

# Receiving Images from the Meteor Satellites

## Preparing for the future following a year of progress

Les Hamilton

It's exactly a year since *GEO Quarterly* published its first article on the reception of images from Russia's Meteor-M2 satellite [1] and there have been several more articles since [2,3,4,5]. But during the year, thanks to new versions of the *SDRSharp* Software Defined Radio application from *Airspy.com*, customised plugins for *SDRSharp* written by Vasili Beliakov (<http://rtl-sdr.ru>) and updated decoding software from Oleg Bekrenev (Robonuka), everything has advanced at an unprecedented rate.

Although much of what has previously been written remains true, recent developments have created problems which now make it more difficult for newcomers to set up a working Meteor LRPT receiving station. Many of the URLs for downloading software have changed; as *SDRSharp* and its plugins develop apace, incompatibilities arise that can cause a system to fail; and support for *Windows XP* has ended. Current versions of *SDRSharp* and its plugins require *Windows Vista, -7, -8 or -10* to function. They cannot be run in *Windows XP*.

The most recent change occurred in September 2015 when *Microsoft's dot NET 3.5 Framework* was abandoned in favour of the newer *dot Net 4.6*. Current versions of *SDRSharp* and the plugins required for Meteor reception have all been recompiled to run under *dot NET 4.6*, and will not run on the older Framework. In many cases the converse is also true, and older plugins may not work under the new Framework.

Another change that will become important when the next satellite in the Meteor series is launched is a new transmission mode. QPSK is to be replaced by OQPSK, and from version 1.5, the *Meteor Demodulator* plugin already possesses this capability.

This article is basically an updated User Guide to receiving Meteor M2 using an RTL-SDR dongle, its key thrust to take onboard new developments and clarify all the essential issues.

### Preparing a Computer for Meteor Reception

Many readers will have benefitted from Alex's tutorial: "*Receiving Meteor M-N2 Images in Realtime with the QPSK Plugin on RTL-SDR Dongles*", which is still a valuable document [6], and can be downloaded from the GEO website at

[http://www.geo-web.org.uk/lrpt\\_Files/MeteorM-N2\\_Realtime.pdf](http://www.geo-web.org.uk/lrpt_Files/MeteorM-N2_Realtime.pdf)

Unfortunately, many of the URLs listed for downloading the necessary software, specifically *SDRSharp* and its plugins, are no longer valid. There have also been name changes: for instance, what used to be termed the '*QPSK Demodulator*' is now called '*Meteor Demodulator*'.

### SDRSharp from Airspy.com

*SDRSharp* is now distributed under the 'Airspy' banner, and can be downloaded from their website at

<http://airspy.com/download/>

where it is the top option on the page. A new development is that this download is a zipped archive already containing most of the files you require to run *SDRSharp*.

Start by creating an empty folder named *SDRSharp* on your computer (preferably **not** in the *Programs* folder) and extract all

the files into it. My own preference is to create the *SDRSharp* folder directly on the C:\ drive.

### Interfacing SDRSharp with the RTL-SDR Dongle

In order that *SDRSharp* can detect your RTL dongle, the appropriate driver must be installed. In earlier versions of *SDRSharp*, the driver installation software *zadig.exe* was provided as part of the package. With the current versions this is no longer the case. Instead, you will find a file called *install-rtlsdr.bat* in the *SDRSharp* folder. Run this as administrator (you must be online, of course) and it will deposit a copy of *zadig* inside the *SDRSharp* folder.

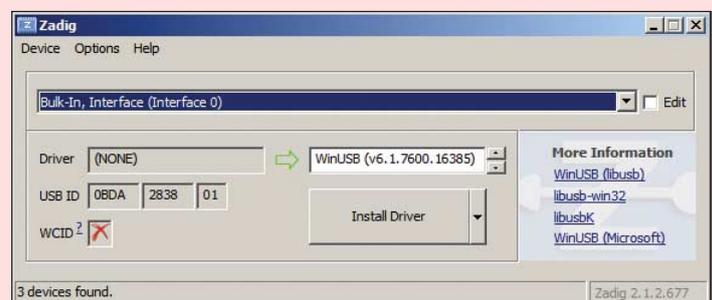


Figure 1 - The 'Zadig' driver installer.

Before carrying out the next step, you **must** plug an RTL-SDR dongle into one of your computer's USB ports so that the *Bulk Interface* options become accessible. Now run *zadig* as Administrator, to download and install the required driver. Make sure that the drop-down selector shows: '*Bulk-In Interface (Interface 0)*'. If you can't see this option, click '*Options*' and tick '*List all devices*' first (figure 1).

