

**UKMOON**



**CCTV Meteor Observation**

## **INTRODUCTION**

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This document is intended to introduce the reader to the aims and objectives of the UK Meteor Observation Network (UKMON) and to provide the information necessary to set up a meteor monitoring station.

This document discusses:

- The background to CCTV Meteor monitoring and what the amateur can contribute.
- The UKMON aims and objectives.
- The equipment needed and set up costs.
- What is involved in running a Monitoring Station.

More details can be found on the UKMON website: <http://ukmeteornetwork.co.uk/>

## **CCTV METEOR MONITORING**

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The use of video techniques to monitor and record meteor activity began in the seventies and has been growing ever since. Though pioneered by professionals, amateurs have taken a strong lead with the setting up of networks in Japan and Holland in the 1980s and now video observations by amateurs are at a semi-professional level with automatic video recording across Europe and in the United States. In the UK, video monitoring and recording of meteor activity has been the domain of a few trail-blazing individuals but until now there has not been a coordinated network.

With video observation we are able to combine the advantages of CCD technology as well as harnessing the power of computers to determine important parameters such as position, brightness, velocity, light curves, and orbital elements. As has happened with all technology, the cost of video technology has fallen to the point that this exciting branch of meteor science is well within the reach of amateurs.

## **WHAT CAN THE AMATEUR ASTRONOMER CONTRIBUTE?**

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These days virtually all meteor observation is undertaken by amateurs with organisations such as the American Meteor Society (AMS) and International Meteor Organisation and many other amateur bodies and networks providing advice and coordinating observation programs. This is where most of our knowledge about meteors and meteor showers has come from.

The amateur astronomy community is continuing to provide data essential to understanding and testing models for origins of meteors and orbital evolution. It remains a field that relies heavily on amateur astronomers for data and CCTV meteor observation in particular is leading to a step-change in our knowledge of meteoroid populations and their interaction with the Earth and its atmosphere. A classic example is the recent meteor which flared

through the skies over Russia's Chelyabinsk. Our understanding of the origin of this spectacular meteor is based entirely on observations by mainly non-astronomers.

Interestingly, amateur astronomers are now competing with the professionals and are undertaking research of their own and are publishing some very interesting findings and have added to a growing list of known meteor showers.

## ABOUT UKMON

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UKMON was launched in 2012 by Richard Kacerek and Peter Campbell-Burns with the aim of encouraging amateur astronomers in the UK to take up CCTV meteor monitoring and to provide a central point through which participants can share their data and collaborate on projects, reports and papers. Our wider objectives are to:

- Establish a network using low cost CCTV cameras to monitor continuously meteor activity over the UK;
- Enable members contribute to, and collaborate with, other networks across Europe using video data acquisition technology;
- Provide a platform for sharing knowledge and experience.
- Make raw meteor data publicly accessible to the amateur and professional astronomy community;
- Encourage involvement by individuals and organizations (including astronomy societies, schools and colleges).

By the end of 2012 four stations were operating in the South of England and discussions were being had with several astronomy societies interested in joining the network.

## WHAT DO I NEED?

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The main components of a meteor monitoring station are:

- A CCTV camera and wide angle auto-iris lens,
- A video decoder to turn the analog video output into a digital stream that can be processed by a computer,
- A windows-based PC (preferably running XP) with a licensed copy of the SonotaCo UFO Capture software installed, and
- A means to synchronize the computer system time (Internet connection or GPS dongle).

In addition, to the above, you will need a power supply, some means of switching the camera on and off at appropriate times, a waterproof enclosure for the CCTV and cables.

A full parts list for a typical installation with estimated costs is provided in Annex A. Annexes B and C discuss each component in a little more detail.

