Engineering process of SLR for LEO orbiters

M. Abele, J. Balodis, M. Caunite, I. Janpaule, R. Rubans, G. Silabriedis, A. Zarinsjih
Institute of Geodesy and Geoinformation,
Rigas GeoMetrs SIA
Overview

• Introduction
• New SLR for LEO satellites (and LAGEOS)
• GNSS network EUPOS-RIGA
• Next steps
• Stars
Three groups

- Institute of Electronics and Computer Science (Y.Artjuh and colleagues)
- Institute of Astronomy (K.Lapushka, K.Salmins, M.Abele)
- Institute of Geodesy and Geoinformation (M.Abele, J.Balodis, A.Rubans, A.Zarinsjh,.....)
Staciju izvietojuma shēma
SLR for LEO Satellites
SLR for LEO Satellites
Ekspla Laser PL2241 532 nm

Pulse length ~ 30 psec
Energy 18 mJ +- 4%
Repetition rate 50 Hz
Mount control hardware

- Compumotor S57-51P stepper motors,
- Heidenhain RON 200 incremental encoders: 72” divisions; interpolated to 0.7” per division,
- InTeCo RT-DAC USB data acquisition and contrunit:
  - PWM generators (2.4 Hz ... 156 kHz),
  - quadrature pulse counters,
  - digital inputs/outputs for servo sensors
  - timer-counters for position time acquisition.
- QuartzLock A8-B GPS-disciplined quartz frequency Standard,
- ET-302 event timer,
- Vaisala PTU200 meteo station.
About Event Timer A032-ET

The A032-ET is the latest commercially available model of Riga event timers

*Event timers used in ILRS laser network. (Data are taken from [http://ilrs.gsfc.nasa.gov/](http://ilrs.gsfc.nasa.gov/))*

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<tbody>
<tr>
<td>PESO</td>
<td>PET4/TIGO</td>
<td>1.2</td>
<td>3.5</td>
<td>3</td>
<td>&lt;0.3</td>
<td>&lt;0.5</td>
<td>&gt;100</td>
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<tr>
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<td>MRCS V.4</td>
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<td>10</td>
<td>1</td>
<td>N/A</td>
<td>1</td>
<td>1000</td>
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<tr>
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<td>MLRO</td>
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<td>1</td>
<td>7-9</td>
<td>&lt;1</td>
<td>&lt;0.5</td>
<td>N/A</td>
<td>10,000</td>
<td>1.5 hr</td>
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Currently the A032-ET is recognized within ILRS community as the best in term of price/performance ratio. During last few years 18 units of the Riga Event Timer A032-ET have been delivered to Japan, Switzerland, China, Spain, Austria, Latvia, Germany and Finland for use in the ILRS laser network.
Calibration
Equipment

Receiver

Base station antenna

Calibration
<table>
<thead>
<tr>
<th>Bāzes stacijas</th>
<th>GPS satelīti</th>
<th>Satelītu numuri</th>
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</table>

- **Bāzes stacijas**: Locales stations
- **GPS satelīti**: GPS satellites
- **Satelītu numuri**: Satellite numbers
- **Redzamais satelīts**: Visible satellite
- **Kritērijiem neatbilstoš satelīts**: Satellite that does not meet criteria
- **Satelīts nav redzams**: Satellite is not visible
EUPOS-RIGA bāzes stacija Lu
Diurnal behavior - Centre (LU) _ no more 0.1 mm
Base station antenna
Precision analyses mm
2008, g, 1, janv, - 28, febr,

- Base station
  RIGA-1884 (IGS, EPN)

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<tr>
<th>#</th>
<th>St,</th>
<th>X</th>
<th>Y</th>
<th>H</th>
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<tbody>
<tr>
<td>1</td>
<td>Ann</td>
<td>0,5</td>
<td>0,4</td>
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<tr>
<td>2</td>
<td>Kre</td>
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<td>0,5</td>
<td>2.0</td>
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<tr>
<td>3</td>
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<td>1.0</td>
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<tr>
<td>4</td>
<td>Msk</td>
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<tr>
<td>5</td>
<td>Van</td>
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<td>0,8</td>
<td>2.2</td>
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</tbody>
</table>
Lu

Lu | Nothing | RMS= 0.3 mm

Lu | Cutting | RMS= 0.4 mm

Lu | Up | RMS= 1.0 mm
Msk
Van
Next steps
Star identification

\[ C = \varphi(P) \]

\[ \begin{align*}
\xi_i &= M \cos \alpha x_s + M \sin \alpha y_s + e \\
\eta_i &= M \cos \alpha y_s - M \sin \alpha x_s + f
\end{align*} \]

\[ i = \varphi(s), i \in C, s \in P \]
\( \varphi^{-1}(i) \in \bigcap \left\{ s, t : \exists j \left( \frac{d(i, j)}{d(s, t)} = M \land \alpha(i, j) - \alpha(s, t) = \tilde{\alpha} \right) \right\} = \left\{ s : \exists i \exists j \left( \frac{d(i, j)}{d(s, t)} = M \land \alpha(i, j) - \alpha(s, t) = \tilde{\alpha} \right) \right\} \)

\[ \forall s \quad \exists i \quad i = \varphi(s) \]

\[ \frac{d(\varphi(s), \varphi(t))}{d(s, t)} = M, \]

\[ \alpha(\varphi(s), \varphi(t)) - \alpha(s, t) = \tilde{\alpha}. \]
Vectors of identified stars
\[ W_i := \left\{ w_i : \sigma_{i_w} = \max \left\{ \sigma_{iw'} : w' \in W_i \right\} \leq r_2 \right\} \]

\[ \sigma_{iw'} := \left\{ \left\{ w'' : \beta_{iw''} = \beta_{iw'} \right\} \right\} \]

\[ i = \varphi(s_i), \]
\[ w[1] = \varphi(t) \]
Identified stars
Thank you