

How to measure more than 110 satellites

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Abstract

Besides the targets defined by ILRS, Graz is routinely measuring distances to a lot of old, defunct satellites; the main purpose is to explore their spin parameters: Once out of control, most of these objects start to spin, some due to external forces – magnetic / gravitational / radiation etc. - , some due to internal forces - reaction wheel momentums, escaping gas / fuel remnants etc. The collected data is used for theoretical research, as well as for practical purposes – e.g. definition of expected spin values during satellite design stage, selection of possible targets for planned active debris removals like e.Deorbit (ESA).

Introduction

SLR stations usually track satellites selected by the Mission Working Group (MWG) of ILRS (International Laser Ranging Service); all these satellites are operational, need their accurate orbit, and are equipped with retro-reflectors. In October 2014, this ILRS standard roster contained about 40 different satellites.

SLR Graz followed some years ago the SLR stations Herstmonceux and Zimmerwald, and added 20 more Glonass satellites, mainly to develop / test / optimize procedures to track large numbers of GNSS HEO satellites.

In mid 2014, SRL Graz added 10 defunct LEO satellites, and 45 defunct Glonass satellites – all of them equipped with retro-reflectors, and previously tracked by ILRS stations – with the main purpose of determining their spin parameters and / or their attitudes.

Extensive Pass Switching for active HEO satellites

This large amount of satellites required optimization of all pass switching procedures:

- Staying on target until about 1000 returns for a single Normal Point (NP) are collected; with 1000 returns per NP the maximum resolution of Graz SLR (0.2 mm) is reached; more returns per NP do not improve accuracy anymore;
- During night, SLR Graz needs less than 1 minute to achieve this with any HEO satellite; as soon as these 1000 points are collected, the observers switch immediately to the next target – needing 15 to 20 seconds to move the telescope and the dome;
- This allows to collect a single, high-accuracy NP for each of 3 to 4 HEO targets, within the standard NP-Bin of 5 minutes;
- With the help of several additional screens – showing the availability, distribution of satellites, together with eventual cloud coverage – the observer can optimize the necessary mount / dome rotations, thus maximizing the output of the system.

This extensive pass switching already allows tracking of all ILRS satellites, *and* also the additional active Glonass satellites, without any problems (fig. 1).

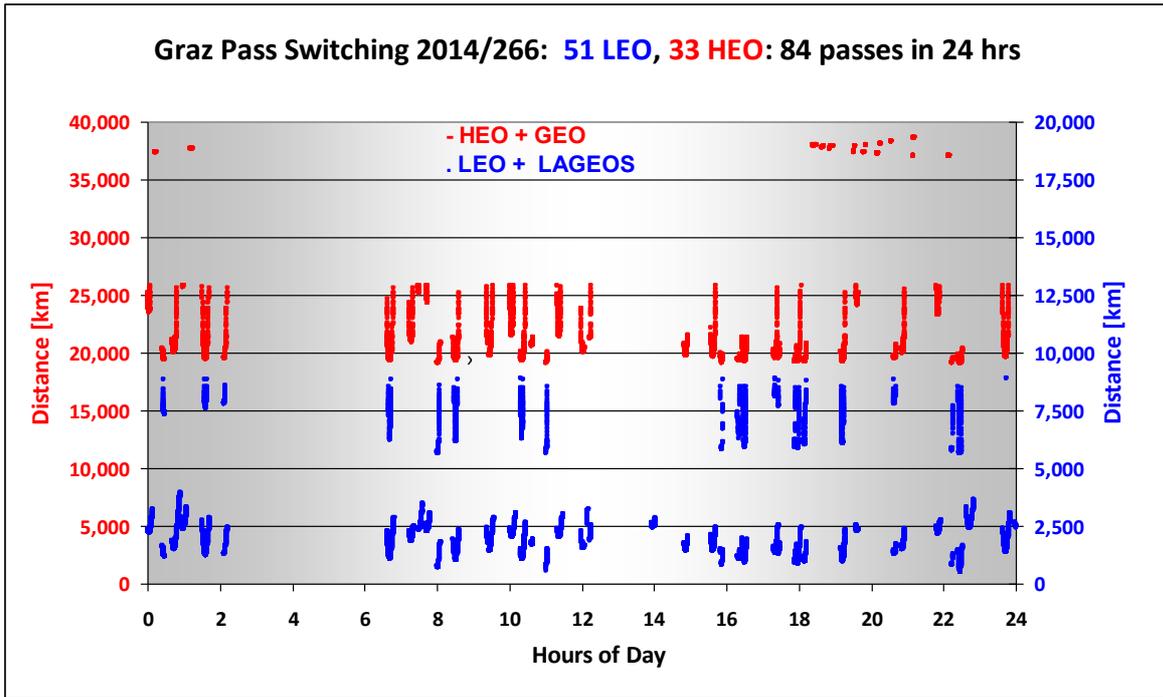


Fig. 1: Extensive pass switching in Graz(day 266 in 2014): Tracking 84 passes in 24 hours; no observers present between 2:00 and 6:00 (UTC) in the morning (we have to limit the amount of money for our student night observers), and some clouds at early afternoon.

