ASA Telescope specifications for Satellite tracking

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1 General

1.1 Identification data

Manufacturer	**ASA Astrosysteme GmbH**
Type designation	Satellite Tracking Specs

1.2 Manufacturer address

ASA Astrosysteme GmbH
Galgenau 19
4212 Neumarkt i. M.
AUSTRIA

Phone: +43 7942 778 11-500
Email: office@astrosysteme.com
Homepage: https://www.astrosysteme.com

1.3 Support

If you experience problems or have further technical questions, feel free to contact our support at support@astrosysteme.com.

If you have questions concerning accessories or prices consult our sales department at sales@astrosysteme.com.

1.4 Changelog

Version #	Date	Change
A	2024-05-13	Release first version;

2 Cause of tracking errors

Unfortunately, no telescope is able to follow a satellite (assuming a perfect CPF) with sub arcsecond accuracy.

The following errors have to be taken into account.

2.1 General pointing error

Pointing errors are caused by temperature effects (not only in the telescope but typically also in the building. They can also be caused by hysteresis in the optical parts).

A lot of these errors, if reproducible, can be removed by pointing models. Usually an <8” RMS pointing error (all sky) remains. Higher accuracies can be achieved if for example a small (typically 4 stars) pointing model is created shortly before the satellite pass. This can even be made during day time on bright stars. In this case usually the Tip/Tilt component of the model is recalibrated and higher accuracies especially near the rise point of the satellite can be achieved.

2.2 Timing errors

Timing is done with the help of GPS based NTP servers which are installed in the local network. However, a timing error of 1 ms is normal. In software, systematic deviations as a constant offset can be applied. Therefore, the timing problem adds another 5” error to the satellite path.

2.3 Jitter

Jitter is caused by vibrations of the mount/telescope and will be more prominent for satellites passing near the zenith in AltAz telescopes where the rotational speed of the mount reaches more than 4 °/sec. The Jitter depends on the quality of the tuning of the direct drive motors but also on the pier, vibrations induced by the dome etc.

2.4 Tracking errors

The satellite tracking error if tracked all sky is the sum of the pointing error, the Timing error and the Jitter. Sometimes we receive specifications where the open loop tracking error is smaller than the specified pointing error. This does not make any sense since the telescopes will use the pointing model during the tracking to correct its speed and position and therefore the all-sky tracking can never be better than the all sky pointing.

2.5 Data accuracy

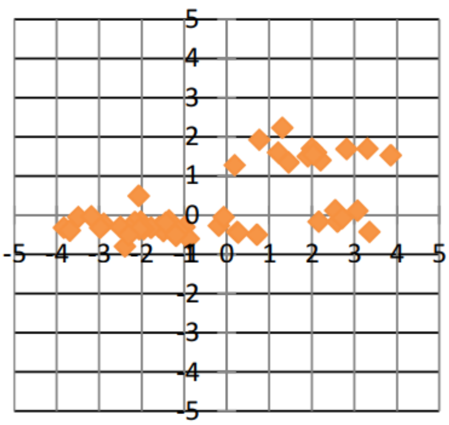

Figure 2.1: TLE errors measured at 40° Alt, Starlink / arcmin
Errors are shown along track (X-Axis) and perpendicular track (Y-Axis)

A prominent error source is also the accuracy of the TLE or CPF elements. Starklink TLE data for example are sometimes very accurate and then loose accuracy continuously over several weeks until the data improves again.
Left you see the data accuracy we measured when during a time of better accuracy. If the data are bad, you can even have 0.5-degree error in the TLE data.
Same applies for data of the ISS.
CPF Data accuracy from some providers are claimed to be in the range of 10”. We could confirm much higher accuracy on these data.

2.6 Closed loop tracking

Since the sum of all possible errors exceeds the error budget in most cases, closed loop tracking is needed. In this case the satellite has to be found (spiral search, large enough FOV) but then the track is realtime corrected by feeding back the satellite position in the loop. Guide scopes or a beam splitter in the optical path are options to close the loop. In this case, the main error which remains is the jitter (which is usually too fast to be corrected) and therefore is the most relevant error source and should therefore be kept as small as possible. The frequency of the closed loop should be around 10 Hz or higher and the software should have an easy-to-use tracking interface so the work of the customer should be limited on finding the offsets on the CCD.