### Front End RTL-SDR Drivers

By default, the *SDRSharp* 'Source' menu defaults to the *Airspy* Front End Driver. To engage your RTL-SDR dongle, this must be changed to the 'RTL-SDR (USB)' option. This provides a relatively simple RTL Driver, with just a single RF Gain slider. If

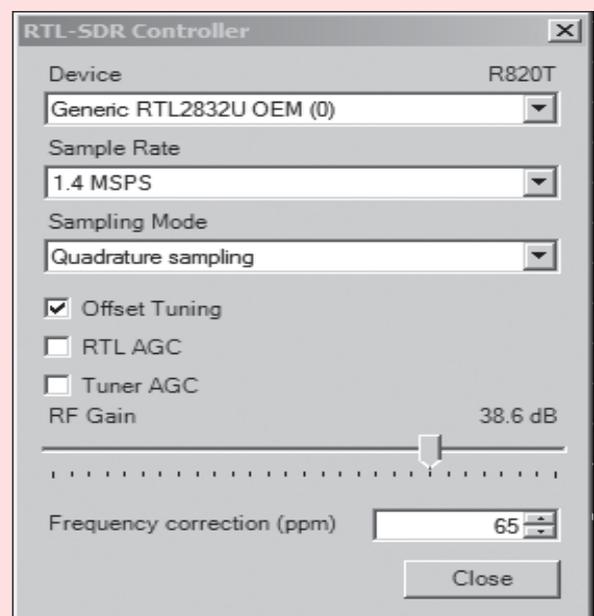


Figure 2 - The simple, default RTL-SDR Driver

you use this driver, you must tick 'Offset Tuning' (figure 2). By default, when newly installed, the RF Gain defaults to zero. Drag this, initially, to at least mid-scale to enable reception of a Meteor signal.

There is, however, a more versatile alternative, Vasili's optional **modified R820T driver**, which offers three levels of gain control (figure 3). This can be downloaded as the file 'modrtlsdr.zip' from

<http://rtl-sdr.ru/uploads/download/modrtlsdr.zip>

Extract the contents of this file and copy the four DLL files into the *SDRSharp* folder.

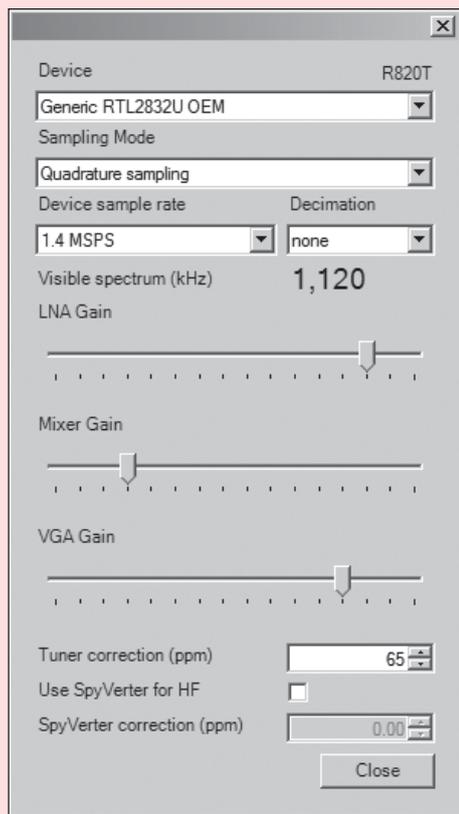


Figure 3 - The modified RTL-SDR Driver

To enable it, you must copy and paste the **front-end key** from the 'ReadMe' file into the *FrontEnds.xml* file in the *SDRSharp* folder (you can easily do this using *Wordpad*), then save it. Next time you run *SDRSharp*, you will find the new option 'RTL-SDR (R820T)' in the 'Source' menu. Note that this driver deals with the offset tuning feature automatically.

You can access the RTL Driver Menu by clicking the 'wheel' icon at the top of the *SDRSharp* screen. Figure 3 shows the settings I use for receiving Meteor. A degree of experimentation may be necessary depending on local conditions and your PC. If you experience difficulties obtaining good images because of ambient rf, it is often possible to reduce this by experimenting with different **Gain levels** and the **Device sample rate**.

### Preparing for Reception

There are two options for receiving imagery from the Meteor satellites. The simplest procedure is to store the satellite transmission as an **S-file**, then decode it into images using Oleg's **LRPTOfflineDecoder** software. An alternative is to make use of the *TCP socket* feature of the *Meteor Demodulator*, coupled with a modified version of *LRPTOfflineDecoder*, which allows real-time visualisation of the satellite images building up, and which also automatically saves these images. I prefer the former system, which is what will be described below.

### Setting up the SDRSharp Radio Section

Here, it is essential to select **WFM** (wide FM) mode, and a **Bandwidth** of 120,000 Hz. It is also helpful to tick **Snap to grid** and set the **Step size** to 100 kHz. You must also check **Correct IQ**.

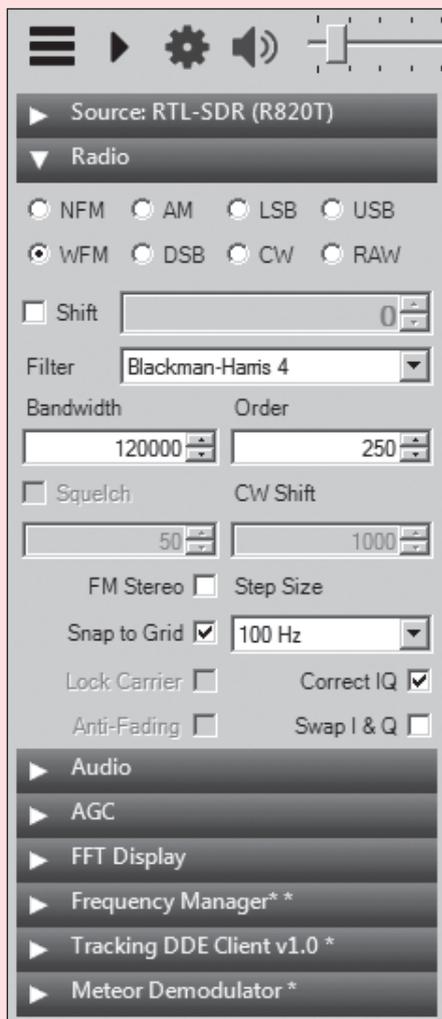


Figure 4 - Setting the Radio Parameters

### The Frequency Manager Section

The best way to centre the precise 137.100 MHz Meteor frequency on the screen is to edit the appropriate details into the *Frequency Manager* (figure 5) then select it from its menu. (figure 6).

