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SLR analysis with the DGFI-TUM software DOGS-OC/CS

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DGFI Orbit and Geodetic parameter estimation Software (DOGS)

The DGFI Orbit and Geodetic parameter estimation Software comprises three libraries: the Orbit Computation library for SLR and DORIS (DOGS-OC), the Radio Interferometry library for VLBI (DOGS-RI; not covered by this poster), and the Combination and Solution library (DOGS-CS) for performing a combination of different satellites or techniques at normal equation (NEQ) level and for solving NEQ systems. DGFI-TUM operates an ILRS Analysis Centre (AC) using DOGS-OC/-CS for routine computations. DOGS-RI/-CS are used by DGFI-TUM's IVS AC for its IVS contributions. in addition, DOGS-CS is used by DGFI-TUM's ITRS Combination Centre (CC) for the computation of ITRS realizations.

DOGS-OC

DOGS-OC provides the ability to integrate (reduced-)dynamic orbits, to simulate SLR observations of existing or new stations or to existing or new satellites, to iteratively estimate geodetic parameters, and to set up single-satellite NEQs (e.g., for inter-satellite or inter-technique combination). The most recent release of DOGS-OC is version 5.5, operational since April 2018. However, DOGS-OC has a long history dating back over more than three decades (Fig. 1).

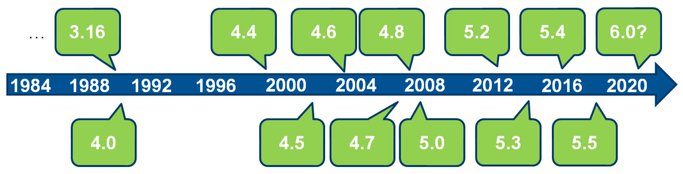

Figure 1: Version history of DOGS-OC (as far as it could be reconstructed by the authors).

DOGS-CS

DOGS-CS is used to combine observation equations or NEQs and consists of several specialized routines which can be used to (i) apply operations on equation systems such as parameter transformations and scaling, introduction of new parameters, elimination of parameters, (ii) to combine equation systems by adding and relatively weighting them, and (iii) to solve NEQ systems.

Satellite constellation processed at DGFI-TUM

Several satellite-specific macro-models and parameters are implemented in DOGS-OC. Using this library, laser observations to up to 15 different spherical satellites (+ 3 planned) and three non-spherical satellites (+ 14 planned) can be analyzed (Fig. 2). All shown satellite missions focus on geodetic and altimetry goals.

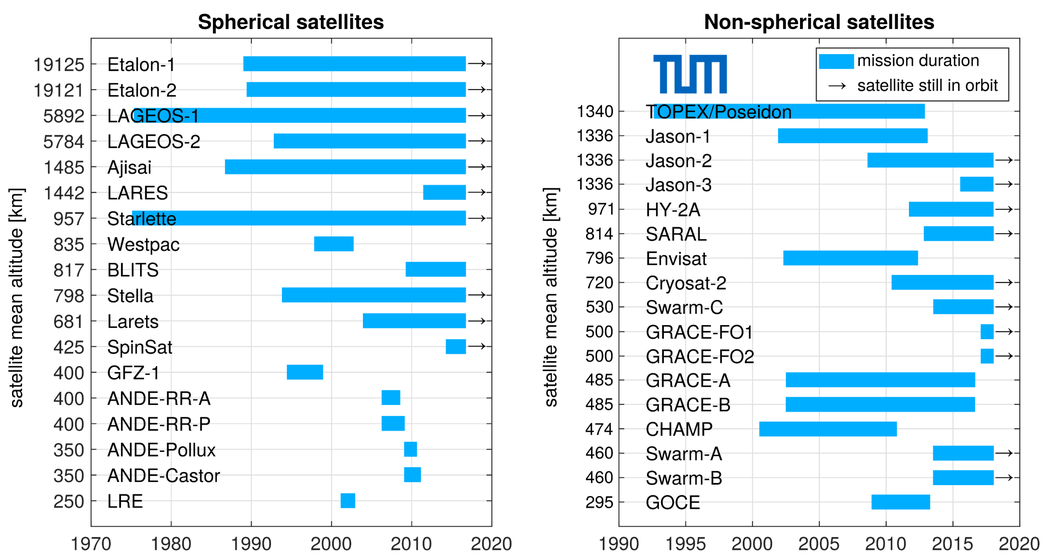

Figure 2: SLR-supported satellite missions at DGFI-TUM (current + planned).