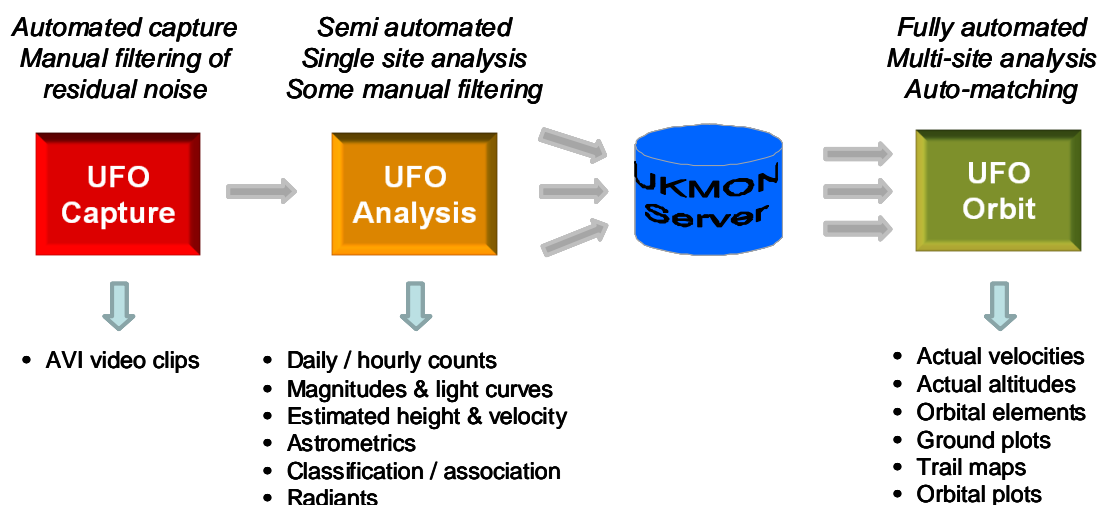
## WHAT IS INVOLVED IN RUNNING A MONITORING STATION

We are asked frequently what running a meteor station involves and have to do and how much effort does it take. There are four key activities to run meteor monitoring station:

1. Data acquisition (UFO Capture)
2. Data analysis (UFO Analyzer)
3. Data management
4. Orbital analysis (UFO Orbit)

Where a station is run by a group or society these activities can be shared and perhaps run on a rota basis to spread the workload and, more importantly, to ensure that everyone is involved in the process.

The diagram below shows the UKMON data acquisition and analysis pipeline for a meteor station and the outputs at each stage.



### *Data acquisition and analysis pipeline*

#### Data acquisition

Although data collection using UFO capture runs as a hands-off / fully automated process there is a need for an operator to review periodically the captured video segments to delete unwanted recordings (usually insects, passing low altitude aircraft, and satellites). UKMON is fairly good at discriminating signal from noise but inevitably there will be some false positives.

Operator review can be done at any time prior to analysis e.g. the day after or weekly and takes only a few minutes.

### **Data analysis**

Analysis using UFO Analyzer is a semi-automated process. Once an initial video segment is calibrated UFO Analyzer will perform a first pass processing of video segments automatically. Once this automated step is completed the operator will review the results and may need to reprocess some segments manually where the accuracy criterion are not met.

This step can be done at any time and will take up to 30 minutes per typical night of recording, and perhaps a little longer if meteor numbers are high due to shower activity.

Data analysis does not need to take place on the monitoring station PC. If, for example, the monitoring station is located in a remote observatory, data can be downloaded to a USB external drive and processed on another PC in the warmth and comfort of your own home.

### **Data management**

Once the video segments have been analyzed the results of the analysis should be uploaded to the UKMON server so that they can be shared with other station operators. Each station will have its own area on the server in which to upload their data.

Uploading data to the UKMON server is done over the Internet using a simple FTP client and only takes a few minutes.

### **Orbital Analysis**

You can spend as little or as much time as you want on this activity depending on your objectives. Once the datasets of interest are downloaded from the UKMON server onto your local PC, producing orbital analysis reports and plots with UFO Orbit is quick and easy.

## **HOW MUCH WILL IT COST TO SET UP A MONITORING STATION**

When we looked at the options it was important to us that the cost of setting up a UKMON monitoring station should not be not prohibitive and it had to be within the reach of individuals, societies and schools.

We believe that we have chosen a solution that is best overall for price and performance. The parts list in Annex A provides indicative costs for setting up a UKMON station; these are estimates for budgetary purposes. We estimate that to set up a station will cost around £400 – £450.

The actual cost of setting up a station will depend on exchange rates (the software is priced in Yen), whether you happen to have some of the equipment already to hand, and how much time and effort you are willing to invest in finding best deals on eBay. With a little effort it is possible to bring costs down.

