Centre of mass values for precise analysis of LAGEOS, Etalon and Ajisai 1980-2013

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Outline

• Previous work * developed generic centre of mass values that take account of station hardware;

• More recently tables of values for LAGEOS and Etalon and software were released and tested by Analysis Working Group

• New table for Ajisai now available

• Some comments on results for all three satellites

* Otsubo & Appleby, JGR, 2003
Station- and epoch-dependent CoM values

- Appropriate CoM value and its accuracy depends upon:
  - System detection hardware (SPAD, MCP, PMT)
  - Return energy level (multi-, single- or mix-)

(pulse transmitted from ground station)

(retroreflected pulse)

(imaginary pulse reflected at centre)
Station- and epoch-dependent CoM values

• Taking these generic, system-dependent results;
• Using up-to-date Site-log information and change records for all stations from ~1980 onwards as a critical resource
• Estimated CoM values and error estimates:
• In general, single-photon return allows determination of most accurate CoM value, even if single-shot precision is low(er):
Single-shot precision (RMS, mm) of LAGEOS ranges

A good proxy for system type (single, multi ph.), not (necessarily) a good indicator of accuracy of range or determination of CoM correction
e.g. High accuracy CoM for LAGEOS single-photon kHz data at SGF Herstmonceux

Model (red) fits very well. Implied CoM value from model is 245 ± 1 mm. Results (R Neubert, 2012) for upgraded Potsdam kHz system are identical (245 ± 1 mm). Single-shot precision only 15 mm in each case.
Station- and epoch-dependent CoM values

• For the multi-photon MCP (e.g., NASA) systems, model implies value of ~250mm, close to ground-measured, ‘standard’ 251

• However:
  – If logfile suggests that return energy variable or even unknown,
  – Larger (~10mm) **uncertainty** placed on model CoM value.
Detail from CoM table for LAGEOS

<table>
<thead>
<tr>
<th>Station</th>
<th>Time-span</th>
<th>detector info</th>
<th>CoM min, max, adopted (mm)</th>
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<td>20 MCP CSM</td>
<td>3.0 6 15 252 248 <strong>250</strong></td>
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<td>2.2 3 9 246 244 <strong>245</strong></td>
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</tbody>
</table>

Data files for LAGEOS and Etalon and Fortran code are available to extract CoM for analyses
Testing the CoM tables during POD

• Tests were carried out by the ILRS ACs on the LAGEOS and Etalon tables via weekly solutions
  – For six months only
  – SGF AC results reported (EGU 2012, Frascati 2012)

• Effect on the quality of the reference frame quite marginal according to AWG & SGF work:
  – difference in scale, driven by more careful use of CoM values, is only 0.03ppb
Testing the CoM tables during POD

• But in detail, for some specific stations, effect is important and clears up some apparent data anomalies:

• e.g. Potsdam 7841, following a system upgrade to 2kHz:

• Time series of station height shows apparent drop in height of 7 or 8 mm (C. Luceri, 2013)

• 6mm of that is explained by use of CoMs 251 and 245mm for PMT and SPAD respectively, pre- and post-upgrade:
7841 - POTS : discontinuity

\[ \Delta h = -8 \text{mm} \]

\[ \text{RB} = +7 \text{mm} \]

\[ \text{RB} = +8 \text{mm} \]

C Luceri, 2013

CoM table entries
But: Of course cannot attribute large effects to CoM effects

Range residuals from LAGEOS for a station that has two modes of operation – choice of two detectors. Plot from H Mueller
Ajisai

• Work has been extended to Ajisai
• 2150 mm diameter satellite, CoM variation of ~45mm
• Same treatment regarding station configuration, return-level, etc., as for LAGEOS and Etalon, from the published generic results
• Table of values produced, and read-software updated
• Will be available at EDC and CDDIS, along with LAGEOS and Etalon:
  • e.g. http://ilrs.dgfi.badw.de/index.php?id=6
Detail from CoM table for Ajisai

<table>
<thead>
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<th>Code</th>
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<th>Code</th>
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</tbody>
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Testing the CoM tables during POD

- For the new Ajisai CoM values:
- Used in-house SATAN code as per main AC work, with fixed ITRF2008
- 7-day and 3-day arcs tested for August 2013, with and without (ILRS default is 1010mm) site-specific CoM values
- At best, marginal improvement of ~1% in post-fit residual RMS
LAGEOS/Etalon/Ajisai CoM conclusions

• Important to model as well as possible:
  – Direct impact on TRF scale, a major output from geodetic SLR
• Must consider (small) CoM effects in context with those of some poor site-ties and systematic range measurement error issues
• A more comprehensive comparison for 1980 onwards will be underway soon via AC contributions to ITRF2013
  – Big changes in network hardware in early decades
  – Important to track CoM changes – systematic
• Also it would be very useful to have similar results for Starlette, Stella and LARES...
Thank you