FROM OPTICAL TRACKING TO LASER TRACKING - THE EARLY YEARS OF SATELLITE GEODESY

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Classical geodesy's operations in the mid 50's were tied to the ground, had to use the vertical and could not work directly in a 3D space. Attempting to use elevated targets such as balloons, rockets and even the moon, did not provide any reliable results. Geodesy got a huge burst when the first artificial satellite became a reality during the International Geophysical Year 1957 (IGY) starting what was called Satellite Geodesy.

The unexpected launching of Sputnik on October 4th 1957, soon followed by more satellites, had an immediate impact on geodesy and earth sciences in general. The scientific community started quickly exploiting this new tool.

In 1958 ISCU established COSPAR to coordinate the activities on space research, organizing international meetings and conferences, while other bodies involved in Geodesy got into action organizing workshops, campaigns, exchanging information and ideas with great enthusiasm.

Scientists and engineers from different disciplines came together to produce new knowledge for the better understanding of our planet and environment. International cooperation and the interdisciplinary approach, together with the contribution of fast computers and advanced electronics were an important factor in this great advancement.

In 1955 SAO was assigned to build and operate, during IGY, a global network of 12 stations equipped with special cameras, known as Baker-Nunn (B/N), for precise optical tracking of satellites. Only one camera was ready in October 1957 but all were in operation by mid 1958. This SAO network provided most of the accurate observations that were used during the following years. The exposed films were measured on a precise comparator to obtain the astronomic coordinates of the satellite.

Within months after October 1957 the first results started coming out for the shape of the earth and its gravity field as well as coordinates of tracking stations. More optical tracking cameras were built as well as electronic tracking systems. TRANSIT, a navigation system based on radio Doppler shift, started operating from 1960, providing valuable geodetic results. Later, satellites dedicated to geodesy were launched equipped with a variety of tracking systems such as ANNA, GEOS, LAGEOS, DORIS, GPS, ERS, SEASAT and others.

Determination of the orbits and the derived geodetic parameters based on celestial mechanics theory, is extremely complicated and computers in the late 50's were not fast enough to do the job using the classical methods. So SAO developed a special Differential Orbit Improvements Program (DOI) that could compute both the orbital elements and the station coordinates. DOI was ready by 1958 to go into production phase. The program was upgraded several times and continued to be the main computing tool for several years.

With the abundance of collected data in the mid 60's we were able to start combining solutions from several sources in order to arrive to numerical models for the earth; defining its size, its gravity field and the coordinates of stations, in a well-defined Reference System. One of the first such models, was the Standard Earth of SAO, a joint work of several people, some of them coming from other countries. It took more than a year to complete this project, which gave coordinates for two dozen stations and the earth's gravity field to degree and order 15. It was published in 1966 (SAO Special Reports No 200, 680 pages).

Since the satellite observations up to 1965 were obtained by optical methods based on space directions and Doppler tracking without accurate direct measurements of distances, the "scale" of all geodetic results depended on the accepted value of GM, which was used for the determination of the scale factor through the observed mean motion, so the precise ranging to satellites was really needed. This became possible with the first ruby lasers that could transmit light pulses of ultra short duration that would reflect on corner cubes placed on satellites. The first ranges to a satellite were obtained in December 1964 with an estimated accuracy of 1-2 meters. Today several satellites carry corner cubes, the most famous one being LAGEOS, and laser technology has progressed so the accuracy obtained is 1-2 cm and even better. Laser ranging to satellites to those accuracies were needed. They have improved considerably the quality of all operations of satellite geodesy and provided the needed scale to the models and to the Reference System. There is no doubt that laser ranging is the most accurate observing system.