Determination of spin parameters of defunct LEO satellites

As already shown at the Japan workshop 2 years ago, we also track defunct LEO satellites like ENVISAT (fig. 2), to determine their spin parameters (Kucharski et al, 2013). Meanwhile we have added 10 other LEO satellites to our observation program (e.g. Topex; fig. 3).

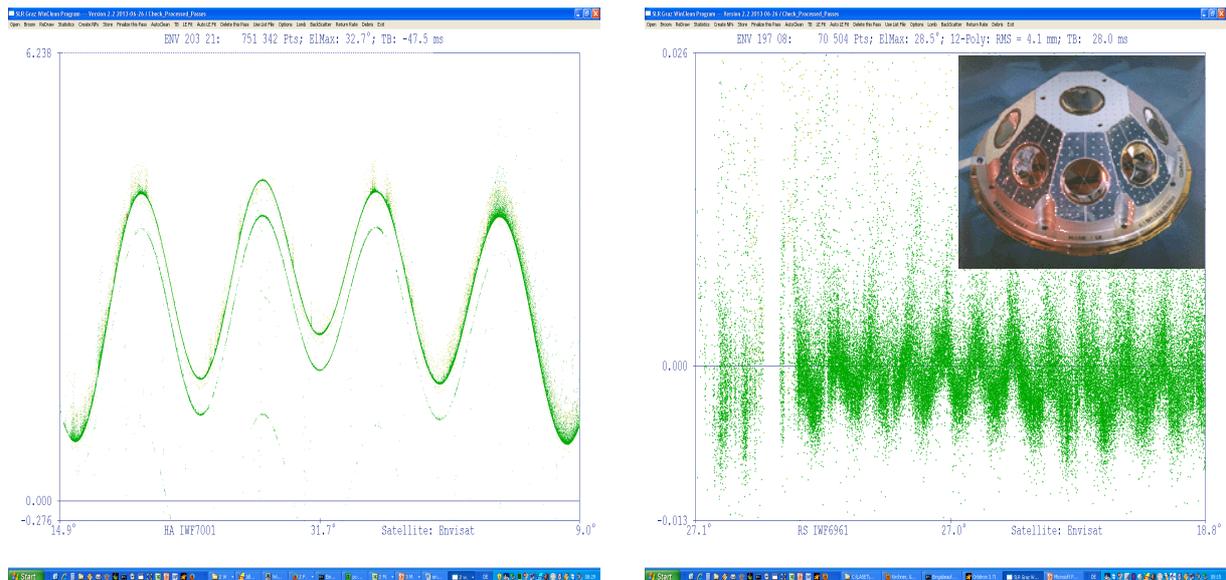


Fig. 2: ENVISAT pass measured in Graz: The satellite spins with about 140 seconds per revolution (about 10 times faster than predicted from theories – possibly prohibitive for eventually planned de-orbiting missions left: few meter oscillations of whole retro assembly; right: few mm retro-to-retro-oscillations