If future Meteor satellites transmit on different frequencies, this will provide an rapid means of switching satellite.

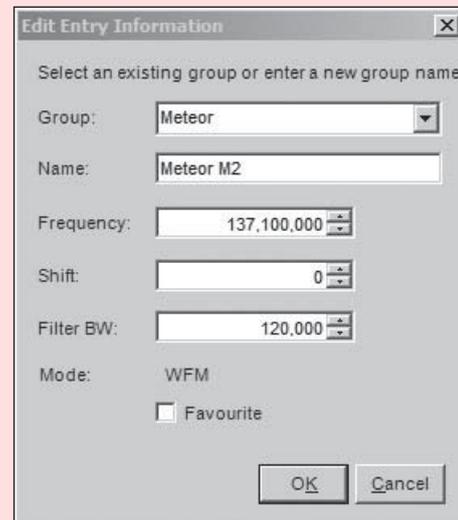


Figure 5 - Entering the Meteor frequency

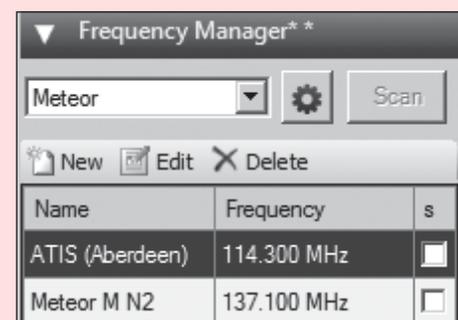


Figure 6 - The Frequency Manager Menu

The top item in figure 6 relates to the ATIS (*Automatic Terminal Information Service*) signal for my local airport in Aberdeen. An ATIS <sup>[7,8]</sup> frequency is useful for precisely calibrating an RTL-SDR Dongle using the **Tuner Correction** feature of the RTL Controller (figure 3).

The ATIS signal shows in *SDRSharp* as a sharp peak with a precise frequency. Zoom in to this and adjust it to exactly centre screen using the RTL Driver's **Tuner correction** option.

### The Meteor and DDE Tracker Plugins

By default, the *SDRSharp* package does not contain the plugins required for Meteor tracking and reception. You must download and install these yourself.

Download the **Meteor** plugin from

<http://rtl-sdr.ru/uploads/download/meteor.zip>

Copy the two DLL files into your *SDRSharp* folder, then copy and paste the 'magic line' into the *Plugins.xml* file.

Download the **DDE Tracker** plugin from

<http://rtl-sdr.ru/uploads/download/ddetracker.zip>

This time there are three DLL files to copy into the *SDRSharp* folder, and additionally the *SDRSharpDriverDDE.exe* file. Copy and paste its 'magic line' into *Plugins.xml*.

## Receiving Images Manually

You are now in a position to receive images from Meteor satellites **manually**, without at this point making use of the *DDE Tracking Client*.

With 137.1 MHz precisely centred on the *SDRSharp* screen, click the triangle icon at the top of the display to initialise *SDRSharp* reception.

In the **Meteor Demodulator** screen (figure 7):

- Click 'Demodulator'
- Click 'File' in the Output section
- Click the 'Start' button
- Check 'Out' above the Diagram
- Check 'Constellation' below it

The software is now active, although you will not see any evidence of this until a Meteor signal is being received (figure 8). The Meteor signal is the pronounced 'hump' at the centre of the *SDRSharp* display (the two peaks to its right are caused by rf interference).

The shaded section encompassing the 'hump' relates to the 120,000 Hz bandwidth set in the 'Radio' plugin.

