MoonSked X

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Appendices

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Introduction

A Moon Bounce Scheduling program, designed for Radio Amateur EME enthusiasts.

Like most users you probably don't need to read the documentation to run the software, however to get the most from this program, you may find the following pages explain some features...

Contact Details

MoonSked X is Shareware, the Registration page is http://www.gm4jjj.co.uk/MoonSked/moonsked_registration.htm

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Web pages: http://www.gm4jjj.co.uk

Shareware Registration

MoonSked is distributed as shareware. It is a demo copy and you may try it for 30 days, after which we ask that you either delete your copy or register it online. The shareware fee is £35, upon registration, you will receive free technical support, free upgrades, and a code to disable the reminder messages which appear at regular intervals as well as add the new features which are available only with the full version.

The Registration page is http://www.gm4jjj.co.uk/MoonSked/moonsked_registration.htm

Please remember to include your Amateur Radio Callsign, it is used to generate your registration code.
If you have no callsign, then your name will be used instead.

If you have any problem with registration please contact the author by email at gm4jjj@amsat.org

Operating System Requirements

This product is designed to run on any of the following Apple Operating Systems and Processors:

- Mac OS X 10.7 Intel
- Mac OS X 10.6 Intel
- Mac OS X 10.6 PPC
- Mac OS X 10.5 Intel
- Mac OS X 10.5 PPC
- Mac OS X 10.4 Intel
- Mac OS X 10.4 PPC
- Mac OS X 10.3 PPC
- Mac OS X 10.2 PPC

Note:-
MoonSked is also available for the Microsoft Windows Platform.

MoonSked X Features

- Easy Interface allows rapid choice of suitable date and time for EME schedules
- Mutual Station AZ/EL data
- 50MHz to 47GHz Band Doppler shift calculated between Stations
- 50MHz/144MHz/220MHZ/432MHz Background Sky Temperatures
- Database of Stations using CALL3.TXT file
- Scrollable list of stations in database
- Grid Locator entry
- Display of Grid locator from Lat/Lon Input
- Moon Elevation Correction for Parallax and Correction for Earth's Oblateness
- Topocentric Moon GHA Declination and LHA corrected for parallax
- Spectral Broadening due to Total Moon Libration (Registered Users Only)
- Moon Range and DGR dB loss
- Spatial Polarity and Maximum Non Reciprocity
- Station details displayed from database
- Show split of DGR in terms of Additional Sky Noise and Distance.
- Choice of Intervals for results
- Radio Sky Map and Noise Source Tracking
- Realtime Moon Tracking
- TX/RX sequence calculator with optional audible alerts
- Moon footprint on World Map.
- Moon Graph shows monthly moon data
- Callfinder – finds likely EME callsigns from partial calls heard
- Supports a variety of computer controllable antenna rotators with add-on Driver programs.

Getting Started

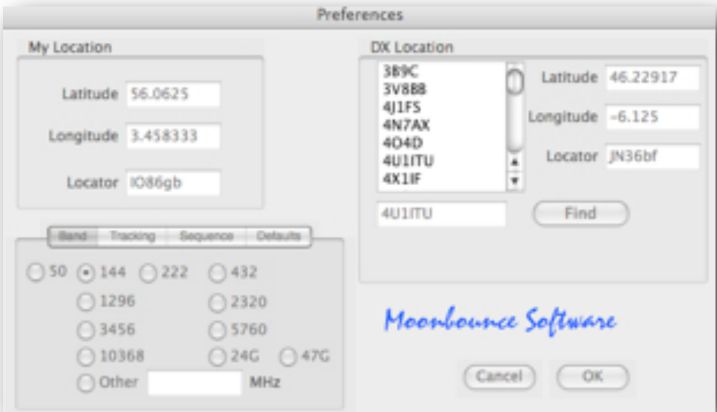
Installation
If you have read this far you have installed the software. MoonSked X looks for its associated callsign database file within the folder that it is located in. You can move the MoonSked folder wherever you like but leave the call3.txt file inside it.

Callsign Database file - CALL3.TXT
The text file CALL3.TXT must reside in the MoonSked X Folder with the MoonSked X Application to allow the Callsign Database to load. If it is not there then you will not be able to enter callsigns in the Preferences dialog panel. CALL3.TXT is regularly updated and available from many places online. It may be also be edited with a text editor. **MoonSked now loads ALL callsigns from the CALL3.TXT file, irrespective of the EME flag set in the 3rd field.**

Note: CALL3.TXT is also used with the popular WSJT software by Joe Taylor K1JT. We have now included the option of selecting an alternative CALL3.TXT file located in a folder other than MoonSked, for example your own CALL3.TXT file in your WSJT folder.

Initial Preferences setup

The Preferences Window is opened when the Preferences button is pressed or from the MoonSked X Menu. Home station and DX station can be chosen from this panel along with the band.



The Preferences Window

Your Location
Enter either your Locator Grid square or your Lat/Lon and the other details will be calculated.

Click into or Tab between entry boxes.

The DX Callsign can be selected from the scrollable list or entered into the box and the Find button will then search the database for the callsign. You can also enter the DX Lat/Lon or Locator for any station not in the list. The DX Callsign will then be shown as ‘DXstation’.

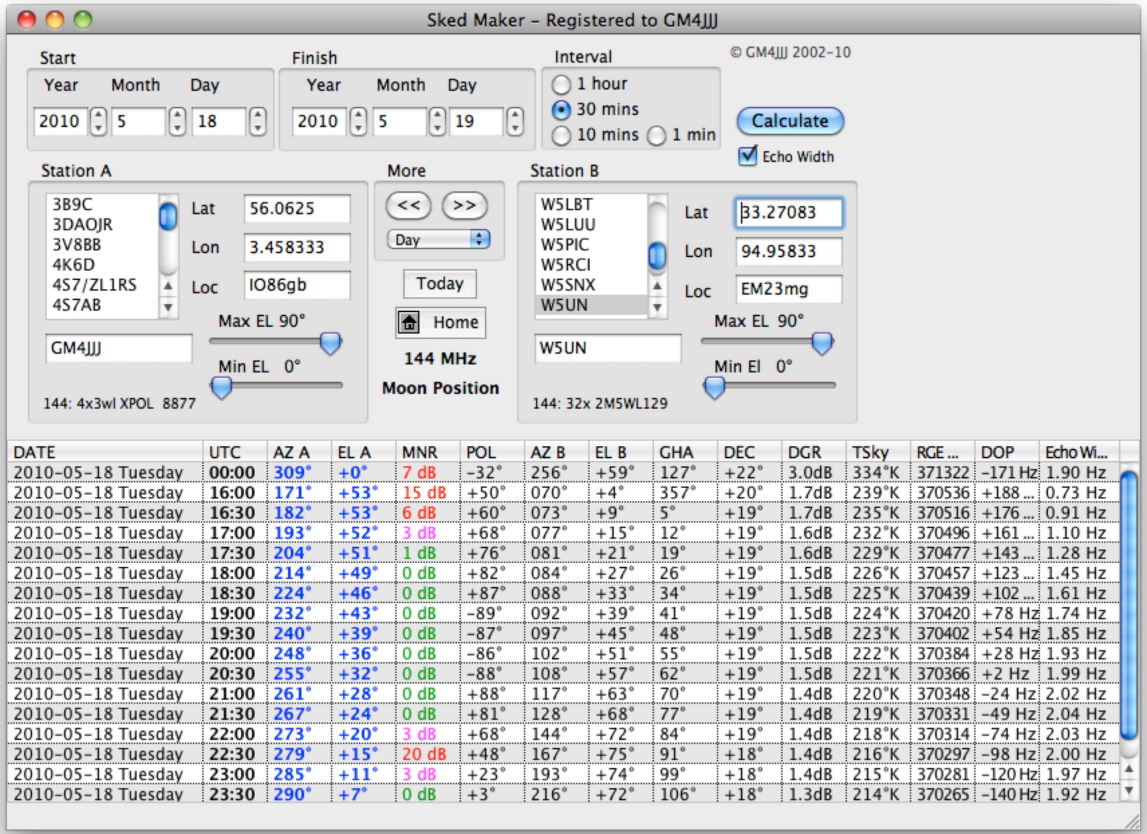
Time Zone
Please ensure that your Time Zone is correctly selected in the OS X Date & Time control Panel in System Preferences. On the Macintosh the System Preferences Date & Time control panel will automatically control whether DST is in effect or not. A Sun symbol is shown in the My Location Group box when DST is in effect.