Parameter space

Within DOGS-OC, static and dynamic parameters can be estimated (see Tab. 1). Corrections estimated to dynamic parameters directly affect the satellite orbit.

	parameters	dynamic	static
Satellite-specific parameters	Initial state vector (Keplerian elements/Cartesian coordinates)	X	
	Center-of-Mass (CoM) corrections	X	X
	Attitude correction	X	X
Perturbing accelerations	Earth's gravity field spherical harmonics	X	
	Ocean tide spherical harmonics	X	
Scaling factors of perturbing accelerations	Solar radiation pressure	X	
	Earth's albedo	X	
	Earth's infrared radiation	X	
	Thermospheric drag	X	
	Relativistic acceleration	X	
	Empirical acceleration (cosine-/sine-term, offsets) [RTN]	X	
Earth orientation parameters	Terrestrial pole coordinates	X	X
	UT1 corrections	X	X
Station parameters	Station coordinates/velocities		X
Biases	Range/Time/Frequency (offset / drift)		X
	Tropospheric refraction		X

Table 1: DOGS-OC parameter space.

DGFI-TUM as an ILRS Analysis Centre

- Responsibility: Mathis Bloßfeld (since April 2018)
- Since September 2018, the ILRS AC is operated on a totally new system
  - complete rewriting of processing environment (pre-/post-processing tools)
  - Switch to DOGS-OC version 5.5
  - Switch to DOGS-CS version 5.1
- After that, submission of test files to ILRS-A/-B CC (ASI, JCET/GSFC)
- After validation, a complete reprocessing of all SLR data available will be performed

The ILRS processing chain at DGFI-TUM

Fig. 3 shows the general ILRS processing scheme applied at DGFI-TUM to generate official ILRS products. Based on both prior described software libraries, numerous geophysical input models, and SLR observations to LAGEOS-1/2 and Etalon-1/2, SINEX files containing weekly station coordinates and daily EOP are computed routinely on a daily/weekly basis. In addition, the integrated orbits of these satellites are delivered to the ILRS CCs.