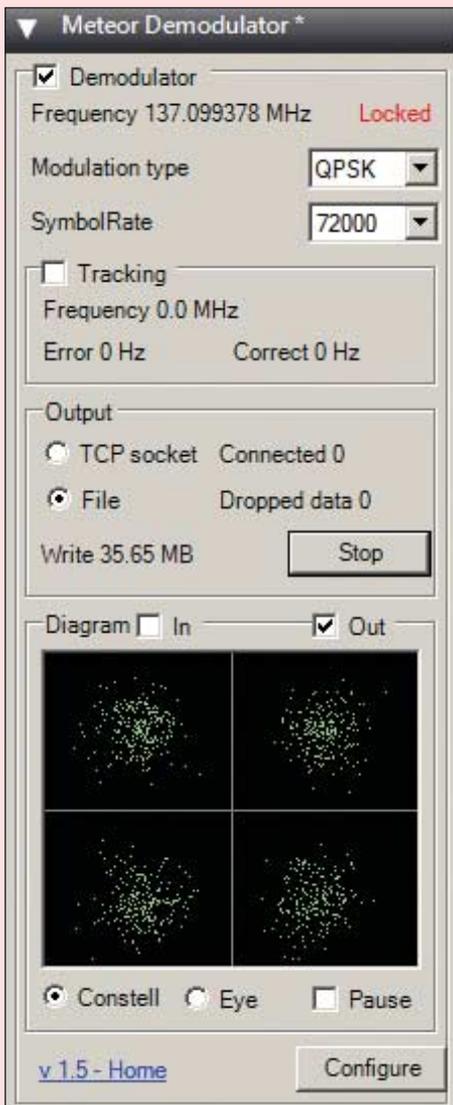


Figure 7 - The Meteor Demodulator Screen

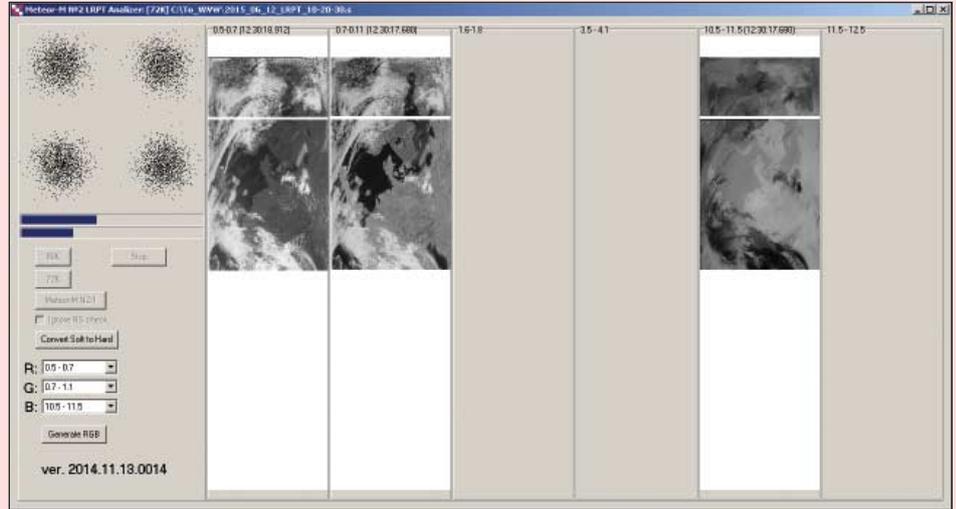


Figure 9 - Decoding an S-file with LRPTOfflineDecoder



Figure 8 - A section from the SDR# screen showing a received Meteor signal

During reception of a QPSK signal, the constellation diagram will display the typical four-dot pattern illustrated in figure 7. Eventually, as the satellite rises higher above the horizon and its signal strengthens, the word **Locked** will appear, indicating that the QPSK-encoded Meteor signal is being demodulated and saved. At the same time, in the 'Output' panel, you will see the 'Write' value increasing as the **S-file** containing the demodulated Meteor data is written to the hard drive. When the signal level falls too low for decoding, the process comes to an end. You can now press the 'Stop' button and process the data (described later), or simply leave the system running to continue unattended reception of subsequent Meteor passes.

By default, **S-files** containing the demodulated Meteor signal, are stored inside the *SDRSharp* folder. I find it more convenient to create a new folder on the hard drive—called QPSK—and use the 'Configure' button in the *Meteor Demodulator* to define this as the default save location. For the record, the saved files have the structure

**2015\_10\_19\_LRPT\_09-28-51.s**

and include the date and time of reception.

Note that all the default parameters within *Meteor Demodulator* have been fine-tuned for the Meteor M2 satellite, and need not normally be altered. Do not change the

'Symbol Rate'. Apart from a few early test transmissions, Meteor M2 always transmits at the 72000 symbol rate.

When future Meteor satellites arrive, at least one change will be essential. Meteor M2 uses QPSK-encoding for its transmissions, but all forthcoming Meteors will abandon this format in favour of OQPSK-encoding. This is already built into the software, and will have to be selected manually using the 'Modulation type' option. Whether any other changes will be needed, only time will tell.

## Producing Meteor Images

I'll cover the use of the *DDE Tracker* plugin to control Meteor reception below, but to complete the initial 'beginners guide' it's time to describe how to decode the saved **s-file** data into images.

The **s-files** saved by the *Meteor Demodulator* plugin can be resolved into images using Oleg Bekrenev's *LRPTOfflineDecoder* (figure 9)

This software can be downloaded from

<http://meteor.robonuka.ru/for-experts/new-lrpt-analyzer/>

There are two versions, the advantage of the more recent one being greater control via an **ini file**. A sample **ini file** for each version is also provided.

The **ini file** can be used to suppress unwanted log files, and also to determine which colour composite image is produced by default. My version is as follows:

```
[IN]
mode=72K
```

```
[OUT]
rgb=125.bmp
logs=no
```

This acknowledges that Meteor M2 operates at a Symbol Rate of 72000/

sec, creates BMP colour composite images by combining channels 1+2+5, and suppresses unwanted log files. Type this into *Notepad* and save it with the same stem filename as *LRPTOfflineDecoder*, but with the extension '.ini'.

To commence processing, click the '72K' button and navigate to the location where you have saved your **s-files**. Processing should start immediately, soon signified by the appearance of a 4-dot constellation in the upper left panel, similar to that seen during demodulation (figures 7,9). Processing is complete when the upper blue progress bar reaches 100% and the lower bar falls to zero.

