Differential Satellite Laser Ranging
SLR System Diagnostics Tool

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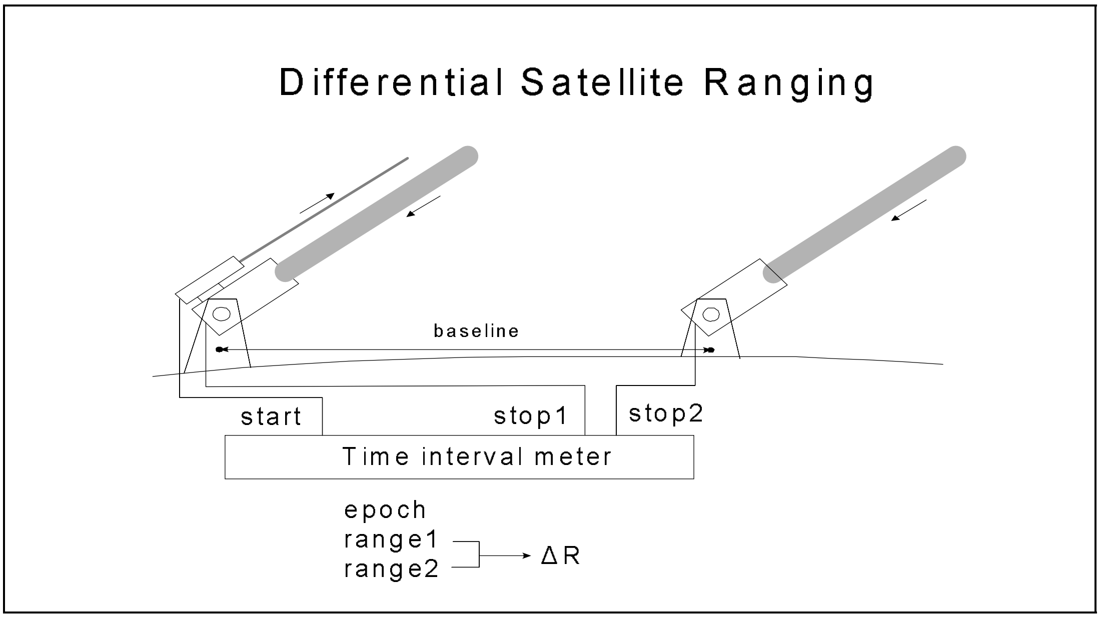
The satellite laser ranging is a measuring technique recently applied in space geodesy. The ground baselines accuracy achievable is of order of one centimeter, it is limited mainly by the systematic errors in atmospheric correction evaluation, ranging machine errors, system calibration and ground survey. New techniques providing an independent test of the systematic errors contributors is highly appreciated. We are presenting a new measuring technique : the Differential Satellite Laser Ranging (DSLR) providing the independent information on the local survey, system reference point position and system calibration [1]. The principle of measurement is as follows : two (or more) satellite laser ranging systems are sharing one common laser transmitter, see figure . Recording the echo pulses arrival times at different locations, the corresponding baseline and relative station heights may be evaluated. Due to the differential approach, most of the error contributors present in the standard satellite laser ranging are minimised or not existing at all. The calibration, ground survey, orbit modelling, atmospheric correction, epoch reference and frequency errors are not contributing to the final solution, the satellite signature effects are minimised, if equal types of detectors are used on the receiving sites. Thanks to this fact, the baseline and station relative heights may be determined with high accuracy on the basis of several satellite passes.



We have developed the software package for DSLR data processing. The package consists of the data screening, editing and fitting algorithms, differential normal points formation algorithm and the solution of the baseline itself. The performance of the programs has been tested on the series of numerical simulations. The sets of DSLR data have been generated using the accurate prediction algorithm, the defined measurement noise contribution has been added. The baseline length and its precision has been evaluated using various number of passes and passes geometry. The stability of the solution has been investigated. As a conclusion of the simulations : the baseline components may be evaluated on the basis of 2 to 8 satellite passes, the baseline final accuracy is better than individual normal points precision, the solution stability depends on passes geometry and distribution (low/high passes, North/ South , East/West direction), see figure.