Frequency Band
The Band setting determines the calculated Doppler shift, Spectral width as well as the Sky Noise contribution.

Click the OK Button when finished.

Sked Maker Window

The Sked Maker Window is the main result screen. It can be resized to fit the whole area of the display if required.



The Sked Maker Window

SkedMaker Prediction Results

- **DATE** - The date in the long format chosen by your settings in Date & Time Control Panel
- **UTC** - Time in standard UTC format
- **AZ** - Azimuth bearing in degrees of moon from home station (in blue)
- **EL** - Elevation bearing in degrees of moon from home station (in blue)
- **MNR** - Maximum Non Reciprocity * See appendix .doc MNR by N1BUG. (Color Coded)
- **POL** - Spatial Polarity angle in degrees between Home and DX station
- **AZ B** - Azimuth bearing in degrees of moon for DX station
- **EL B** - Elevation bearing in degrees of moon for DX station
- **DEC** - Declination of the moon in degrees (Geocentric)
- **GHA** - Greenwich Hour Angle of the moon in degrees (Geocentric)
- **DGR** - Additional Loss (dB) at 144MHz or 432MHz (Degradation over ideal) Sum of losses over 'ideal' conditions. Additional path loss due to moon not being at perigee plus extra contribution from additional sky noise over lowest possible. RX noise figure is taken as 60°K at 144MHz and 30°K at 432MHz.
- **TSky** - Background sky temperature in degrees Kelvin at the frequency chosen in the preferences. (50,144 220 & 432 MHz only) At 1296MHz and above the sky noise contribution is assumed to be always 3°K. Displays !Sun (in red) if New Moon.
- **RGE Km** - is the Geocentric Range of the moon shown in Km.
- **DOP** - The Doppler shown is the net Doppler shift of the Station B as received at Station A.
- **Echo Width** - The width of the libration broadened signal of Station B as received at Station A.
- **The Calculate button** starts the moon predictions running.
- Start - **Start Date** for predictions - default today.
- Finish - **Finish Date** for predictions - default tomorrow.
- **Interval** - Choice of 1, 10, 30 or 60 minute time period intervals for the results.
- **Home button** - (House Icon) - makes Station A and B become the same.
- **Next or Previous Weekend or Day** - Calculates again for the next or previous day or weekend.
- **Today Button** - Calculates for today.

- **Max and Min EL** sliders allow setting of limits in elevation for Station A and Station B

- **Echo Width Checkbox** - when ticked will calculate the Spectral broadening due to Total Libration. This feature is available to Registered Users of MoonSked only.
-

Contextual Menu - Right Click (or ctrl-click) with the mouse on the results list and a popup menu will give you the choice to save as a text file either all the result columns or only the dat/time/and the Echo Spread width. (This may be useful for graphing purposes). Registered Users Only

Note on Libration:
Libration spectral broadening of the echo is caused by the relative rotation of the Moon's surface with respect to the stations on the surface of the Earth. This broadening is frequency and location dependent and at microwave frequencies can be large enough to make copying of weak signals difficult. At lower frequencies the broadening is proportionally less, however the broadening figure can also give an indication of the rate of libration multipath fading that may be expected.

At certain dates/times the total libration can be at a minimum for a very short period of time. (A few minutes).

Total Libration includes the Moon's Libration in Latitude and Longitude, Physical Libration of the Moon, and Diurnal Libration cause by the daily rotation of the Earth.

Menus

MoonSked X Menu

About MoonSked...
Information about MoonSked and special thanks to those who helped directly or indirectly.

Register MoonSked...
Enter your registration code here (after paying the Shareware fee). If you have any trouble please email the author. The Register OnLine button will take you right to the Registration Web Page.

MoonSkedX Preferences... Command +,
Opens the MoonSked Preferences window

Edit Menu

Copy Command+C
Allows copying of single of multiple selections from the result lists in the windows.

Select All Command+A
Quick selection of all of the items in a result list.

Call3 File Location...
Allows a CALL3.TXT file located in another folder to be selected.

File Menu

Print… Command+P
Prints Schedules or Predictions (also MoonGraph)

Page Setup...
Printer page settings

Quit Command+Q
Quits the Program!

Window Menu

Sked Maker Command+L
Selects the main Prediction window

Moon Track Shift+Command+M
Selects the realtime moon tracking window.

Noise Sources Command+N
Selects the realtime SUN, Noise Source tracking window. \

World Map Shift+Command+W
Selects a World Map showing the Moon's footprint – Size can be set in Preferences.

Call Finder Command+F
Finds valid EME callsign from partial callsign fragments.