## WHO CAN USE MY DATA?

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All meteor data uploaded to the UKMON server is publicly accessible and it is our aim to find the widest possible audience for UKMON data across the amateur and professional astronomy community. We believe that sharing data openly is the best way to serve the astronomy community and achieve maximum statistical significance from meteor data.

By uploading data to the servers UKMON members are agreeing to make their data available to others. If any reports or papers are published based on data taken from the UKMON server we only ask that the originators (the Station IDs) of the data used and UKMON are acknowledged.

## HOW DO I JOIN?

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If you are interested in setting up a meteor monitoring station and would like to be part of the UKMON project please get in touch via the following email address:

[ukmeteornetwork@gmail.com](mailto:ukmeteornetwork@gmail.com)

Alternatively you can contact us via the UKMON website:

<http://ukmeteornetwork.co.uk/join-in/>

## ANNEX A - FULL PARTS LIST

All prices are approximate and are provided for budgetary purposes only.

<b>Core Station Components</b>		
CCTV Camera	e.g. KPF 131 HR	£60 <sup>1</sup>
Auto Iris wide angle lens	e.g. Fujinon Lens YV2.8×2.8LA-SA2 1/3" 2.8-8mm / F1.4, Auto Iris or Tokina 3-8.2 mm F0.98 (IR)	£40 <sup>1</sup>
USB video decoder	e.g. Dazzle DVC 101	£30
PSU for the camera	Any 12v 1A PSU (240v supply)	£6
Mains timer switch for camera	Lighting timer is adequate so long as is power rating is sufficient for the PSU	£5
Computer	Modest spec, XP-based, preferably dual core, 1TB disk	£60 <sup>2</sup>
UFO Software	SonotaCo UFO Capture	£150 <sup>3</sup>
<b>Mounting and housing</b>		
Waterproof Housing with mounting bracket	Preferably an IP6 enclosure with 12v dew control <sup>4</sup>	£50
PSU <sup>5</sup> for dew control	Needs to be matched to dew control power requirements but typically a 12v 2A PSU (240v supply)	£12
Cabling	Video and power	£10
Mains timer switch for dew control heater	Lighting timer is adequate so long as is power rating is sufficient for the PSU	£5
<b>Other</b>		
GPS Dongle	Almost any USB GPS device will do, e.g. GlobalSat BU-353 WaterProof USB GPS Receiver	£25
GPS Software	GPSTime (COAA)	FOC

<sup>1</sup> Price based on CCTV and lens units sourced by UKMON

<sup>2</sup> Price based on cheap desktop sourced from eBay

<sup>3</sup> Price as at December 2012 and subject to exchange rate

<sup>4</sup> Housings requiring mains voltage (240v) for dew control are not recommended

<sup>5</sup> A separate PSU is preferred as switching of the heating element generates signal noise.

## ANNEX B – ABOUT SONOTACO

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UKMON is based on the Sonotaco UFO Suite developed by SonotaCo in Japan. The UFO suite is a set of software packages for the automatic detection and analysis of video meteors.

The UFO suite comprises three components for detection and analysis:

- **UFO Capture:** a motion detection program that scans the video stream for moving objects and when motion is detected a short AVI sequence is written to the computer disk.
- **UFO Analyzer:** processes the AVI files and determines the type of event that was recorded, performs photometric and astrometric analysis to determine meteor properties and, if applicable, associates the meteor with a shower.
- **UFO Orbit:** performs multi-station analysis and calculates precise trajectories and orbits.

Existing meteor networks around the world are generally based on one of two solutions: SonotaCo UFO suite or Metrec. Metrec is used by the International Meteor Organisation's monitoring network. It is an excellent system but is designed to work with a specific make and model of video decoder that is no longer in production and which can be difficult and expensive to source.

We chose to base the UKMON network on the SonotaCo suite for two key reasons:

- The UFO suite best fits the UKMON principles of accessibility and affordability.
- The UFO suite is used by many other stations across Europe and therefore gives the UKMON community best opportunity to share data with other European networks.