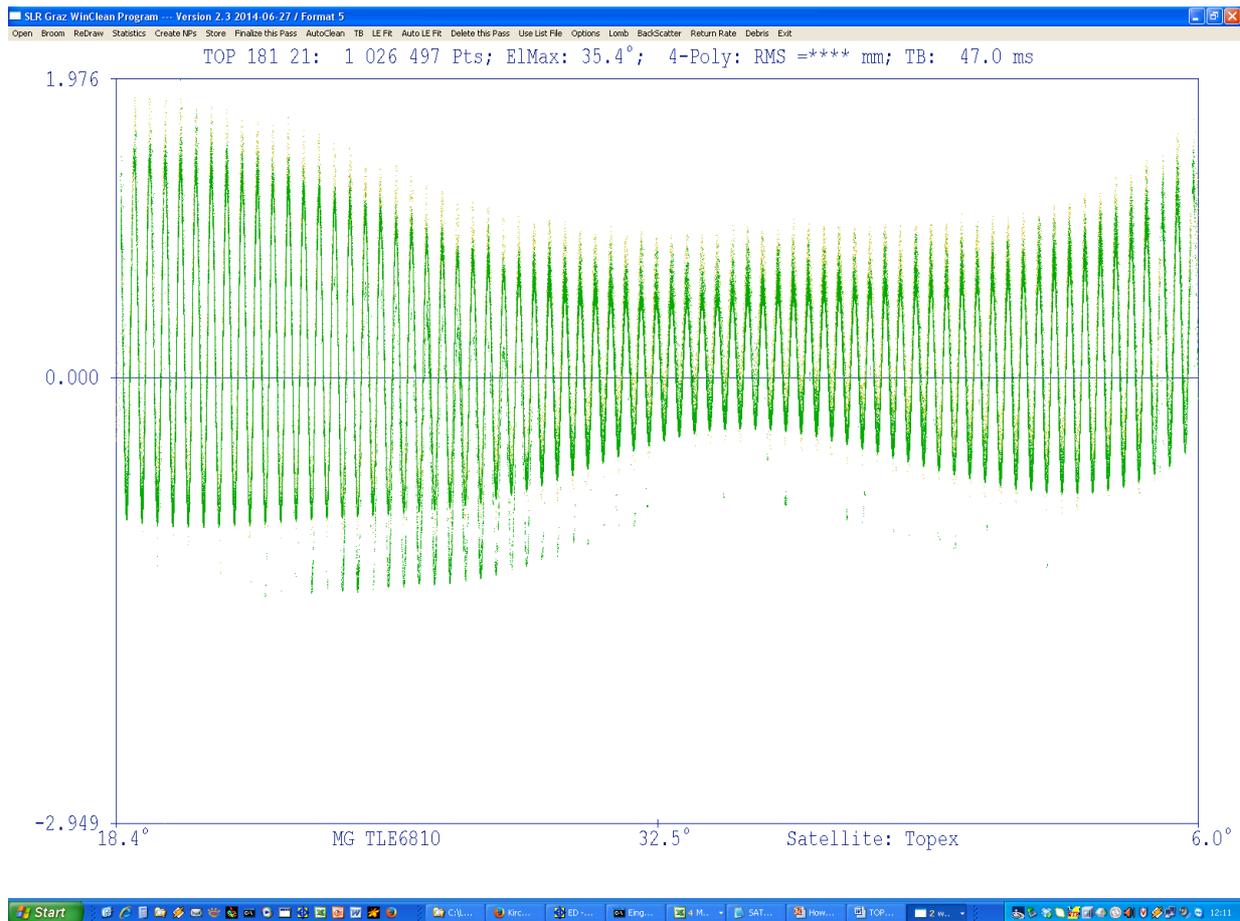


Fig. 3: Graz SLR measurement residuals to TOPEX (defunct since > 10 years); Topex is spinning fast (< 12 secs per revolution) and stable ('flat spin'): It always 'shows' us its retros, allowing even daylight tracking using TLE predictions with limited accuracy.

Determination of spin parameters of defunct HEO satellites

In autumn 2014, we added 45 defunct Glonass satellites to our schedule – reaching now more than 110 satellites. Main goal is to determine the spin of these objects, and spin change with time – offering a large variety of targets in different orbital planes, with at least slightly different constructions, and covering very different time spans since being out of control.

Because there are no accurate predictions (CPFs) available for these defunct satellites, we use TLE (2-line element) predictions; due to their limited accuracy, and also due to the non-continuous visibility of the retros, we have to restrict these activities to night only.

Fig. 4 shows a typical example of such a HEO pass: Glonass-88, which needs about 50 seconds for one revolution, allowing laser echoes for about 10 seconds per revolution.

While the fastest spinning Glonass satellite (Glonass-41) needs only 8 seconds for one revolution, others need several hundreds of seconds (fig. 5); only a few of these defunct Glonass satellites do not show any spin at all – or their spin period is larger than e.g. a few hours....

Meanwhile, we have measured the spin data of > 30 defunct Glonass satellites; we will continue this for some time, to establish time series to check for spin developments too.