Moon Graph Shift+Command+G
Selects Chart of Moon data for a calendar month

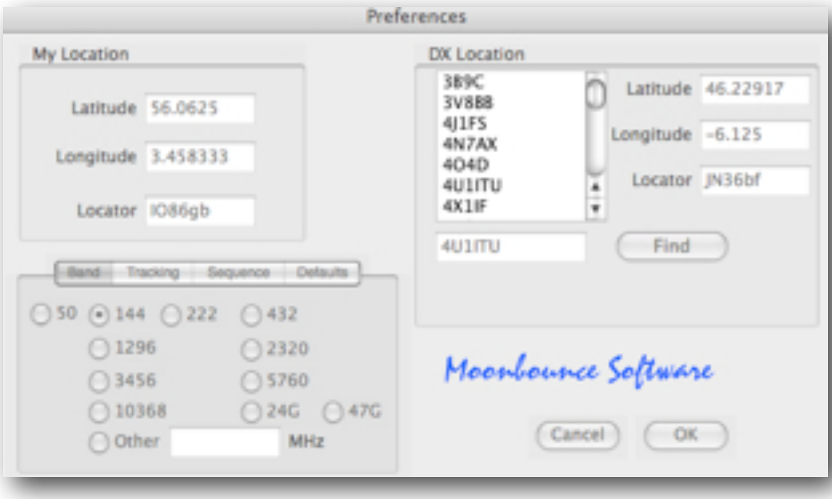
Help Menu

Register MoonSked X
Opens the Registration Window

Check for updates...
Check the GM4JJJ website for newer versions of MoonSked. (Needs Internet Connection)

Reset Call3...
Resets the location that MoonSked looks for the CALL3.TXT file to the MoonSked folder.
Reset MoonSked...
Resets all MoonSked Window sizes and positions to their defaults.

MoonSkedX Preferences...



The Preferences Window

This is opened when the Preferences button is pressed or from the MoonSkedX Menu. Home station and DX station can be chosen from this panel along with the band.

Enter either your Locator Grid square or your Lat/Lon and the other details will be calculated.

Click into or Tab between entry boxes.

The DX Callsign can be selected from the scrollable list or entered into the box and TAB will then search the database for the callsign. You can also enter the DX Lat/Lon or Locator for any station not in the list.
The DX Callsign will then be shown as 'DXstation'.

On the Macintosh the Date & Time control panel will automatically control whether DST is in effect or not. Please ensure that your Time Zone is correctly selected in the OS X Date & Time control Panel in System Preferences.

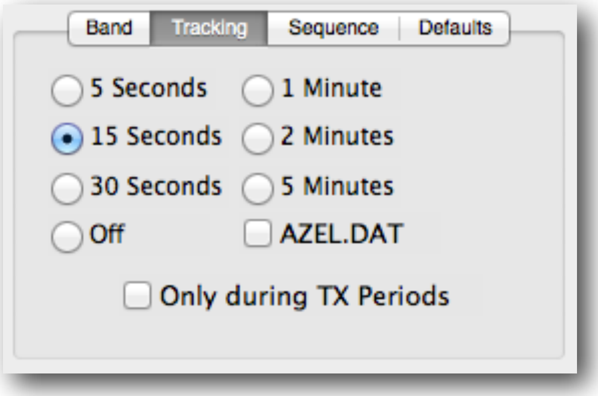
The Band setting determines the calculated Doppler shift, Spectral width as well as the Sky Noise contribution.

Click the OK Button when finished.

Preference Tabs

Tracking

The rate at which the Rotator drivers are sent updated tracking data from MoonSked is determined by the setting here. The default is 15 seconds.

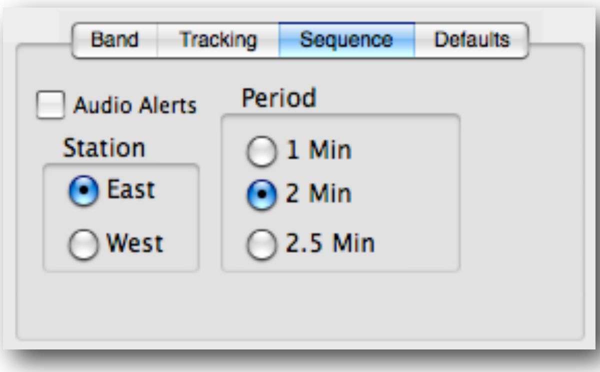


MoonSked Rotator driver programs do not now require the AZEL.DAT file, however if you want to use that file with other rotator drivers then it is available as an option by checking the AZEL.DAT box.

If you want to avoid RF noise when your rotators move, then selecting "Only during TX Periods" will disable tracking data from being updated during receive periods. (As defined in the Sequence Tab below). Applicable only to Moon Track Window, not the Noise Source Track window.

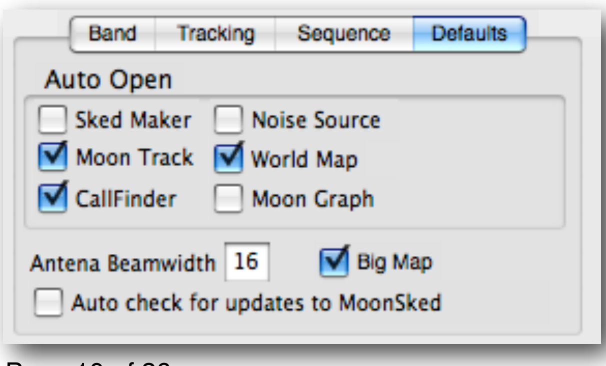
Sequence

The settings determine when the Transmit and Receive periods are. East stations use the first period.
Audio alerts will make a system alert sound at the start of a new Transmit period.



Defaults

The **Auto Open** settings determine which of the MoonSked Windows will automatically open when MoonSked is started.



Big Map
when checked will use a larger World Map.

Antenna Beamwidth regulates the size of the circle displayed in the Noise Source Tracking Radio Sky Map.

If **Auto check for updates to MoonSked** is checked then MoonSked will attempt to check via the Internet if a newer version of MoonSked is available. No personal information is sent to the Internet.

Realtime Moon Tracking

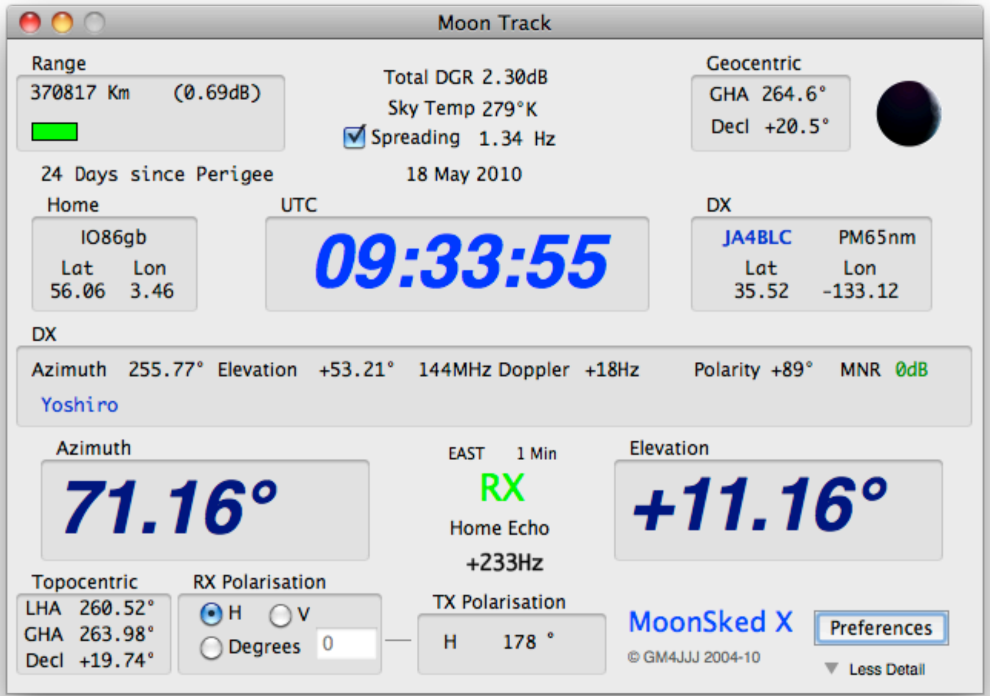
Moon Track Window

Moon Position is shown in realtime.

