METEOR DETECTION IN WIDE-FIELD SURVEY TELESCOPES

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Meteor observing requires huge field of view (FoV) as its appearance in the sky cannot be foreseen. In the new era of the time-domain astronomy many telescopes will cover the whole sky with a cadence of a few days. These requirements lead to fast large telescopes with wide FoVs, like the Schmidt cameras that were widely used for meteor observing in the past.

These requirements lead to fast large telescopes with wide FoVs, like the Schmidt cameras that were widely used for meteor observing in the past. We present here an estimation of the number of meteors detected as a byproduct of these surveys, with the detailed example of the Test-Bed Telescopes, an ESA project for NEO and space debris surveillance.

Telescopic meteors

Meteors have been widely observed with the use of telescopes [1], but in the vast majority of the cases these are serendipitous detections [2][3]. Nevertheless identifications could be an issue in wide-field telescope images. Fortunately these telescopes usually have focal lengths long enough to show meteors (at 100km high) out of focus [2] [3]. Also low-earth orbit satellites are easily discarded taking images only when the Sun is not illuminating these orbits (usually within 2 hours after or before the twilight).

Due to their nature meteors within the hundredths of micron range are monitored using radar sensors. Most optical meteor surveys observe meteor down to magnitude 6 (millimeters range), however smaller meteoroids are able to produce meteors as they suffer ablation down to 100 microns [4]. We assume they have similar luminous efficiencies and there is constant mass index (s) in the range of the meteors detectable by wide-field survey telescopes (magnitude <11).

To determine the number of meteors detectable by the telescope we need to calculate the flux of meteoroids in the detection range of the telescope, it is the integral down to the limiting magnitude (lm) of the meteor luminosity function F(m). Therefore these meteors are observable in the optical range with the use of silicon devices (i.e., CCDs) and the aid of large collection area optical devices.

$$F(m)dm = dN_m \approx m^{-s}dm$$

Inputs for this study are the sporadic meteoroid fluxes detected in the visual range (down to magnitude +6) by IMONET [5] and in the radar range for fainter meteors [6].

Average sporadic meteor

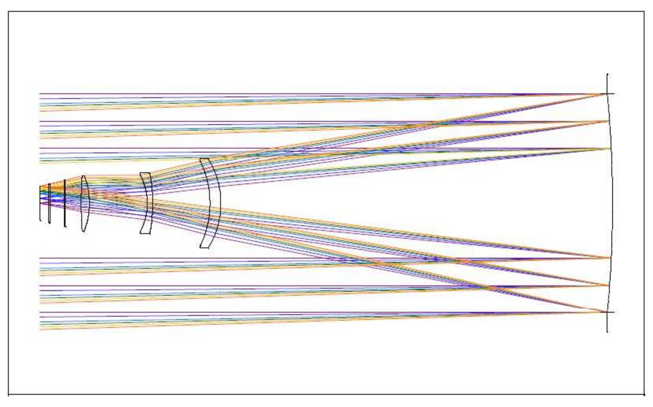
We define some 'standard' values to simplify the problem. They are educated guesses to get a rough order of magnitude of the detectable meteors. The best approximation for such a problem would be a proper simulation with real population and conditions.

The limiting magnitude of the meteor depends on the sky brightness, the time of integration and the speed of the meteor. Then the photons reaching a certain pixel coming from a meteor should be numerous enough over the photons coming from the sky during the whole time of integration. As the distribution is close to potential, the radar meteors would be the most numerous. For this range the sporadic flux is well above the meteor shower flux. Thus we can assume some average properties (i.e., 30km/s,), an average elevation of the FoV of 50 degrees and a mean radiant distance to the sporadic sources of 45 degrees. This leads to an apparent speed of 8 degrees/second.

The area is the projected FoV at 100km high, the average beginning height of meteors. Therefore we would calculate the number of meteors starting in the FoV, but not the ones crossing it. Consequently we consider the meteors being around 5-10 degrees long to calculate the number of meteors crossing the FoV.