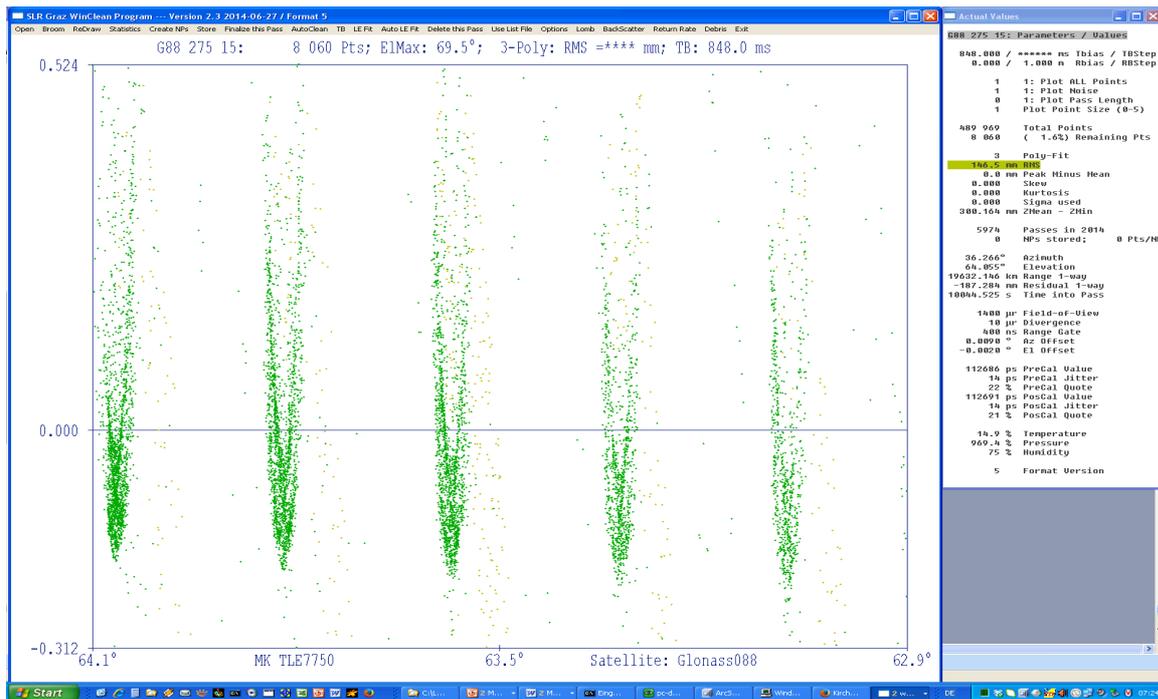


Fig. 4: Glonass-88, spinning with about 50 seconds per revolution, allowing laser echoes for about 10 seconds per each revolution.

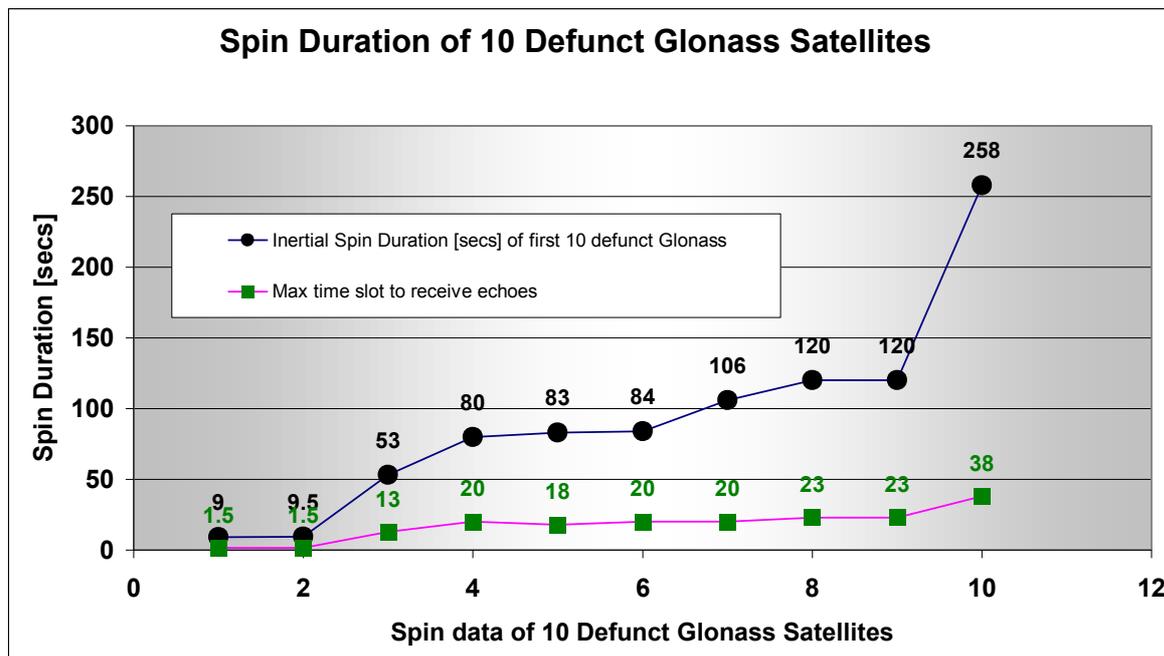


Fig. 5: Spin duration of 10 defunct Glonass satellites; spin duration varies largely, from < 10 seconds, up to almost 300 seconds; visibility of retros is usually around 20% of spin duration.

References:

D.Kucharski, G. Kirchner, F. Koidl, C.Fan, R. Carman, C. Moore, A. Dmytrotsa, M. Ploner, G.Bianco, M. Medvedskij, A. Makeyev, G. Appleby, M. Suzuki, J-M. Torre, Z. Zhang, L. Grunwaldt, Q. Feng: "Attitude and Spin Period of Space Debris Envisat Measured by Satellite Laser Ranging". TGRS vol. 52, issue 12, pages 7651-7657, 10.1109/TGRS.2014.2316138.