Note UTC is shown and is calculated from the local time and the Time zone info stored on your computer.
Note:- Summertime also has to be taken into account – see preferences.

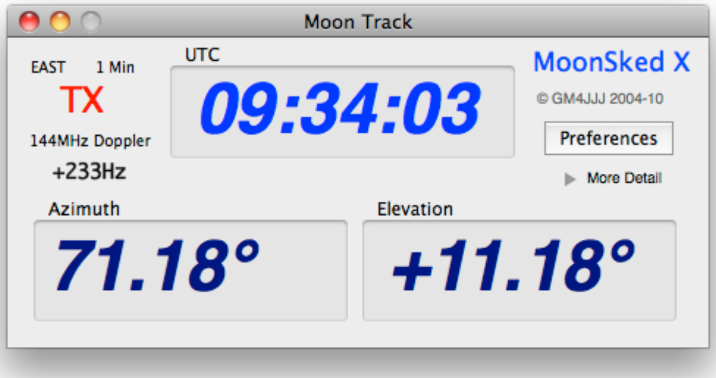
- Best TX Polarisation (calculated from Spatial Polarisation and the Best Receive Polarisation)
- Moon Range graphical representation of Pathloss (Green, Yellow, Red)
- MNR result is also color coded.
- Same information as shown in the Predictions Window.
- Moon's GHA, LHA, Declination corrected for the Home Station's position. (Topocentric)
- Total Doppler shift of the DX station as received by you shown as well as the shift of your own echo.
- Can be reduced to show only basic info by clicking "less detail" triangle
- The Moon's Phase is shown by the picture above the DX station.
- Spreading checkbox gives the option of doing the lengthy libration spreading calculations.

Note: Unregistered Users will only be able to view this window for a limited time during any session.



The Full Moon Track Window

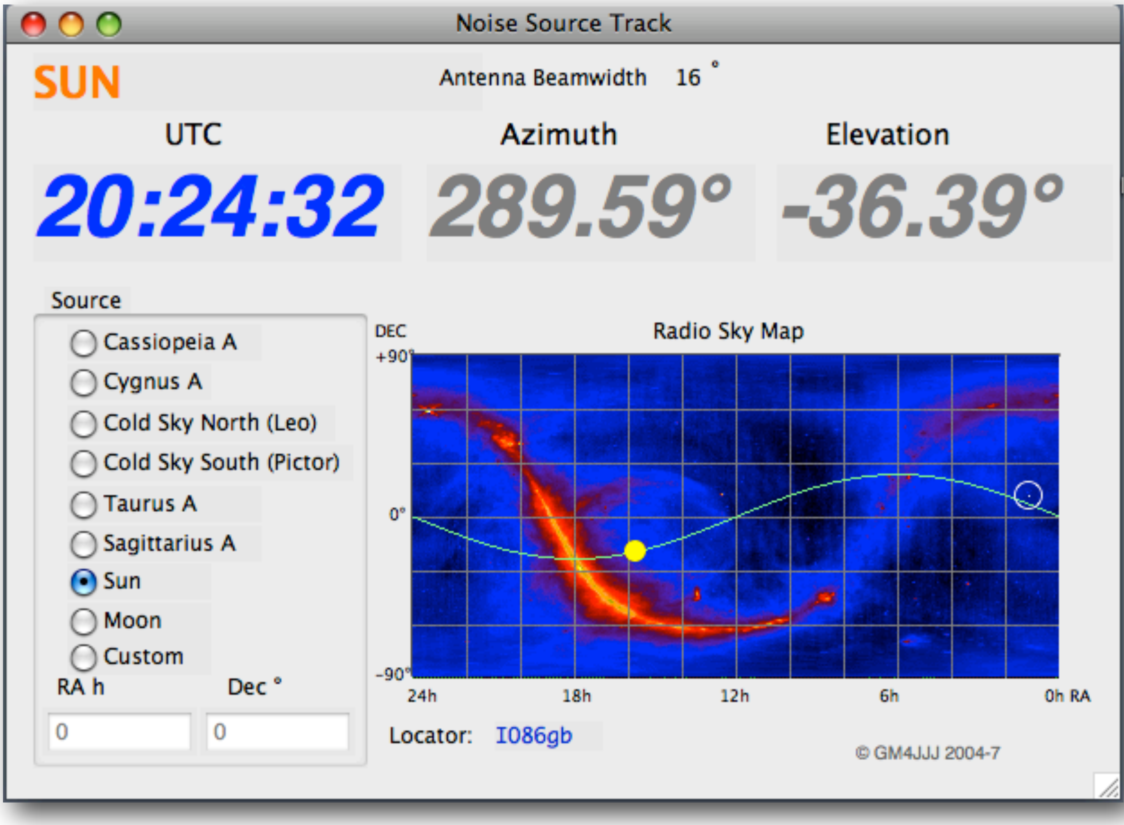
Click the "Less Detail" triangle to get a smaller Moon Track Window with only basic information.



The Less Detailed Moon Track Window

Realtime Noise Source Tracking Window

- UTC calculated from local computer time and Time Zone
- Note:- Summertime (DST) also has to be taken into account – see preferences.
- Position of selected Noise Source shown on Radio Sky Map by flashing circle
- Sun position shown as yellow disc (not to scale)
- Moon Position shown by white circle (8 degree radius)
- Custom sources can be input by entering RA and Declination or by clicking on Sky Map.
- Ecliptic (path of sun) through the year) is shown as a sine wave.
- Different antenna beamwidths can be entered and the size of the circle around the source will change.
- If automatic antenna tracking is in operation then this window's source will take precedence over the Moon Track window.



Note: Unregistered Users will only be able to view this window for a limited time during any session.

World Map Window

The World Map shows the present area illuminated by the Moon, the dark area is not in range of the Moon.

The 'footprint' is updated in realtime.