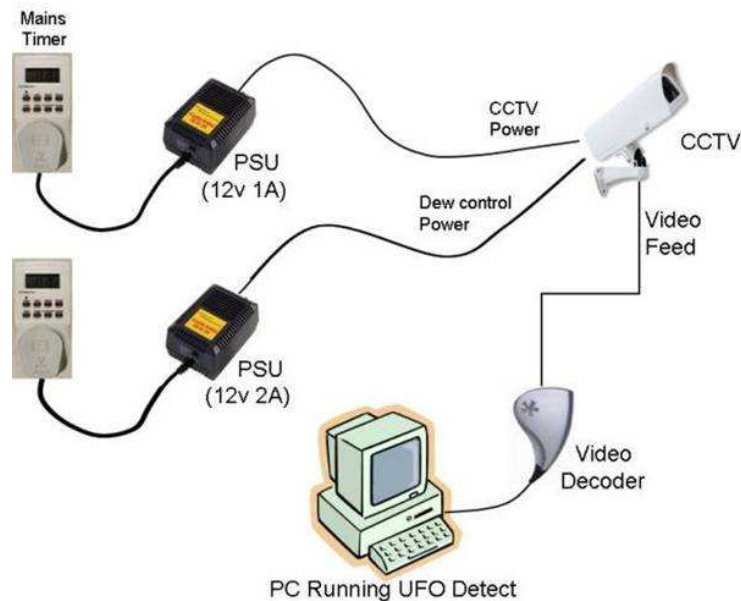
UFO Capture requires a licence whereas the use of UFO Analyzer and UFO Orbit is free to individual researchers. UFO Capture is also available as a 30 day free trial. The UFO Detect license can be purchased from the Sonotaco website (see below). Note that it is priced in Yen and so the actual cost will vary according to the exchange rate at the time of purchase.

More information is available from the SonotaCo website including downloads and technical documentation for the three main applications: [http://sonotaco.com/e\\_index.html](http://sonotaco.com/e_index.html)



## ANNEX C - BUILDING A METEOR MONITORING STATION

This annex discusses the monitoring station components in more detail and provides some advice and guidance where applicable.



**A typical UKMON station**

### CCTV Camera and Lens

The SonotaCo UFO Detect software supports a range of CCTV cameras and video decoders, the choice is yours. However our recommendation is a Chinese made KPF 131 HR with one of the following lens options:

- Fujinon YV2.8×2.8LA-SA2L varifocal lens, or
- Tokina 3-8.2 mm F0.98.



With their larger sensor and higher sensitivity Watec 902 H2 Ultimate CCTV cameras are a popular choice for meteor monitoring applications but a down-side is that Watec cameras are significantly more expensive. However, our experience is KPF 131 HR offers good overall balance for price and performance and is achieving very good results. There are other cameras and lenses that are compatible with the Sonotaco UFO detect software, the choice is yours. However, bear in mind the need for good sensitivity and the need to remove any IR filters.

The table below provides a comparison between the KPF 131 HR and the Watec 902 H2 Ultimate CCTV cameras.

	KPF 131 HR	Watec 902 H2 Ultimate
<b>Sensor</b>	1/3" Sony Super HAD II	1/2" Sony Ex View HAD
<b>Resolution</b>	582 x 500	752 x 582
<b>Sensitivity</b>	0.0002 lx	0.0001 lx
<b>S/N</b>	> 50db	> 50db
<b>Power</b>	12v	12v
<b>Est. Cost</b>	£60	£180 – £220

Some webcams are compatible with SonotaCo UFO detect but we do not recommend their use due to their relatively low sensitivity.

The primary considerations for the lens are its field of view, aperture, auto-iris, and of course the fit to the camera. The ideal field of view is around 70°, any larger than this and the spherical aberration and accuracy becomes problematic.

The Fujinon lens gives good brightness and a good overall image quality. Its field of view on a 1/3" camera ranges from 35 degrees to 99 degrees but for our purposes operating much beyond 70 degrees is not ideal and optical aberration becomes very significant. A fixed focus auto-iris lens may offer better image quality. The Tokina 3-8.2 mm F0.98 (IR) also provides good quality images.



The camera will be outside day and night and direct sunlight entering the lens is likely to damage the CCD sensor. An auto-iris provides a means to protect the CCTV sensor from direct sunlight because it will close whenever the camera power supply is disconnected. Protection from direct sunlight is ensured using a simple timer on the camera power supply. However, if you are prepared to switch the camera off manually at sunrise then there is no need for an auto-iris lens. The Hampshire Astronomy Group has been a little more innovative and use light sensors to switch off the 12v supply during the daytime. Two light sensors are set up in series in case of a single unit failure (see photo).