Next, click the Generate RGB button to create the colour composite image. If no image appears, make sure that the frequencies showing in the three RGB selector boxes correspond with the channels that produced images in *LRPTOfflineDecoder*. In figure 9, channels 1, 2 and 5 are displaying images, so it is the frequencies shown at the top of these that should be chosen for the R, G and B selectors (figure 10a). The resulting RGB image is shown in figure 11a.

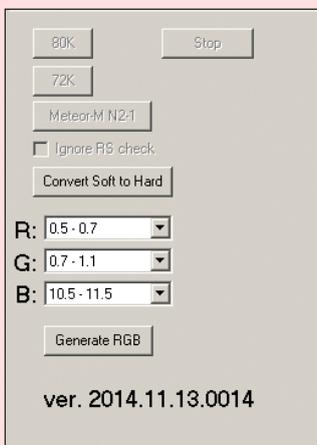


Figure 10a  
Selecting an RGB125 image

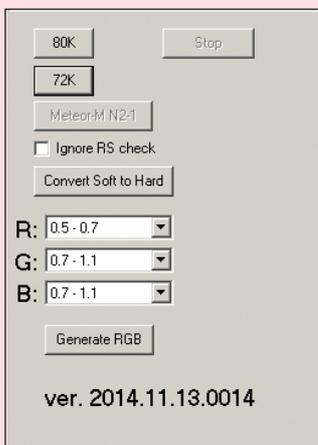


Figure 10b  
Selecting an RGB122 image

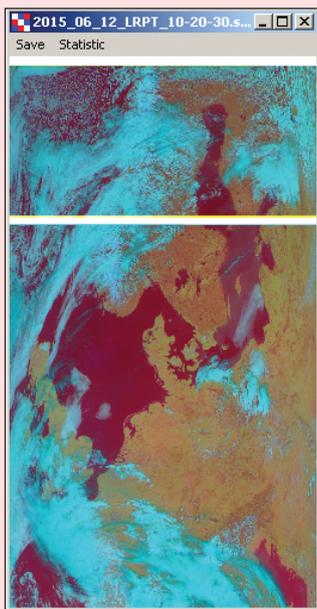


Figure 11a  
The resulting RGB125 image

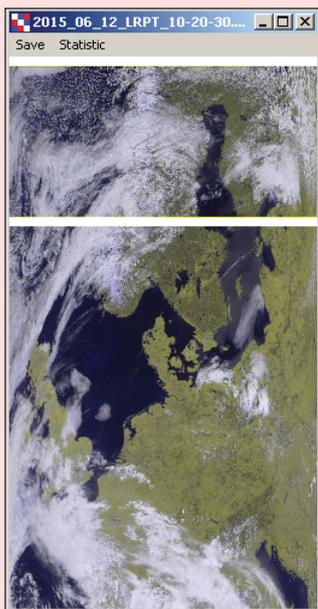


Figure 11b  
The resulting RGB122 image

This has a distinctly unusual appearance but don't discount it. But if you prefer a more appealing instant result, select the channel 2 image for **both** the G and B components (figure 10b) to produce the more realistic rendition shown in figure 11b. To save the displayed image as either a BMP or JPG, click the 'Save' option above it.

As explained in David Taylor's article in our previous issue [5], so-called RGB125 images (formed by combining channels 1+2+5) are your gateway to a wealth of processing options. You can download his free program, *LRPT Processor*, from this URL

<http://satsignal.eu/software/LRPT-processor.html>

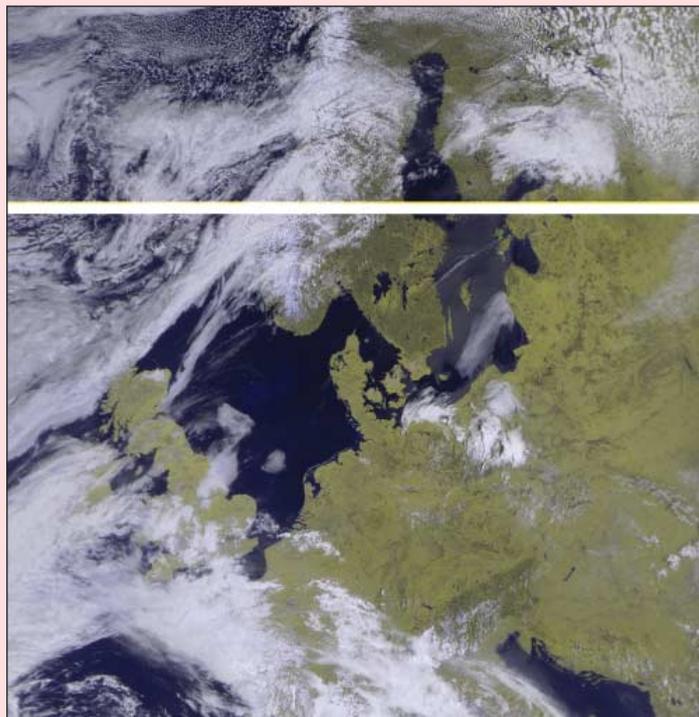


Figure 12 - A geometrically corrected version of the image

**Geometrically Rectifying Images**

The images received by Meteor satellites show geometrical distortion to east and west as a result of Earth's curvature. This can be corrected to produce more satisfying results using the program *SmoothMeteor*, which can be downloaded from this page

<http://leshamilton.co.uk/meteor3m.htm>

David Taylor's *LRPT Processor* also provides an option to provide this geometrical correction. The corrected version of figure 11b is illustrated above in figure 12. Note that the broad white gap in the image is due to a hardware fault aboard the satellite. This results in a break roughly every 6½ minutes during almost every transmission.

