Target signatures of existing sub-cm targets and prospects for future SLR constellations

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Since 20 years ago, the so-called 'target signature' effect due to multiple reflectors located on the satellite's surface has been recognized as one of the major error sources in satellite/lunar laser ranging (Appleby, LW8, 1992). In the case of spherical satellites, the detection timing of a return signal is dependent on the hardware configuration and the observation policy of each station, and as a result, the centre-of-mass correction is not a single constant value but a station-dependent value. Otsubo and Appleby (JGR, 2003) revealed that it can range by 1 cm for LAGEOS and by 4 to 5 cm for AJISAI and ETALON.

We extend the same approach to smaller satellites, STARLETTTE and LARES. The signature effects on these satellites are much smaller, but we find it observable using up-to-date laser ranging systems. The sum of five sets of terrestrial target ranging data is used as a system response, and the satellite response function is adjusted so that the convolved function fits to the observed residual histogram. Fig. 1 is the experimental case using STARLETTE data. The best-fit satellite response function can be used to derive centre-of-mass corrections for various kinds of systems.

The centroid of the best-fit function is located at 75 mm from the centre of mass, which is the

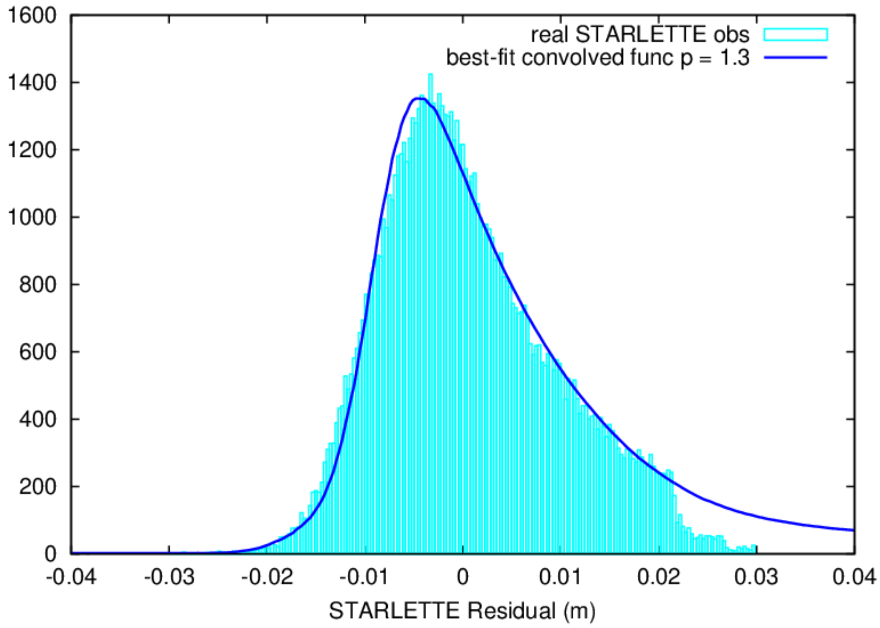

Fig. 1. A residual histogram of STARLETTE ranging data obtained at Herstmonceux's kHz ranging system (light blue) and the best-fit convolved function (dark blue).

minimum limit. The leading edge is located at 83 mm, which is the maximum limit. That is, the centre-of-mass correction of STARLETTE varies by 8 mm according to the detection method. The standard value has been 75 mm, but, in this study, it is found to be small by a few mm for the overall average value. These results are applicable to its twin satellite STELLA.

The same procedure is applied for LARES, newly launched in February 2012. Values of between 128 mm and 137 mm are obtained. The residual scatter is close to what we have expected from the specification data, and therefore the pre-launch centre-of-mass correction 133 +/- 5 mm, reported at the ILRS website, is found to be a very good prediction.

Although LARES (diameter = 36.4 cm) is much larger than STARLETTE (diameter = 24 cm) in size, the residual scatter amounts almost the same. This is because the back faces of STARLETTE reflectors are coated while those of LARES reflectors are uncoated. Coated reflectors have much wider acceptance angle than uncoated ones.

Note that these values are still provisional and not suitable for critical purposes. In this study we have taken the terrestrial ranging data to define the ranging system response, but we could also use the small (or zero) signature data from certain satellites. There is a small but significant difference in scatter width between terrestrial ranging and satellite (GRACE) ranging in Herstmonceux data. The difference could be ignored in the case of larger satellites, but we need to solve this issue before finalising the centre-of-mass correction for the STARLETTE and LARES satellites.