## Video Decoder

The CCTV camera produces a composite video output that needs to be converted into a digital format for the PC. There are many UFO Detect compatible video capture devices available which provide a simple and cost effective plug-and-play package that is.

Tried and tested video decoder devices include:

- Dazzle DVC 101
- Digitus USB 2.0 video grabber
- Ezcip Video Capture

## PC Specification

Just about any old PC will do. The software was developed to run on XP and it operates best in this environment, but it is being used successfully by UKMON members on Windows Vista and Windows 8 platforms.

The UFO suite is not particularly demanding on CPU and graphics and so the sort of modest specification dual-core PC available through 'office disposal' companies is ideal. The one exception is disk space! A typical meteor recording can require anything from 50Mb to 100Mb meaning that a typical night will require 500Mb to 3,000Mb (0.5Gb to 3Gb). A minimum disk capacity of 1Tb is recommended to allow for storage of up to a year of data.

## CCTV enclosures and mounting

Obviously, the CCTV camera will be exposed to the elements and so some form of waterproof housing is required, but with just a little ingenuity a DIY enclosure can be made simply and (Waterproof torches for example can be adapted to make excellent enclosures.)

There are many low-cost enclosures available commercially which claim to be weatherproof but our experience is that you get what you pay for. Remember too that weatherproof does not mean waterproof. A particular issue is that CCTV housings are generally designed to monitor a terrestrial view from a high viewpoint. When pointed towards the sky many features designed to stop water ingress will do exactly the opposite. The camera window can be a particular problem. With a housing angled upwards water tends to pool around the seal on the CCTV window rather than run off.



When buying an enclosure look out for an IP (Ingress Protection) rating and aim for at least IP67. If there is no rating it is perhaps best avoided. Our preferred commercially available housings are the Genie TPH housings which are rated at IP68.

Some form of dew control is recommended although being mounted close to a house wall does tend to slow the formation of dew. Many enclosures come with inbuilt dew heaters. These are effective but require a power supply. Enclosures requiring a 240v mains supply are best avoided and there are plenty of low voltage (12 / 24v) enclosures available.

If dew heaters are used then we recommend using a separate supply rather than doubling up with the camera. This is because switching of the heating element can create significant voltage spikes which interfere with camera operation. The resulting signal noise can lead to false detections. The same problem can occur if the heater cable is in very close proximity to the CCTV video cable.

Mountings need to be sturdy enough to prevent movement of the CCTV camera in windy conditions. Most commercial enclosures come with mounting kits but often these may have limitations on mounting angles. Careful planning (and sometimes careful modification with

a hacksaw) is required to obtain the required altitude and azimuth. Special care is needed if cameras are to be mounted at heights requiring ladders. Think safety!

### Camera Positioning

Ideally cameras need to be positioned to allow multi-site observations. In other words you will want your station to monitor an area of sky that is covered by at least one other station. The UKMON team will advise on optimal positioning of stations.

Another aspect of camera positioning is the length of the cable run to the PC. We are running stations successfully with cable lengths of 10m but keeping cable runs as short as possible is always advised.

