Description and understanding of the dynamic Earth system, which changes in time and space, are one of the main goals of the International Association of Geodesy. This goal is being pursued by improving the main three pillars of geodesy: rotation, geometry, and gravity of the Earth, which provide a conceptual and observational basis for high-quality geodetic reference frames, global geodetic parameters, such as Earth rotation parameters, low-degree gravity field coefficients, coordinates of the Earth center of mass, station coordinates, and the realization of the International Terrestrial Reference Frames (ITRF). Four basic observation techniques and services used for deriving global geodetic parameters and ITRF include: Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR), Very Long Baseline Interferometry (VLBI), Global Navigation Satellite Systems (GNSS), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS).

The SLR technique is based on the registration of time-of-flight of laser signal from station telescopes to the retroreflector mounted on a satellite, where a laser pulse is reflected back to the detector at the station. Multiplying this ‘‘two-way” time interval by the speed of light, the half of the resulting value gives an approximated range between the station and the artificial Earth satellite. Typically, SLR measurements to dedicated, passive, geodetic, cannonball-like satellites (e.g. LAGEOS) are used for the determination of global geodetic parameters, determination of the gravity field coefficients, verification of the general relativity effects, the realization of the ITRF, and other purposes. In the case of other types of satellites equipped with laser retroreflectors, such as active low Earth orbiters (LEOs), e.g. GRACE, Sentinel-3A or GNSS constellations (e.g. GPS, Galileo, GLONASS), the main purpose of SLR measurements is the validation of their GNSS-based orbits. Moreover, due to fact that we also have retroreflectors installed on the Moon, we can register and use the SLR measurements to our natural satellite.

At present, 9% of all SLR observations are collected to passive geodetic satellites, whereas 81% and 10% are to LEOs and GNSS satellites, respectively. Therefore, only 9% of all SLR observations are actually used for the realization of the ITRF and deriving fundamental geodetic products. LEOs and GNSS satellites due to their particular mission objectives, such as sea-level change for Sentinels-3A/B or precise positioning in the case of GNSS, require the highest precision of their orbits, which nowadays reaches the level of 1-2 cm. **Despite the high orbit precision and constituting the 91% of all SLR measurement targets, the LEO- and GNSS-based SLR data is not used for the realization of the ITRF nor determination of global geodetic parameters.**

The goal of this project is to improve the quality of global geodetic parameters, such as: pole coordinates and length-of-day, Earth’s oblateness term and degree-2 to 4 coefficients, geocenter coordinates, SLR station coordinates, and the ITRF realization, by using microwave orbits of LEOs, GNSS and SLR measurements to different satellite types, such as passive geodetic, active LEOs, and navigational GNSS satellites. For the first time, the full potential of SLR observations to different constellations will be explored with the focus on the contribution to space geodesy and science. In the project, we include observations to about 10 LEOs, 9 geodetic (including LARES-2 and BLITS-M) and 64 GNSS satellites, which orbit at different altitudes from 300 km to 40 000 km. We will also try to SLR and LLR observations to determine, for the first time, station coordinates for LLR and SLR sites.

This project incorporates independent processing of the microwave GNSS and optical SLR observations. The processing will be performed in the Bernese GNSS Software with additional implementations related to special handling of SLR observations to LEOs and using of LLR data.

We expect that the results will bring groundbreaking outcomes, will improve derived global geodetic parameters, and will bring us closer to the integration of various satellite missions at the observation and solution levels, which has never been investigated before.