Test Bed Telescopes for SSA activities

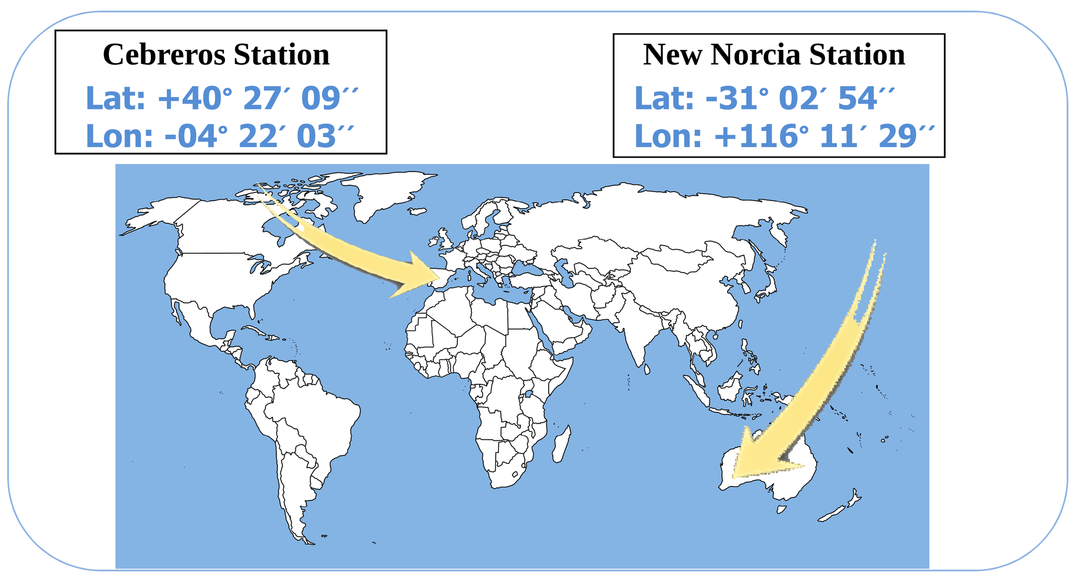
Within the Space Situational Awareness (SSA) programme of ESA, it is foreseen to deploy several robotic telescopes to provide surveillance and tracking services for man-made as well as natural near-Earth objects (NEOs). The Test-Bed Telescope (TBT) project will procure a validation platform for an autonomous optical observing system in a realistic scenario, consisting of two telescopes located in Spain and Australia, to collect representative test data for precursor SSA services.



Optical layout: 60cm prime-focus telescope with 3-lens Wynne corrector

These small telescopes are a clear example of this new astronomical survey era. They will be 60-cm telescope with a 2.5 x 2.5 square degrees FoV taking short exposure images during clear nights all year round. The result of this study for the TBT telescopes with ca. 12 square degrees of FoV is the detection of meteors in the range of tenths per hour. Low-noise CCD read-out, short exposures and dark sky are essential to increase the SNR of meteors and the subsequent detection probability. Else the limiting magnitude is diminished rapidly due to the short time the meteor spends over a pixel compared to the constant sky background.

Large focal plane at Prime Focus : 61 mmx 61 mm – 4K x 4K, 15 micron pixel, – 2.2 arsec/pixel



Telescope location: in ESA stations in both hemisphere for combined SSA activities

Meteor detection: estimations

Once the flux of meteoroids down to a certain mass/size is known, we can evaluate the performance of these systems (meteor rate) as the product of the flux of meteoroids by the atmospheric area A monitored by the telescope.

$$\text{meteor rate} = A \cdot \int_{-\infty}^{lm} F(m)dm$$

TBT telescopes have a plate scale of 2.2arsec/pixel. For a meteor at 8 degrees/sec, the light will be over the pixel only 0.08ms. Therefore the relationship between plate scale and meteor speed is the main constraint for the limiting magnitude. For a typical exposure of 2s, the stellar limiting magnitude for TBT telescopes (A=25km²) will be around 18, however it would be around 7 for our average meteor. This leads to a value of only 0.06 meteors starting in the field per hour, and around 1 meteors per hour through the field.

However the SuperWASP survey is covering 482 square degrees with a plate scale of 13.7 arsec/pixel. The same 'average' meteor will spend 0.5ms over each pixel. For a typical exposure of 30s, the stellar limiting magnitude for SuperWASP will be around 18, however it would be around 8 for meteors. This leads to a value of only 0.6 meteors starting in the field per hour, and around a tenth of meteors per hour through the field.