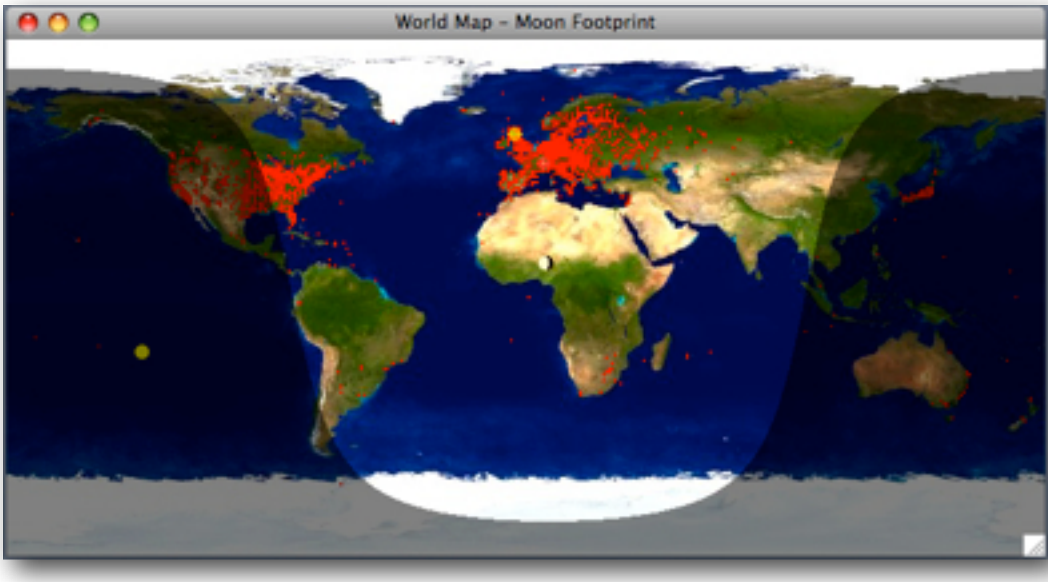
The Position of Home & DX stations are shown.

The Position of the Sun and the Moon are shown.

The Phase of the Moon is shown graphically.

Clicking on the Map will display all stations in the database (red dot displays positions)

Note that there are two sizes of maps available – choice in the MoonSked Preferences Defaults.
The Big Map is resizeable.



Clicking on the map will show the locations of all of the EME stations in the callsign database (CALL3.TXT)

Moon Graph Window

The Moon Graph allows the user to see details of the Moon conditions a whole month at a time.

New Moon when the Sun is in the same part of the sky as the Moon is indicated by a Sun symbol.

Weekends are shown in blue.

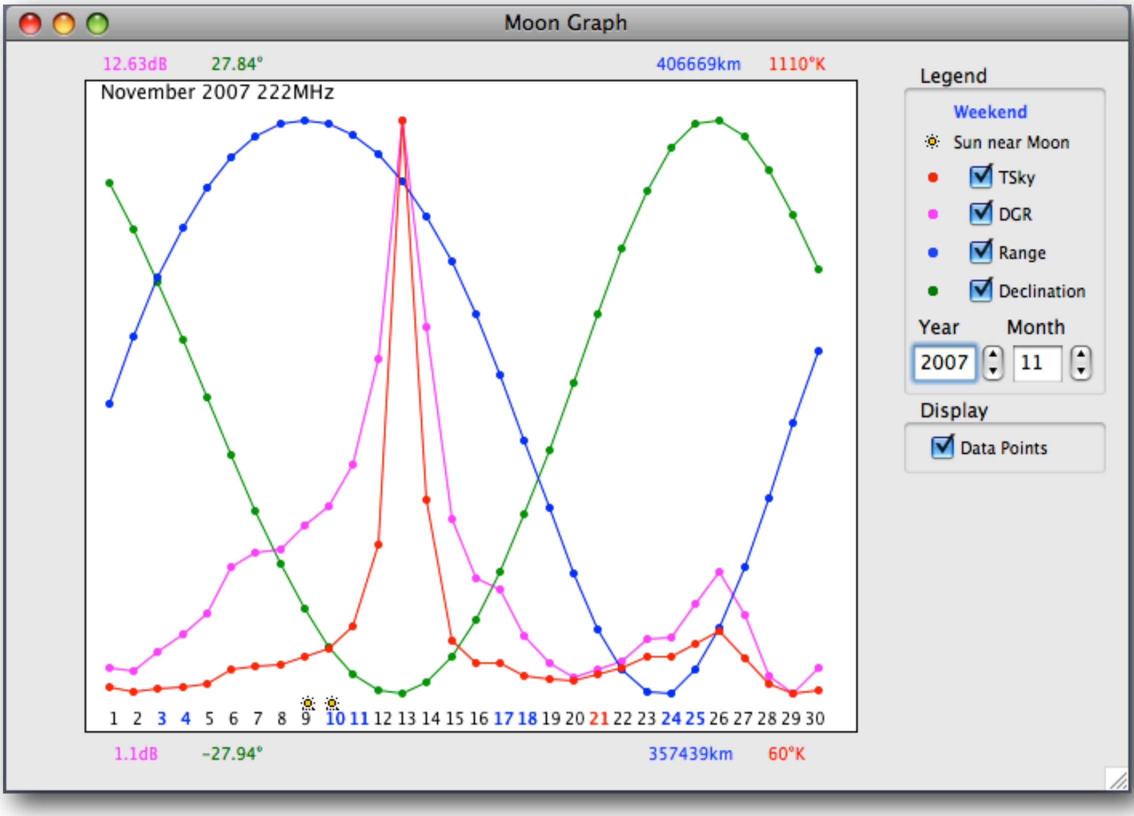
Today's date is shown in Red.

The size of the window is scaleable.

Dots for each day can be added to the graphs.

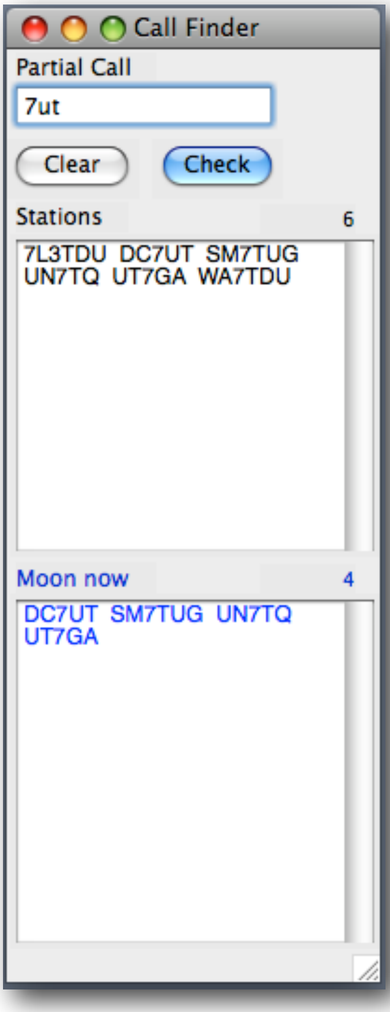
Any combination of the four plots can be displayed

Maximum and minimum values are shown in text above and below the graph respectively.