2.7 Measurements

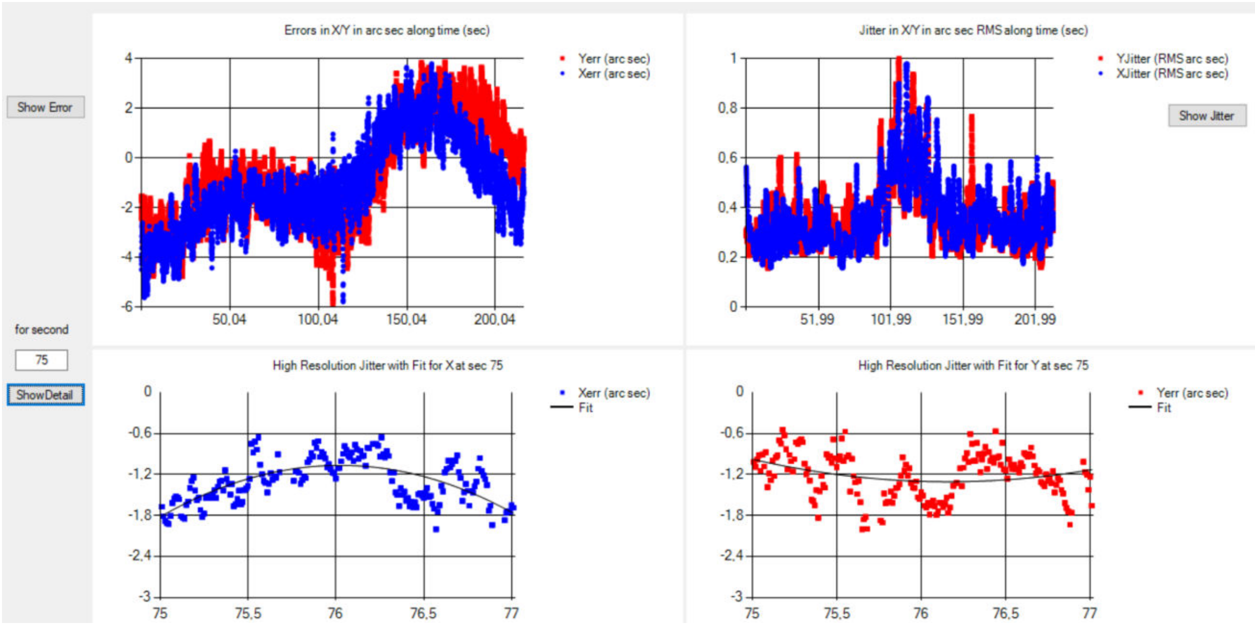

Figure 2.2: Jitter analysis

In above case a small finder scope with only 200 mm focal length was used to find and centre Starlink satellites in the AZ800. The ASA software allows autoguider commands to be sent during the track by 2 different autoguider sources. Only centroid offsets need to be sent, the field angle is always calculated by ASA Autoslew. In this example we use a video camera with 100 frames/sec to measure jitter and tracking errors.

The figure to the upper left shows the tracking error, which is mainly a flexure between the small finder and the main telescope. The jitter (upper right) is the RMS error, if you subtract the errors within 1 second (100 frames) from a linear fit. This is the error which will remain in case you track with a beam splitter on the main optical path. Then there is a typical high-resolution display of the errors in the main camera during 2 seconds (lower graphs). Part of the errors can be even further reduced with a fast-steering mirror.

2.8 Zenith blind hole

An AltAz telescope will have a blind hole since a satellite passing through the zenith reaches a rotational speed exceeding infinity. The size of the blind hole depends on the increasing jitter during high speeds and the maximum speed. ASA software allows the satellite to be re-caught after passing the blind hole (the telescope will lose the satellite, then rotate with maximum speed in Azimuth and catches the satellite again. A lot of effort has been invested to minimize the time to stabilize again on the satellite path after this procedure.

2.9 ASA Satellite tracking specifications

1. All sky pointing error (20°-85°) 8” RMS
   Of course the telescope can be pointed lower and also higher (usually ASA hasa hard stop at 10° and one at 88°) but this will then be with decreased accuracy.
2. All Sky open loop LEO Tracking (20°-85°) 10” RMS (pointing error + time error)

3. All Sky closed loop LEO Tracking (15°-80°) <1” RMS
4. All Sky closed loop LEO Tracking (80°-83°) <2” RMS
5. All Sky closed loop LEO Tracking (80°-86°) <3” RMS
6. Maximum rotational Speed 8°/sec
7. This is only for safety considerations. Faster speeds would be possible, but regarding the increasing jitter higher speeds than 10°/sec are not useful and fast LEO satellites are lost for (typically) around 15 seconds if they pass higher than 86°.

2.10 ASA dedicated satellite tracking interfaces

The interface is a TCP/IP Alpaca interface where the user can pass TLE, CPF and EPH data to be tracked by Autoslew. The user does not need to develop its own autoguider algorithms but can simply pass the found offsets on the autoguider detector to Autoslew. Autoslew has an AI Autoguiding Interface that will filter the centroid positions, check them on plausibility and try the smoothest guiding possible with these data.

More information can be found in a document describing this guider interface which you can request from ASA.