**Fully Automated Meteor Reception**

Recording Meteor transmissions manually, as described above, can produce very satisfying results: but improvements are possible. As the satellite approaches and recedes from your station, the Doppler effect modifies the received frequency, increasing it as the satellite approaches and decreases it as it departs. If a means can be found to continuously adjust this Doppler effect during a satellite pass, the software will lock on to the signal earlier, provide longer images, and be less susceptible to the effects of local rf interference.

The solution is to use a satellite tracking program such as Sebastian Stoff's *Orbitron* (figure 13) to control *SDRSharp* and feed it an updated Doppler-corrected frequency throughout the satellite pass. *Orbitron* can be downloaded from

<http://www.stoff.pl/>

Double-click on the file 'orbitron.exe' and install it directly to the C:\ drive (**not** to the 'Programs' folder). When first run, *Orbitron* has an annoying habit of taking over the entire screen. Press Alt+Enter on the keyboard to reduce it in size.

## Interfacing Orbitron with SDRSharp and DDE Tracker

The most important task in configuring *Orbitron* to engage with both *SDRSharp* and the *DDE Tracker* module is to open the 'Orbitron/Config' folder and edit its 'setup.cfg' file to add an entry for the SDRSharp driver. Load *setup.cfg* into a text editor such as *Wordpad* and add the following two lines at the end of the file, immediately following the [Satellites] section, then resave it.

```
[Drivers]
SDRSharp=C:\SDRSharp\SDRSharp.exe
```

This, of course, presupposes that you have *SDRSharp* installed directly on your PC's C:\ drive. If not, replace 'C:\' with the path to the *SDRSharp* folder.

### Setting up Orbitron

There is an excellent, illustrated guide to setting up all the required parameters for *Orbitron* in Alex's tutorial document referenced above [6]. Every step of the procedure is illustrated by a screenshot, making the entire process very straightforward. A brief summary follows here.

#### Updating Satellite Orbital Elements

It is important to keep *Orbitron* updated with the latest Two-Line Elements (TLEs) for the Meteor satellite in order that the software can track the satellite accurately. These are available from the *Celestrak* site as a text file called 'weather.txt'. *Orbitron* can download these automatically.

Click the **Setup** icon, which is located just above the tabs along the foot of the *Orbitron* display (circled in red on figure 13). Select the 'TLE updater' tab and make sure that the 'www.celestrak.com - All' group is selected (this should already contain 'weather.txt'), and check the box against 'Mark this group to autoupdate'.



#### Load the Satellite 2-lineData

Click the **Load TLE** button below the panel at top right in the *Orbitron* display. Navigate to 'weather.txt' in the browser that opens and double-click to select it. The names of the various weather satellites will appear in the pane (figure 13). Select Meteor M2 as the active satellite by ticking the checkbox to the left of its name in this listing.

#### AOS Notification

Open the 'Miscellaneous' tab. If the **Play** sound box is ticked, an alert will sound as soon as the satellite rises above your horizon. There is also an option to delay the alert till the satellite elevation is several degrees above the horizon.

#### Make Meteor the Active Satellite

Open the 'Extra' tab. Tick the final option 'AOS notification: make satellite active'.

#### Select the Displayed World Map

Open the 'World map' tab, where you can select from a variety of maps. The popular 'coloured' option is shown in figure 13.

#### Set your Time Zone

First, make sure that your computer clock is correct for your time zone. Absolute accuracy is not crucial, but should be within a few seconds of the true time. It's a good idea to check regularly, or use software to maintain accuracy.

If your PC clock is not set to local time, open the 'General' tab and add a correction for **Local time**.

#### Set your Location

On the main *Orbitron* screen, open the 'Location' tab at the foot of the display and select your location. If this is not

