system serial port parameters (like the /br
          command line option)  Note this changes the operating system
          serial port configuration.  In order to guard against
          accidentally "bricking" a receiver by setting a
          hard-to-recover-from configuration,

          Currently Heather does not ever change the receiver serial port
          configuration. (someday this command might be able to configure
          the receiver serial port parameters)

    !B  - send a 300-500 msec BREAK to the serial port

SENDING COMMANDS to RECEIVER
    !U  - sends a command string to the receiver.  This is mainly for
          NMEA and SCPI receivers that accept ASCII commands.  For NMEA
          receivers you do not need to include the leading '$' character.
          Also the NMEA checksum will be automatically added if it is not
          included.

RUNNING RECEIVER DIAGNOSTICS
    !D  - command the receiver to run its internal self-tests.  Note that
          on many devices this takes a long time and/or resets the receiver
          and Heather may take a long time (or forever) to re-establish
          communications.

SWITCHING RECEIVER MESSAGE FORMATS
    !M  - If a receiver can speak NMEA, but is currently running in its
          native binary mode,  this will switch the receiver back to NMEA.
          On receiver that are speaking Motorola binary data, this command
          usually switches the receiver from Motorola mode to some other
          (device dependent) language.

CHANGING THE RECEIVER NAVIGATION / MESSAGE OUTPUT RATE
    /nr=Hz - from the command line
    !R=Hz  - many modern receivers can output data at greater than 1 Hz.
             This command lets you change the "navigation rate" of the
             receiver.

             Note that most timing receivers cannot provide an accurate
             1 PPS signal unless they are running at 1 Hz navigation rate.

             High navigation rates produce a lot of data and serial port
             traffic.  If the receiver serial port is set to a low speed,
             they usually drop messages to lower the data rate. Some
             receivers just go bonkers.  This condition usually shows up
             as lots of time-skip indications in the plot area and/or
             jittery watch or digital clock displays.

             Sometimes a high navigation rate produces enough serial port
             traffic that Heather never sees an idle time in the data
             stream where it can process keyboard commands.  The keyboard
             will stop responding.  You can recover from this by killing
             the program and restarting it with the /nr=1 command line
             option to lower the navigation rate back to 1 Hz.
```

```
TERMINAL EMULATOR

   Heather has a built in terminal emulator program that is handy
   for monitoring data from the receiver and sending ASCII commands to it.
   Receiver data is shown in GREEN and user keystrokes are shown in
   YELLOW.

      !T  - enter terminal emulator from the keyboard
      /bt - start Heather in terminal emulator mode from the command line

   The terminal emulator mode has several keyboard commands for
   controlling it:

      END    - exit terminal emulator
      HOME   - erase the screen
      UP     - re-sends the last keyboard line to the receiver
      F1     - toggle keystroke echo mode
      F2     - toggle writing receiver data to a log file
                 Heather uses the "raw data log" file name. If the raw
                 data log file is open, it is closed.  If it not open, it
                 is opened in "append, binary" mode.
      F3     - toggle HEX binary data display mode.  In HEX mode
                 bytes that could be part of a start/end-of-message
                 sequence are shown in YELLOW
      F4     - toggle writing to the screen
      F5     - CR-LF mode - adds a CR after any LF or add an LF after
                 any CR (this option does not show up the terminal emulator
                 help info header!)
      F8     - send a BREAK
```

-MISCELLANEOUS COMMANDS

   There are several commands that don't fall under any of the previous
   sections.

   Whenever Heather is idle and not doing something or receiving data
   from the GPS receiver, it does a short Sleep() that returns control
   to the operating system and greatly reduces the CPU usage. You can
   specify how long to Sleep() for in milliseconds:
      /tw[=#] - Sleep() for # milliseconds when idle (default=10)

   You can control the audio functions of Lady Heather:
      /kb   - toggle Beeps from the command line
      /ks   - toggle playing Sound files from the command line

      GS   - toggle all sounds from the keyboard. If beeps OR sound
                 files are enabled, they will both be disabled. If beeps
                 AND sound files were disabled, they will both be enabled
                 and a BEEP will be sounded as confirmation.

   Normally you exit Heather from the keyboard by pressing "ESC y". You
   can allow ESC ESC to exit the program with:
      /ke   - toggle quick exit with ESC key

   You can put Heather into a "read-only" mode that blocks sending commands
   to the receiver over the serial port. This mode can interfere with
   functions or displays that require commands to be sent to the receiver:
      /ir   - toggle read-only mode for receiver commands

   This is similar to the "/ir" command, except it blocks sending ALL data
   to the serial port:
      /is   - toggle read-only mode for serial port

   Normally Heather periodically polls the receiver for various pieces of
   data, status, or configuration information. Usually a new piece of
   information is polled for every second. It can take around 30 seconds
   for Heather to acquire everything from the receiver. You can block
   Heather from polling the receiver for data. This is mainly useful when
   using the "TK" command to analyze receiver message timing.
      /it   - toggle no-polling mode for receiver data

   Heather can output some debug information (mainly on Linux and macOS).
   This debug information is independent of the debug log file and most
   goes to stdout. This command line option sets the level of debug
   information that is shown.
      /de[=#] - set debug information level

   The "R" keyboard command can read some other type of files. Many of these
   file formats are also readable from the command line using the "/r="
   command line option.

      You can read lat/lon/alt logs. These files
      must have an extension of ".LLA"   Data lines require:
        time-of-week flag lat lon alt
        flag=0 means good reading, otherwise skip it
      This format can be generated by TBOLTMON log command.