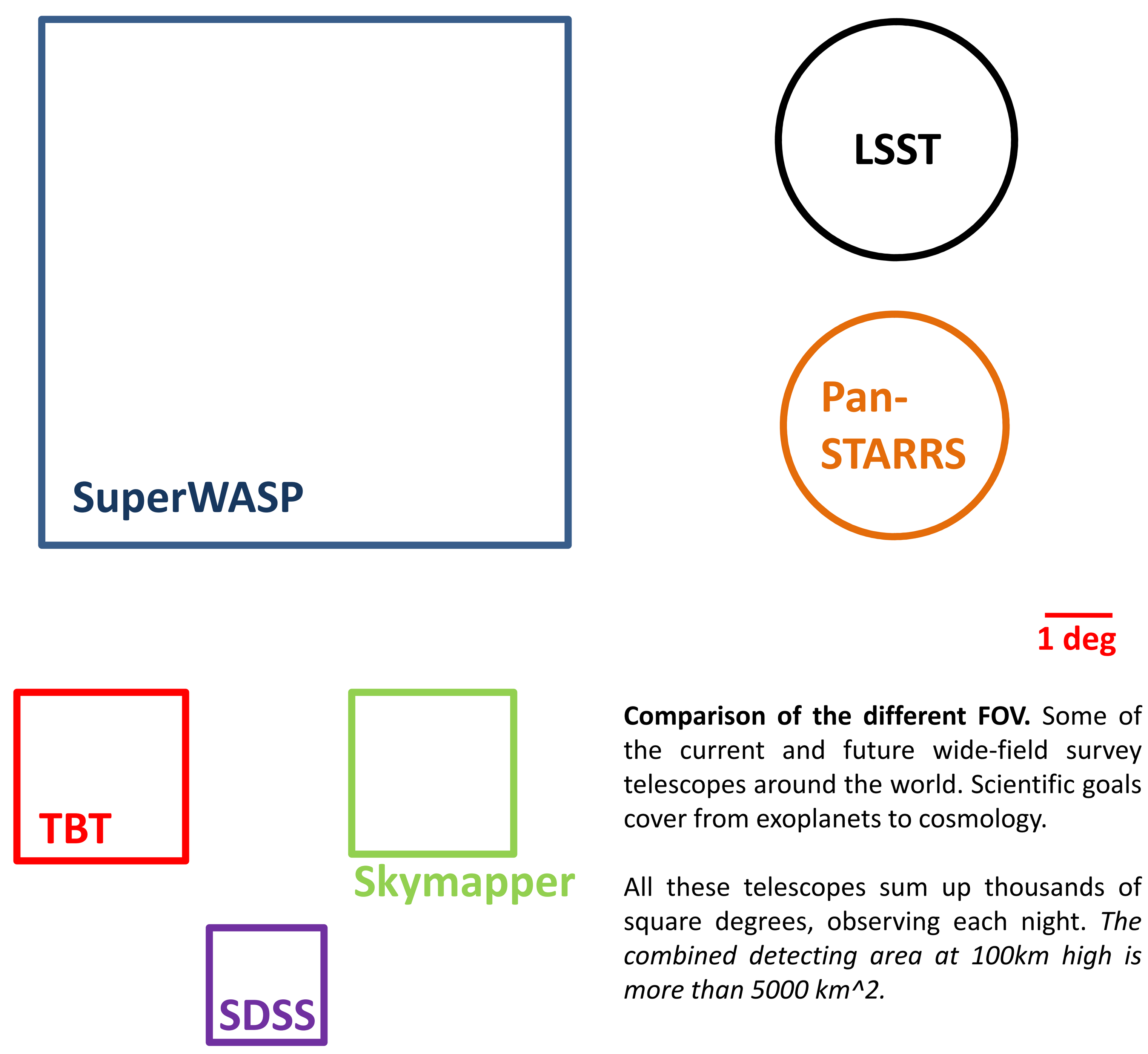
Conclusions

Meteor detection rates to be achieved with the future wide-field survey telescopes are similar to the ones for current video networks. Therefore meteors detected as byproducts in these surveys will be a free source of meteoric data. For this purpose survey images should be analyzed by meteors scientists using survey archives or even dedicated algorithm in their processing pipelines.

Camera/Telescope	FoV (sq. Degrees)	Meteor limiting magnitude	Meteors /hour
TBT	6.25	7	~ 1
SuperWasp	482	8	~ 15
HINWO/ACR	557	7	~ 5

Comparison: with theoretical numbers with real data from IMONET (camera ACR operated by Wolgang Hinz) [7]

Wide-field Survey Telescopes



Comparison of the different FOV. Some of the current and future wide-field survey telescopes around the world. Scientific goals cover from exoplanets to cosmology.

All these telescopes sum up thousands of square degrees, observing each night. *The combined detecting area at 100km high is more than 5000 km^2.*

References

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