Note: Unregistered users can only view the data for the **previous** month

The Call Finder Window



Entering text will search the callsign database for stations that contain parts of the callsign entered.

Pressing the Check Button will show only those stations found that actually can see the Moon at this time.

The Clear button will clear all of the fields.

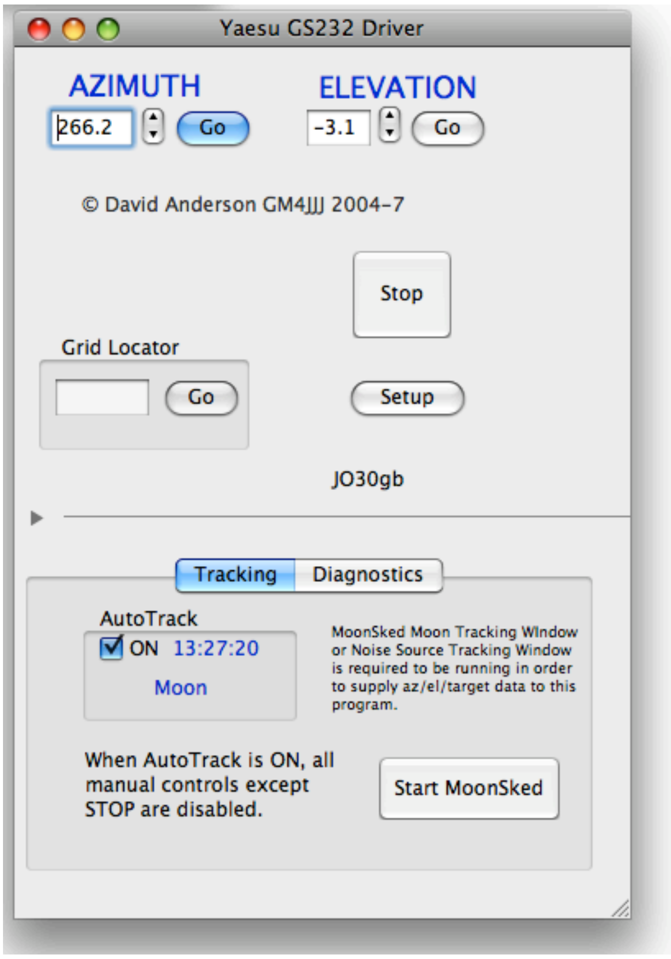
Tip: A Station callsign can be dragged and dropped onto the Moon Track Window and that Station will then be used for the DX Station.

Using Automatic Antenna Control

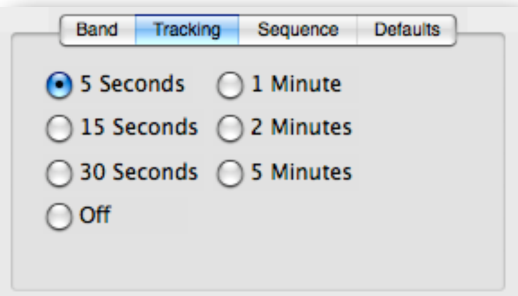
Additional Rotator Controller Driver programs have been written for MoonSked. These drivers are separate applications that can control a suitable serial controllable antenna controller. A USB to Serial adaptor is required. MoonSked can control up to 2 Rotator Drivers simultaneously.

The user can control the antennas manually from the driver and when desired automatically track the Moon, Sun and other targets by enabling the AutoTrack checkbox. A MoonSked Moon or Noise Source **Tracking Window** has to be running in order to generate tracking data for the driver program.

If the **Noise Source Tracking** Window is open in MoonSked then the selected source (Moon, Sun etc) will be used for tracking.



MoonSked's Tracking Preferences must be set to some interval other than Off.



Note: MoonSked Registered Users may contact the author by email for MoonSked Rotator Drivers.

Legal

Although GM4JJJ has no reason to suspect that this software could do any damage to either you or your computer, for my protection I must include the following statement.

Standard Disclaimer

This is a legal agreement between you, the end user, and David Anderson GM4JJJ

Be sure to read the following agreement before using the software.

IF YOU DO NOT AGREE TO THE TERMS OF THIS AGREEMENT,
THEN PLEASE DISCONTINUE USING THIS SOFTWARE.

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Appendices

Appendix 1

MNR Theory by Paul Kelly N1BUG

Appendix 1

Paul Kelly, N1BUG wrote this explanation of his MNR theory, MoonSked includes MNR for the benefit of those who wish to test it out.

A BRIEF TUTORIAL ON Z-TRACK's "MAX NR" INDICATOR

MM Software Systems
April, 1993

I've been asked about the "Max NR" figure generated in Z-TRACK by several users of the program. Most of the questions were just plain old "Huh ???" , indicating that I really goofed. Max NR, as far as I know, had never been used in any moon-tracking software prior to the first release of Z-TRACK. I developed it as a new indicator to supplement the "Spatial Polarisation Offset" so often seen in such software. I firmly believe it is a much more meaningful and easily interpreted indicator of polarisation conditions. So, here goes my best shot at removing the shroud of mystery from the Max NR index !! I've had a go (or two, or...) at explaining this verbally, without the kind of success I was hoping for. MAYBE I can do better writing it down (???).

THE PRE-BASICS

I suspect few people will argue these days that the polarisation of an incoming signal with respect to the polarisation of the receiving antenna makes a tremendous difference in how well the signal can be heard. A signal perfectly aligned in polarisation with the receiving antenna system will suffer no loss of strength due to polarisation mis-alignment. A signal arriving perpendicular to the polarisation plane of the antenna (90 degrees to it) will suffer the greatest loss - How much depends on many factors, but for a typical modern yagi it is generally taken as between 20 and 30 dB. In between these extremes the loss varies logarithmically with the cosine of the angle (by angle I mean the difference in degrees between the polarisation plane of the incoming signal and that of the antenna). A formula for this is:

Loss (dB) = 20 log(cos Ç)

where Ç = the angle in degrees.

This formula assumes a perfect yagi with no unwanted response to signals of the opposite polarisation. It is VERY close up to about the 18 or 20 dB point, but beyond that needs a correction factor to keep the result down to a realistic level.

That's all well and good for two antennas of like polarisation pointing toward each other along the Earth's surface. But what of two antennas of like polarisation pointing off into space? The situation becomes a little more complicated. In my own crude way let me try to help you visualise what I mean. Suppose you had a large round ball sitting in front of you. If you took two samll model yagis and planted one on the very top of the ball (be sure to align the elements so they are parallel to the surface of the ball directly below the antenna) so that it is pointing straight away from you toward a distant wall, and the other on the left side of the ball (elements parallel to the surface of the ball) pointing to the same distant wall, You will have the basis of this visualisation. Both antennas are horizontally polarised with respect to the surface of the ball (simulated Earth), right? But stand back and sight along the boom of each yagi, toward that wall. If you can visualise a signal leaving each antenna and travelling to the the wall (simulated moon),you will see that the polarisation planes of the two signals hitting the wall are actually 90 degrees out of sync with each other. This difference is what we call "Spatial" Polarisation Offset! Gee Whiz!