The performance of the measuring method and the software package has been tested using the satellite laser ranging data from station Helwan. Two independent receivers and detectors have been installed on the same mount. Their outputs have been passively added and registered on the common time of flight measuring instrument. This way, the DSLR has been accomplished with the baseline length equal to zero. The standard receiver is based on the photomultiplier, the additional one on the Single Photon Avalanche Diode detector package. Totally 9 passes of Starlette, Stella and Diadem-C satellites consisting of only 35 common normal points have been collected. The pass geometry was rather poor, all the passes did cover less than one half of the available sky. Despite this limitations, the baseline length has been determined with the accuracy equal to normal point precision in its horizontal components and half the precision in the vertical component, see the last figure. Both the numerical and real data experiments verified the proper function of the DSLR technique and newly developed data processing algorithms.

We have demonstrated a new space geodesy technique capable of determining the short ground baselines with the millimetre accuracy applying the existing satellite laser ranging technology. The DSLR technique may be used as an independent check of the ground survey, mount eccentricities and calibration procedure. The application of this method is limited by the reflected signal footprint diameter on the Earth and by the possibility to interconnect the co-operating stations by the high quality coaxial cables. The maximum achievable baseline length is expected to be 200 meters. The main application of this method is in collocation experiments as an efficient diagnostics tool to trace back possible problems in system calibration, ground survey and system invariant point position.

[1] Prochazka I., Hamal K., Kunimori H.: *Differential satellite laser ranging and its application in a Keystone project*, European Symposium on Aerospace Remote Sensing, IEE, London, UK, September 22-26, 1997, SPIE [3218-09]

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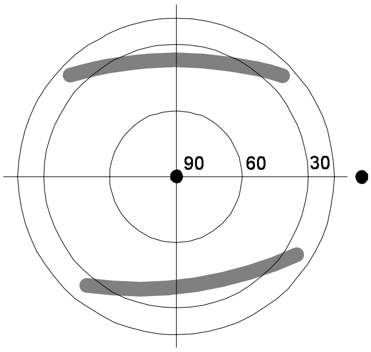
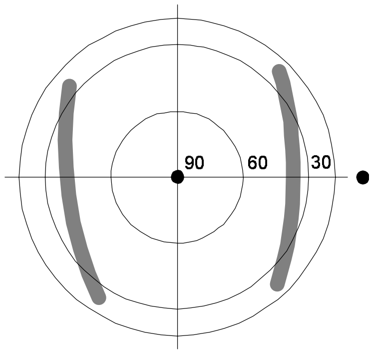
Differential Satellite Ranging

Baseline Precision Estimate

simulation, NP precision = 1
poor coverage
low passes only, 20 NP

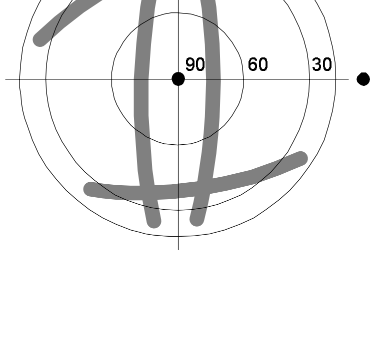




dx=1.9
dy=0.6 ←
dz=1.5

dx=0.5 ←
dy=1.4
dz=1.3

optimum pass coverage, 100 NP, common delay



dx=0.3
dy=0.2
dz=0.6

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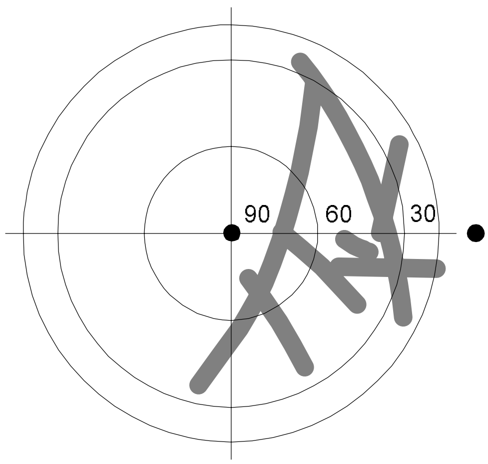
Differential Satellite Ranging

Baseline Precision Estimate

Real data, SLR station Helwan Sep. 97

used coverage:



35 NP in 9 passes

input NP precision 25 mm

dx=13
dy=30
dz=46

J.Blažej, I.Procházka, Prague Sep.1997