### Time Synchronisation

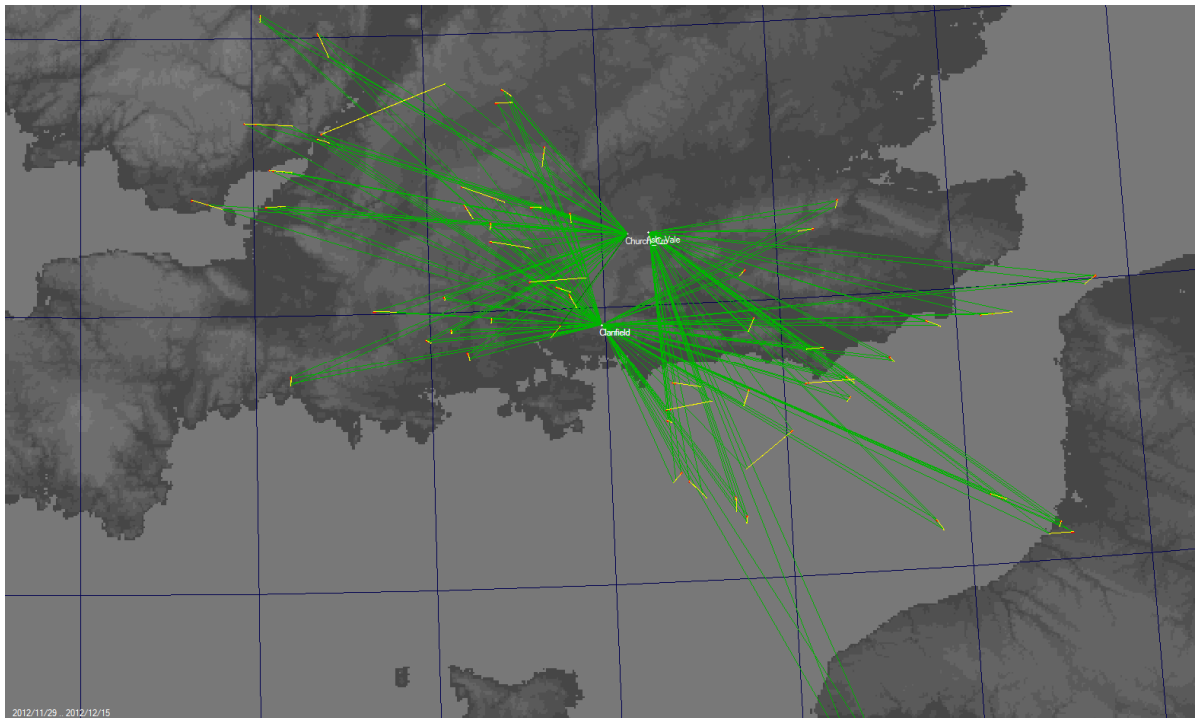
Multi-site observations requires the system clocks on all stations in the network to be accurately. The simplest method is to update the clock with a remote time server by using the Network Time Protocol (NTP) setting in Windows (note that NTP computes the round-trip delay time to account for network latency). Of course, an active internet connection is required for NTP to operate and this is not always possible if, for example, a station is located at a remote observatory location. 3G Internet solutions are less than ideal and expensive.

If no internet connections, accurate time synchronisation can be achieved using a low cost GPS dongle. The Fleet station is running successfully using the GlobalSat BU-353 WaterProof USB GPS Receiver (available from Amazon).

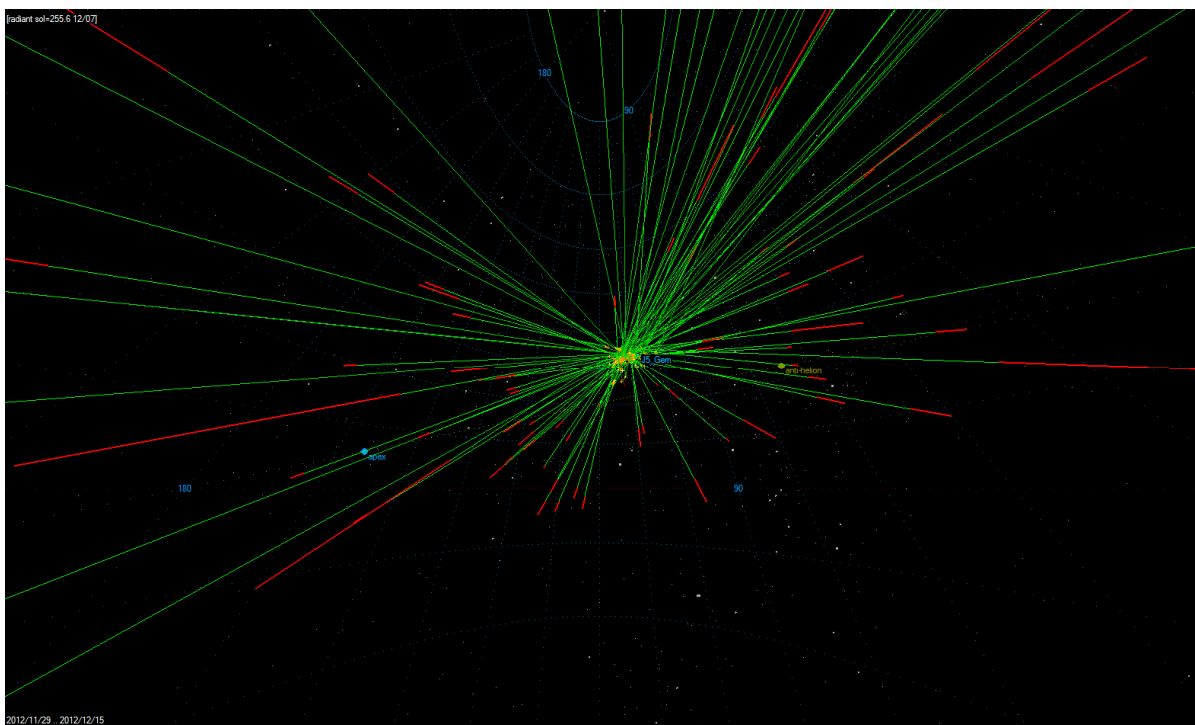
Not all dongles are supplied with software that will set the system time but there are several freeware solutions available. The fleet station uses "GPSTime" which is compatible with the BU-353 dongle and can be downloaded from the COAA (Centro de Observação Astronómica no Algarve) website: [http://www.coaa.co.uk/software\\_astronomy.htm](http://www.coaa.co.uk/software_astronomy.htm)