```
Other .LLA file commands supported are:
   # text comments
   #title: Title text (note that the ': ' is required)
   #lla: ref_lat  ref_lon  ref_alt (your assumed exact location)
The first line of an LLA file must be a '#' line.

You can play/test sound files.  These files must have an file name
extension of ".WAV"

You can read greetings calendar files.  These files must have an file
name extension of ".CAL"

Can also read ".TIM" files from John Miles' TI.EXE
program.  The .TIM file CAP/TIM/IMO, PER, and SCA commands are
used.

If you attempt to read a file that does not have a filename .EXTension
or end in a '.',  the Heather tries to read a .LOG, .XML, .GPX, .SCR,
.LLA, .CAL,  .SIG,  .ADV, and .TIM files in that order.



A few legacy command line options... nothing to see here, move
along...

   /lo     - enable reading of old format LUXOR log files
   /lh     - don't write timestamp headers in the log file when the file
              is periodically synced to the disk.

In WINDOWS, both the TCP/IP link and help dialog features use
a windows message timer to keep the program running
if the command line help dialog box is active or the screen is
being dragged, etc.  At one time, this timer had the potential to
cause very intermittent, random "unhandled exception"
aborts, but this seems to have been fixed.  You can still disable the
timer feature with the:
   /kt     - toggle Windows dialog/message timer


The "/bs" command line option will adjust the displayed time by the
solar Equation of Time.  The only indication that solar time is in use
is on the analog watch display. The watch name/day of week will
be "Solar".  Using solar time is now best done with the "TZ" and "/tz"
time zone commands.


/nt  - attempt to wake up Nortel "telecom" GPSDOs  (this is now
        done automatically)


/rt[=#] - use Resolution-T serial port config (9600,8,ODD,1)
          [#=1]=force Resolution-T  [#=2]force Resolution SMT
          (for REsolution-T devices you should now use the "/rxr" command
           line option).
```

```
      You can change the input device on the fly
      from the keyboard with the /# or /ip keyboard command
      just like from the command line.
      Changing the input device from the keyboard resets
      the satellite tracking and signal level maps.
      You can also use these commands to re-establish
      the a dropped connection or device.  If you had
      previously set an IP connection address/port, you
      don't have to type the "=addr:portnum" after the /ip

      You can also use the "/rx" commands from the keyboard to change
      the input device type.




      Added '$' and '=' command line/.CFG file  options for
      building lists of hex bytes to send to the receiver
      The '=' list is sent when the program starts.  The '$'
      list is sent when a primary timing message is received
      (i.e. once each second).  For example with a TSIP receiver:
          $10,3a,00,10,03   would request doppler/code phase
                            data every second.
          $10,3C,00,10,03   would request satellite status
                            and position data every second.
      Note that the '$' and '=' command line options should
      not be preceeded by a '/'.