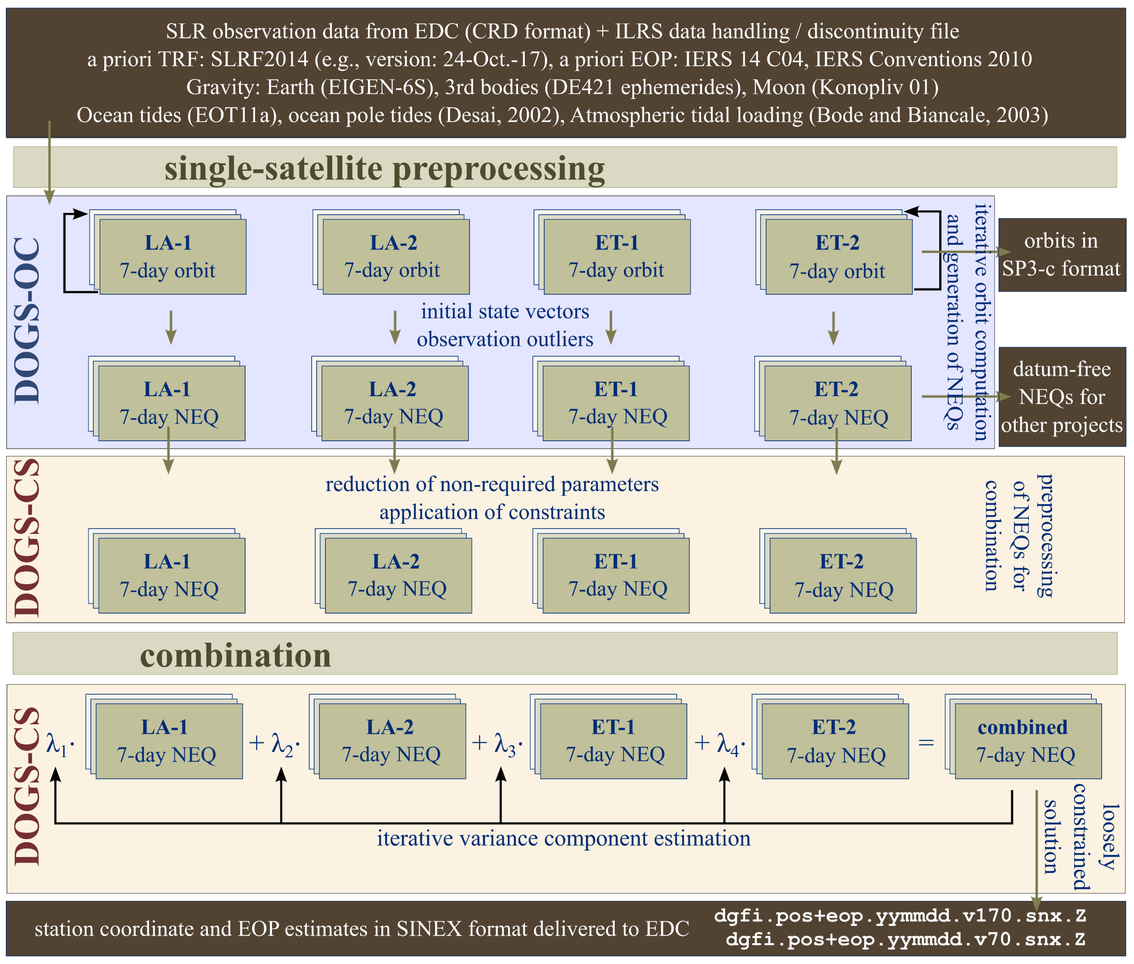

Figure 3: ILRS routine product processing scheme realized at DGFI-TUM.

DOGS at DGFI-TUM: Contribution to selected ILRS pilot projects

DGFI-TUM contributes to all currently established ILRS pilot projects such as

- Estimation of low-degree spherical harmonics of the Earth's gravity field
- Inclusion of LARES as the 5th satellite in the ILRS operational products
- Discussion of a plan for the expansion of targets used in operational products
- Quantification of non-tidal loading and gravitational effects on official IRLS products

Simulation studies

DOGS-OC enables the generation of simulated normal point data in order to investigate the impact of the observation scheduling, additional stations, or additional orbits on the estimated parameters. With this feature, DGFI-TUM is able to participate in the efforts in order to tailor the optimum SLR network of the future, e.g. within the framework of the GGOS Standing Committee on Performance simuLations and Architectural Trade-Offs (PLATO). Moreover, DOGS-OC simulations were used to quantify the benefit of an E-GRASP orbit to gravity field parameters.

References

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- Bloßfeld M., Rudenko S., Kehm A., Panafidina N., Müller H., Angermann D., Hugentobler U., Seitz M. (2018): ***Consistent estimation of geodetic parameters from SLR satellite constellation measurements.*** J Geodesy 92:1003-1021, DOI: 10.1007/s00190-018-1166-7.
- Kehm A., Bloßfeld M., Pavlis E. C., Seitz F. (2017): ***Future global SLR network evolution and its impact on the terrestrial reference frame.*** J Geodesy 92:625-635, DOI: 10.1007/s00190-017-1083-1.