**ANNEX D – EXAMPLE PLOTS**

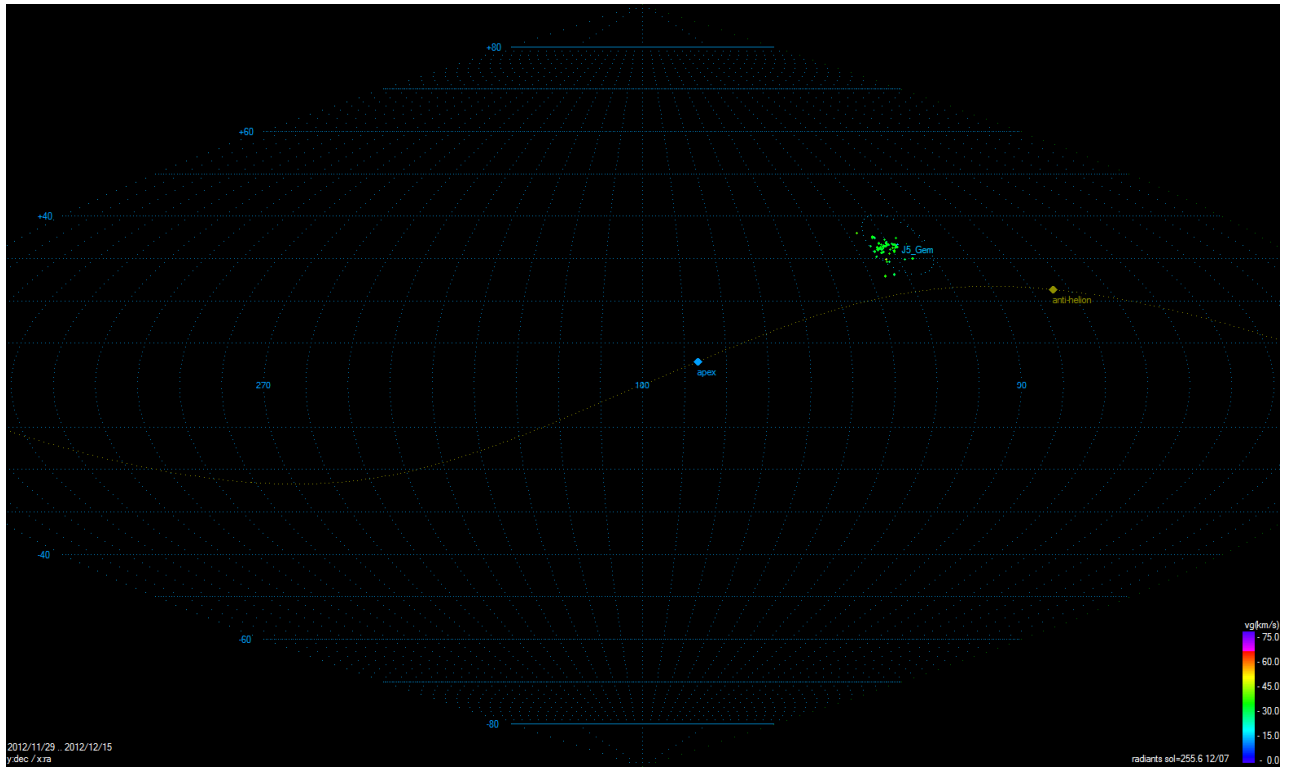
These plots for the 2012 Geminids are generated using UFO Orbit and data obtained from Hampshire Astronomy Group (Clanfield), Ash Vale and Church Crookham stations.