The geometry involved on an EME path is a little more complex, what with elevation angles and so on. The point of reference used for such calculations is generally the Earth's polar axis, but a complete discussion of the mechanics involved is beyond the intent of this discourse (and is a fantastic way to get a headache). Here is the basic formula used to calculate a spatial polarisation for an antenna with respect to the Earth's polar axis:

$$P = \mathrm{ATN}\ \frac{(\sin L * \cos E - \cos L * \cos A * \sin E)}{(\cos L * \sin A)}$$

where L = Latitude of station {footnote 1}
A = Azimuth of antenna
E = Elevation of antenna
P = Polarisation angle

The spatial polarisation offset (read 'difference') between any two stations is simply P1 - P2, but keeping it within a range of -90 to +90 takes additional steps.

MOVING ON TO THE REAL WORLD

For some time we have been accustomed to seeing a "Polarisation" or "Spatial Polarisation Offset" figure in moon-tracking programs that track the moon for two stations. This figure is in degrees, with some programs keeping it within a range of -90 to +90 degrees while others allow it to approach 180. Along with this, many of the programs have also tried to include a "Polarisation Loss" figure in dB, with 0 dB indicating a polarisation offset of 0 (or 180) degrees and 25 dB or more indicating a polarisation offset of 90 degrees.

It doesn't take a rocket scientist to figure out that this just cannot be the case. We've all made some fine EME QSOs when software told us to expect 20+ dB loss of signal based on polarisation! So what's the deal here? The problem is that programs like that don't consider the affects of Faraday rotation. The fact is that due to Faraday rotation in the ionosphere signals can arrive at the receive antenna at ANY polarisation, regardless of the spatial polarisation relationship between the two stations. Given that consideration, the next thing we're confronted with is the argument that ALL of this spatial polarisation business should be disregarded since the unpredictable Faraday is going to modify the polarisation anyway. In other words we "make our skeds blindly and take our chances".

BUT - and this is a B-I-G but - the ionosphere has another unique little property that should make us re-think the situation. Simply put, a signal polarisation which rotates in a given direction when passing through the ionosphere on its way to the moon will rotate the same amount in the same direction (from the observer's viewpoint) on the return trip. You can visualise it this way: Suppose you were standing behind the reflector on your EME antenna and sighting down the boom to the moon. Further suppose for a moment that you could see the polarisation plane of the signal leaving your antenna and travelling to the moon and back again to the antenna. If you sent out a burst of RF and observed that the polarisation plane shifted 45 degrees to the right (clockwise) on the way out to the moon, your first assumption would probably be that the signal will rotate in the opposite direction (from your perspective) on its way back, thus "un-twisting" itself and arriving perfectly in line with the elements on your antenna. But the ionosphere doesn't see it in that way. In fact the polarisation plane will rotate by the same amount in the same direction (clockwise) from your vantage point on the return trip - thus making it now 90 degrees out of alignment with your antenna.

So what? Consider this: If you add a second station whose QTH is far enough away from yours so that the spatial polarisation offset between the two of you is 45 degrees, something interesting begins to take shape. Suppose you transmit and the Faraday causes the polarisation plane of your signal to rotate 45 degrees clockwise by the time it reaches the other station. It started out at 0 degrees (the spatial polarisation of your antenna) and was twisted 45 degrees clockwise, so it arrives at his antenna perfectly aligned with it (his spatial polarisation is 45 degrees greater than yours, don't forget). Sounds like the Faraday is doing us a big favour, right? WRONG! Now suppose the other station transmits a string of O's back to you (having heard your signal very well by virtue of the perfect polarisation alignment). The polarisation plane of the signal starts out at 45 degrees (his spatial polarisation) and then gets rotated 45 degrees clockwise on its way to you, making the polarisation of the signal 90 degrees in "spatial" terms. Yikes! Your antenna is still at 0 degrees "spatial" polarisation, and his signal is coming in at 90 degrees! Unless you're a BIG GUN, you just won't be able to hear him. Good grief, one-way propagation!

WHEREAS THE ABOVE SITUATION IS AVOIDABLE...

Fortunately, there is a way to figure out what times are most likely to yield frustrating one-way conditions in advance. Going back to the example above... If the spatial offset between the two stations were 0 degrees, then Station A transmitting to station B would result in a clockwise twisting of 45 degrees, arriving 45 degrees out of alignment with his antenna. On the return trip, the exact same relationship holds. If the Spatial offset were 90 degrees, then station A transmitting to station B would result in a signal at 45 degrees "spatial polarisation" being received by an antenna with a polarisation of 90 degrees, for a difference of 45 degrees. On the return trip, 90 degrees starting from his antenna gets twisted clockwise to 135 degrees (135 degrees is equivalent to -45 degrees. It should always be kept in a range of +/- 90 degrees by adding or subtracting 180 degrees as necessary. 180 degrees is physically the same as 0 degrees), which is an offset of 45 degrees with regard to your antenna. In either of these cases the signal will be mis-aligned by the same amount (45 degrees) at both stations. There will be a resulting loss of 3 dB, but at least it's reciprocal (and 3 dB isn't as bad as 20+ dB).

I could (and probably should) sit here and go through various possible combinations of "spatial offset" and Faraday rotation for a L-O-N-G time. I'm not going to, but I would like to bring up one other point before going on. If one works away at this problem long enough (I've been fretting away at it for 5 years now), one then begins to think in terms of "windows of opportunity". Considering the original 45 degree spatial offset again... The absolute best that can be achieved (under normal circumstances) in this case is a Faraday of 0 degrees or 90 degrees. This would indeed result in a reciprocal path with 3 dB loss of signal at both ends. BUT, if the Faraday changes by only 15 degrees in either direction, the signal misalignment at one station will become 30 degrees (1.24 dB loss) and at the other station 60 degrees (6 dB). Notice how quickly the signal falls off at one end of the path for very small changes in prevailing Faraday - thus a small "window of opportunity" for reciprocal conditions, what with Faraday being such a changeable entity. On the other hand, consider either of the perfect cases - that is either spatial 0, Faraday 0 or spatial 90, Faraday 90. Under these circumstances the path is reciprocal with 0 dB loss at either end. If the Faraday changes 15 degrees in either direction the reciprocity will remain, and the signal will drop by only 0.3 dB at both stations. Indeed, the Faraday must shift 45 degrees one way or the other before the signal drops to -3 dB and even then it is still reciprocal. Hence a greater "window of opportunity".