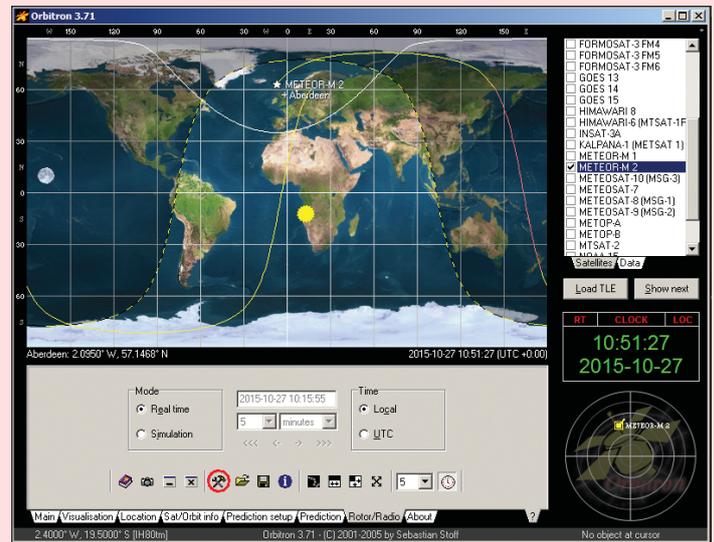


Figure 13 - Orbitron - Main Screen

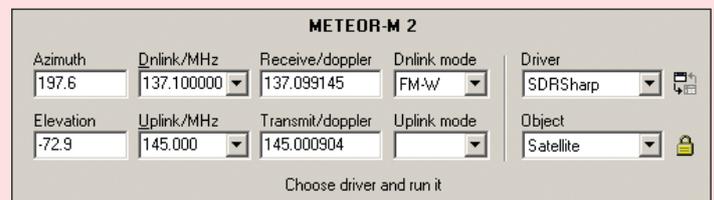


Figure 14 - Orbitron - Rotor/Radio Tab

listed in the menu, you must insert it and enter your latitude and longitude coordinates manually.

#### Interfacing with SDRSharp

Finally, open the 'Rotor/Radio' tab (second from right at the foot of the display - figure 14) and enter 137.100 in the **DNlink/MHz** field. In the **Dnlink mode** field, select 'FM-W'.

Finally, select your driver from the dropdown list. You should find an entry for *SDRSharp* there (you appended this to *Orbitron's setup.cfg* file earlier).

**Note:** If you find that the *SDRSharp* driver has not been added to the dropdown list, the most usual cause of the problem is installing *Orbitron* in the **Program Files (x86)** folder. It may be sufficient to move the entire *Orbitron* folder directly to the C:\ drive. If this doesn't help, delete the *Orbitron* folder and make a fresh install **directly to the C:\ drive**.

#### Running SDRSharp via Orbitron

There are three things you must do to initiate automated Meteor reception after starting *Orbitron*:

- Open *Orbitron's* 'Rotor/Radio' tab, and click **once** on the icon immediately to the right of the 'Driver' slot (which should now show 'SDRSharp'). There are often a few seconds delay before the *SDRSharp* screen appears.
- Click the triangle icon at the top of the *SDRSharp* screen to start radio reception.
- Make sure that the 'Scheduler' option in the *DDE Tracker* plugin is ticked (in fact, if you open *SDRSharp* on its own, set this option, and close down, it will automatically be ticked every time you run the program via *Orbitron*).

At the end of a session, close *Orbitron*, which will automatically close *SDRSharp* too.

#### Configuring the DDE Tracker Plugin

The *DDE Tracker* must be programmed to perform appropriate tasks, when a Meteor M2 signal is first detected (AOS: Acquisition of Signal) and at the end of the pass (LOS: Loss

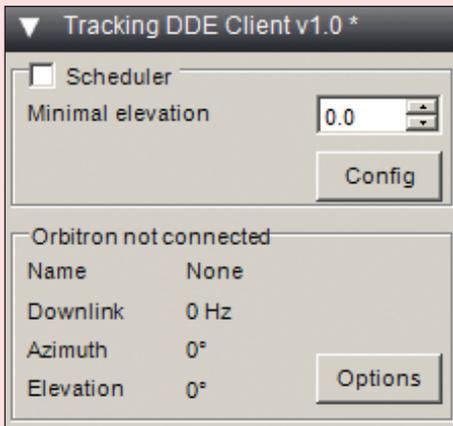


Figure 15 - The inactive DDE Client Panel

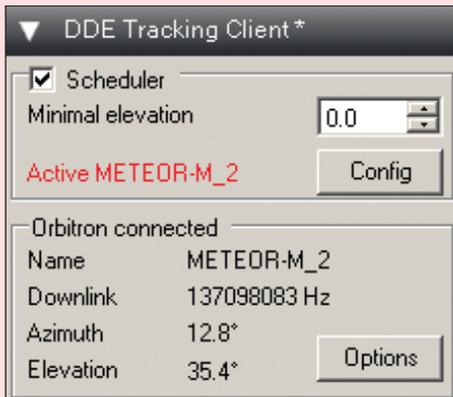


Figure 16 - The DDE has detected QPSK

of Signal). At AOS these consist of the transmission frequency, modulation type and bandwidth, plus commands to send the corrected frequency (calculated by Orbitron) to the Meteor Demodulator, then finally to activate the 'Demodulator' checkbox in the Meteor plugin panel as soon as QPSK has been detected in the transmission.

At LOS, the final two items are switched off again (figure 18).

### 1. Entering the Satellite Name

The name you type into the 'Satellite name' field must be identical with the way it appears in the TLE (2-line Keplerian Element) file used by Orbitron: with one important exception. Any 'space' character must be replaced by the 'underscore' character. So 'METEOR-M 2' in the TLE file translates to 'METEOR-M\_2' in DDE Tracker. Even changing the lettering from upper case to lower case means that tracking will not work.

### 2. Preparing for Satellite AOS

Any of the options listed in the right hand panel of figure 17 can be selected with the mouse and copied into either of the centre panes using the arrow buttons. The top panel, labelled 'AOS' relates to Acquisition of the satellite signal.

#### Add Radio Modulation Type

Click `radio_modulation_type<>` and copy it to the top centre panel. Edit it by typing 'wfm' between the angle brackets.