    Other (mostly rather obscure) keyboard selctable options:
    Those marked with "---" are either no longer implemented or have proper
    keyboard or command line options.

      OA   - toggle AMU vs dBc signal level displays.
      OB # - set ADEV bins per decade
      OC   - toggle satellite constellation plot scaling mode
      OD   - toggle FFT plot display in dB or raw values
      OE   - toggle Thunderbolt-E display mode
      OF   - toggle periodic refresh of adev calculations
  --- OG   - toggle plot area background highlight color
      OH   - toggle erasing of Lat/Lon/Alt survery plot every hour
  --- OI # - set signal level display type
      OJ   - toggle logging of serial port data stream
      OK   - toggle logging of TSIP message faults as time skips
      OL   - toggle live FFT mode
      OM # - set plot magnification factor
      ON   - toggle real-time update of trend line plot title
      OP   - toggle plot scaling mode to peak value seen
      OQ   - toggle plot queue sampling fast / slow mode
      OR   - reset ADEV bins and recalculate ADEVs
      OS   - toggle temperature spike filter mode
      OT   - toggle alarm/dump/exit time triggers to be based upon local time
             (default) or displayed time which can be in one of the
             astronomical time scales.  Previous versions used OT to toggle
             12/24 hour clock mode which is now available from the T menu.
  --- OU # - set daylight savings time area number (0 .. 5)
      OV   - toggle ADEV base value mode
      OW # - select analog watch face type (0 .. 5)
  --- OX # - set receiver configuration value
  --- OY # - set tempurature-dac plot (G3 plot) scale factor
  --- OZ   - toggle auto-centering of plots
```

This program requires the following operating system dependent routines:

init_hardware() - put screen in a high res graphics mode or open a
                  graphics window and open the com port (9600,8,N,1)

dot(x,y, color) - draw a colored dot

get_pixel(x,y) - read a pixel from the screen

kill_screen() - close graphics screen or window

sendout(c) - send byte 'c' to the serial port

SERIAL_DATA_AVAILABLE() - a routine or macro that returns true if
                          there is serial port data available

get_serial_char() - get a character from the serial port. You should check
                     SERIAL_DATA_AVAILABLE() befor calling this.

kill_com()   - close down serial port

SetDtrLine(state) - used for PWM fan control for temerature control PID
SetRtsLine(state) - used for PWM fan control for temerature control PID
SetBreak(state)   - used to wake up Nortel GPSDO's by sending a BREAK condition

KBHIT() - a routine or macro that returns true if a keyboard key has
          been pressed

GETCH() - a routine or macro that returns the keyboard character

refresh_page() - copy any virtual screen buffer to the screen
                 or flip pages if doing screen buffering. Can be
                 a null routine if writing directly to the screen.

BEEP() - sound a beep if beep_on is set

set_cpu_clock() - has OS dependent code for setting the system time

GetMsecs() - returns a double precision count of milliseconds. Can
             be since program started, os boot, or any base time
             reference (used to do pwm control of the heat/cool cycle
             if doing precise temp control and checking for loss of
             serial port communications. Also sets wall_time variable
             to system clock time with high resolution.

GetNsecs() - return high resolution timer count in nanoseconds.

Also the get_mouse_info() routine will need to be updated to handle
the system mouse. You need to get the current mouse coordinates into
variables mouse_x and mouse_y and the button state into this_button.

play_tune() - play a sound file asynchronously (non-blocking)

Also, you can improve performance with operating system dependent
line and circle drawing and area erasing functions.

To see where you might need to add support for a new operating system
search the code for the strings:
   WINDOWS   (Windows related stuff)
   __linux__   (Linux related stuff)
   __MACH__   (macOS OS/X related stuff)
   WIN_VFX   (Windows video/keyboard/mouse stuff)
   USE_X11   (X11 video/keyboard/mouse stuff for Linux and OS/X)

Note: stupid DOS linker does not allow initialized variables to be declared
      in more than one file (even if defined as externs). Therefore any
      variables that are used in more than one file are initialized
      to non-zero values in the routine set_defaults();