The bottom line is that one-way conditions are much more likely to occur when the spatial offset is in the vicinity of 45 degrees and drops to nearly 0 when the offset is 0 or 90 degrees. Data collected over the past few years clearly shows that statistically the chances of completing an EME QSO drop off sharply when the spatial offset approaches 45 degrees, especially for the smaller stations who just don't have the signal to spare. Many have clearly benefited in the past few years by careful consideration of these polarisation issues.

A BETTER WAY ???

Considering the spatial offset in degrees is all right up to a point, but it can become a nuisance. I couldn't help thinking that what we really wanted to know was how non-reciprocal a given path could get at a particular time. The spatial offset information was nice, but I would find myself wanting to know more. When working up sked times, I often wondered about the actual non-reciprocity that might come into play. Hmm, the offset is 38.2 degrees, the cosine of 38.2 is ahhh... and the log of that is ummm..... Blast and drat! After a few false starts (not to mention sleepless nights) I came up with the "Max NR" figure. This gives a good approximation of the non-reciprocity that is likely to be encountered based on a given spatial offset. The name is somewhat of a misnomer, since Max NR does not always give the absolute maximum non-reciprocity that is possible for a given time. It gives a precise maximum only for offsets of 0, 45, or 90 degrees. At other offsets it gives a very good approximation of typical non-reciprocity values that are actually observed on EME. Spatial offsets near 45 degrees will show the highest Max NR figures, as offsets in that range are the most likely to cause severe one-way conditions.

One must bear in mind that this is neither a worst-case nor a best-case indication. However, it is a very good indicator of the typical non-reciprocities seen on EME and correlates quite well with EME logs analysed to date. What the Max NR does is provide a convenient and user-friendly way of weeding out times that have been statistically proven to have the lowest chance for success.

A VERY GOOD "FIT"

When I devised the new Max NR index, I needed to see how well it would fit with observed EME results, compared to other methods. I analysed several EME logs for percentage of QSOs vs spatial offset and Max NR. The graphs of QSOs vs. spatial offset showed the anticipated dip around 45 degrees (+/- a fair bit), but it was less than dramatic, all things considered. I next plotted the QSOs vs. Max NR and found an amazing correlation. I was not prepared for the results. All of the logs checked showed 90 percent or more of the QSOs occurred when the Max NR was less than 3 dB! It was a smooth curve with a very sharp drop for low but increasing values of Max NR, levelling out as it approached 25 dB. There was usually a small "anomaly" at 25 dB, caused by the method used to round off (or limit) Max NR indices that soar above that point. Remember my previous comment about the equation for dB loss needing a correction factor above 18 or 20 dB? I am very pleased with the results obtained.

Here is an attempt at reproducing the graphs in text form (for a typical log): [These are lacking in resolution - it's tough to reproduce graphics on an 80x25 text screen!!!].

```
                     EME QSOs VS SPATIAL OFFSET

#   100-|*
     90-|**  *
O    80-|*****
F    70-|******* **
     60-|*************   **                                 * *    *  **
E    50-|********************                       *   ****************
M    40-|**********************                 ************************
E    30-|*********************** **           **************************
     20-|****************************   **  ****************************
Q    10-|***************************************************************
S     0-|***************************************************************
O    -------------------------------------------------------------------
s       0     10     20     30     40     50     60     70     80     90
                         SPATIAL OFFSET (DEGREES)
```

```
                         EME QSOs VS MAX NR

#   1000-|*
     900-|*
O    800-|**
F    700-|**
     600-|***
E    500-|****
M    400-|*****                                        round-off anomaly
E    300-|********
     200-|**********
Q    100-|**************                                              **
S      0-|**************************************************************
O    -------------------------------------------------------------------
s        0    2    4    6    8   10   12   14   16   18   20   22   24
                                  Max NR (dB)
```

RECOMMENDATIONS FOR USE

Having introduced the concept of "Max NR" , here is a brief comment on what I have used it for. When making skeds I start with the smallest stations I want to run with, scheduling them when the Max NR is at its lowest (typically less than 1 dB). Then I move up to progressively larger stations, accepting somewhat poorer times as the size of the station increases. If you make many skeds you will find that it is not possible to schedule them all at "ideal" times! Generally speaking, I try to keep the Max NR on all skeds under 3 dB. I rarely suffer the "one-way blues" any more, although it does happen on rare occasions. (For every rule, there is an exception).

Spatial Offset (and hence Max NR) varies drastically from day to day as the declination of the moon changes. Hint: if you can't find a time with low Max NR on a given day, try a few days later or earlier. Sometimes, you have to give up... During the recent EME expedition to KC6, I ran a statistical analysis of the path from my QTH to KC6 and found that the lowest Max NR for the entire common moon window during that month was 12.6 dB! Arghhh!!!

EXCEPTIONS - QSOs NEAR 25 dB MAX NR

Any discussion on the subject of one-way EME conditions would not be complete (or fair) without some comments about why some good QSOs are indeed possible at 45 degrees spatial offset (or 25 dB Max NR). You will have noticed that while the graphs above show a dip in the number of EME QSOs in this region, it certainly does not drop to zero. There are at least 3 reasons for this.

Perhaps the most obvious exception is when the two stations have enough power and combined antenna gain to overcome very substantial losses. It's certainly possible to give up many dB and still work some of the super-stations.

As mentioned before, a situation exists when the spatial offset is 45 degrees and the Faraday is 0 or 90 degrees (and very stable) causing reciprocal conditions but 3 dB loss of signal at both ends of the QSO. Sometimes the Faraday is indeed stable enough to permit complete QSOs in this case (assuming both stations can deal with the 3 dB loss).

The third exception is that it is possible for the polarisation of a signal passing through the ionosphere to become diffused or elliptical. In this case weak signals may be heard at a variety of receive-antenna polarisations, but not without some sacrifice in signal strength. Depending on the size of the two stations and the exact nature of the polarisation diffusion, some QSOs are indeed possible in this case regardless of the spatial polarisation offset. From observations made over a period of time it seems that such conditions occur more frequently at times of high solar activity.

Again, the whole point is that it is less likely to complete EME QSOs when the spatial offset is near 45 degrees (and Max NR is high) than when the offset is closer to 0 or 90 degrees (in which case Max NR is low). Therefore, a careful consideration of the polarisation issue when scheduling EME activities can significantly improve the chances for success (by weeding out times that have the lowest chance for success), but will never offer an absolute guarantee of anything. While working on the Max NR concept for use in Z-TRACK, many controlled tests were run with stations at various spatial polarisation offsets. It was found that QSOs could be made more frequently and with less effort when the offset was near either end of the scale than when it was approaching 45 degrees. Some QSOs were made in the worst-case 45 degree condition, but in almost every case involved significantly weaker signals at one or both ends of the QSO than when the offset was more favourable.

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1. This equation was developed by C.H Hustig and was taken from an article "Spatial Polarisation and Faraday Rotation" by Tim Pettis, KL7WE. This article appeared in PROCEEDINGS of the 22nd CONFERENCE of the CSVHF SOCIETY (Lincoln, NE 1988).