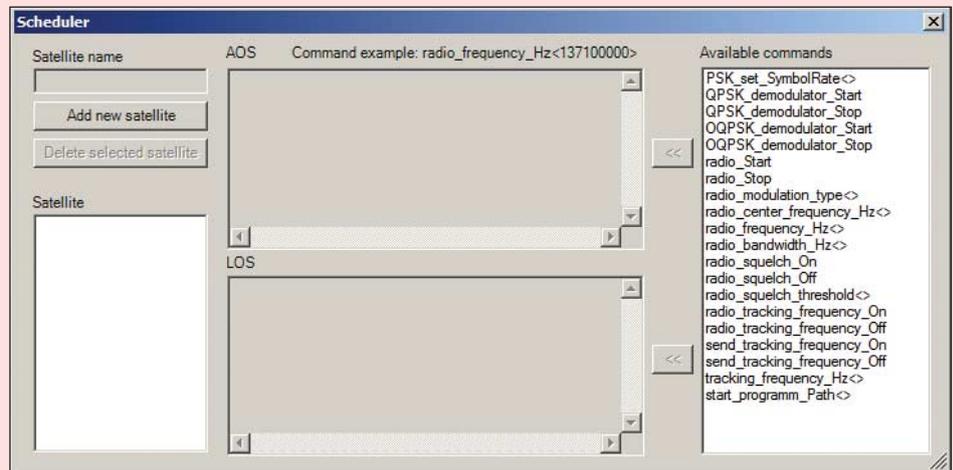


Figure 17 - The blank DDE Tracker 'Scheduler' screen.

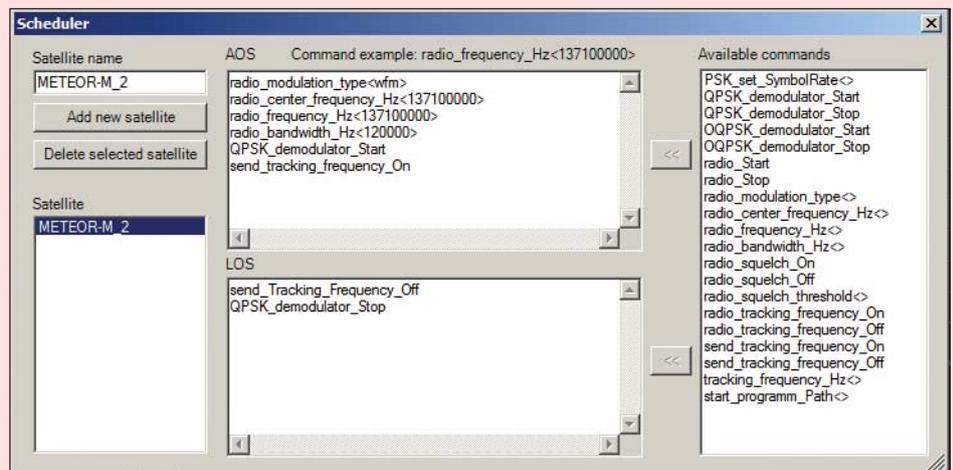


Figure 18 - The DDE Scheduler, configured to receive Meteor M2.

#### Add the Centre Frequency

Click `radio_center_frequency_Hz<>` and copy it across too. Type 137100000 between the angle brackets.

#### Add the Radio Frequency

Click `radio_frequency_Hz<>` and copy it across. Type 137100000 between the angle brackets.

#### Add the Radio Bandwidth

Click `radio_bandwidth_Hz<>` and copy it across. Type 120000 between the angle brackets.

#### Finally

Click `send_tracking_frequency_On` and copy it across.

Click `QPSK_demodulator_Start` and copy it across (this switches on the Meteor Demodulator).

### 3. Preparing for Satellite LOS

Only two items need to be added to the lower centre panel, `QPSK_demodulator_Stop` and `send_tracking_frequency_Off`.

Note that there is no 'Save' button. All entries and alterations are automatically saved to a file called

`DDESchedule.xml`, which is found in the `SDRSharp` folder.

### Running SDRSharp/Orbitron

Everything is now in place to record **s-files** from Meteor M2 transmissions fully automatically, and under Doppler correction. Just run Orbitron, select the *Rotor/Radio tab*, click the icon beside the *SDRSharp Driver*, and wait a few seconds till SDRSharp activates. Click the 'triangle' icon to start the radio, and wait.

### References

- 1 Receiving Meteor M2 with an RTL-SDR Dongle Raydel Abreu Espinet - GEOQ 44, page 6.
- 2 Trials and Tribulations Receiving Meteor M2 LRPT Les Hamilton - GEOQ 45, page 41.
- 3 EMC Advice for using an SDR Dongle Norbert Pütz - GEOQ 46, page 21.
- 4 Reducing Noise on an SDR Dongle Marc Peigneux, GEOQ 46, page 32.
- 5 Enhance Meteor imagery with LRPT Image Processor David Taylor - GEOQ 47, page 6.
- 6 Receiving Meteor M-N2 Images in Realtime by 'Happysat' [http://www.geo-web.org.uk/lrpt\\_Files/MeteorM-N2\\_Realtime.pdf](http://www.geo-web.org.uk/lrpt_Files/MeteorM-N2_Realtime.pdf)
- 7 ATIS frequency list <http://www.javiation.co.uk/vu.html>
- 8 UK ATC Frequencies <http://www.lightning.org.uk/frequencies.html>