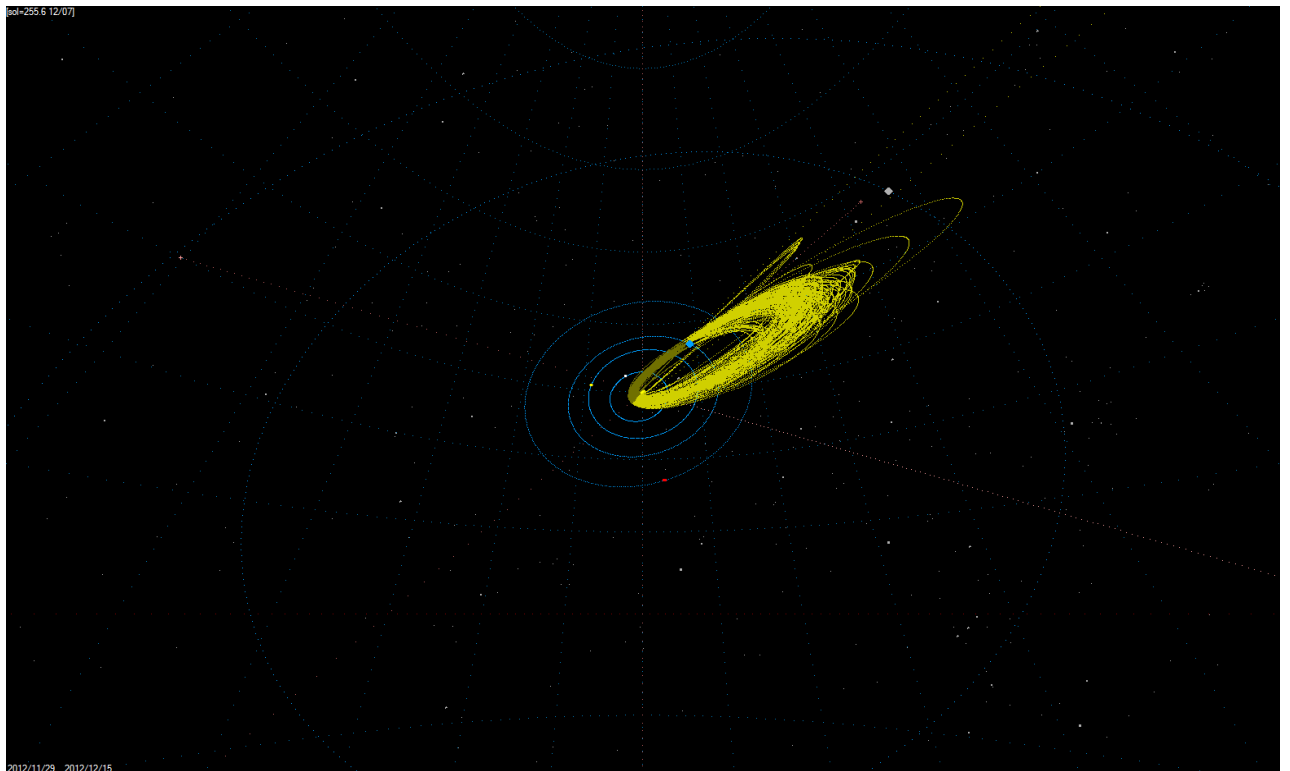
**Ground Trail Map**



**Trail Map**



Radiant Plot



Orbits

