Journal of Novel Applied Sciences
Available online at www.jnasci.org
©2014 JNAS Journal-2014-3-S2/1712-1715
ISSN 2322-5149 ©2014 JNAS

Satellites Used in Geodesy

Reza Hemati[1], Milad Khosravi[1], Ali Khodakarami Fard[2*] and Mohammad Khosravi[3]

1- Department of Civil Engineering, Shahrood Branch, Islamic Azad University, Shahrood, Iran
2- Department Of Geology, Khorramabad Branch, Islamic Azad University, Khorramabad, Iran
3- Department Of Surveying, Nonprofit Institute of higher education Yassin Boroojerd, Iran

Corresponding author: Ali Khodakarami Fard

ABSTRACT: Most of the satellites which have been used, and still are used, in satellite geodesy were not dedicated to the solution of geodetic problems; their primary goals are various. Typical examples of this group are the navigation satellites of the TRANSIT and of the GPS systems, and remote sensing (Earth observation) satellites carrying a radar altimeter. Examples of satellites which were exclusively, or primarily, launched for geodetic and/or geodynamic purposes are:

PAGEOS (PAssive GEOdetic Satellite)	USA 1966,
STARLETTE,STELLA	France 1975, 1993
GEOS-1 to 3 (GEOdetic Satellite 1 to 3)	USA 1965, 1968, 1975,
LAGEOS-l, 2(LAser GEOdynamic Satellite)	USA 1976, 1992,
AJISAI (EGS, Experimental Geodetic Satellite)	Japan 1986,
GFZ-l (GeoForschungs Zentrum)	Germany 1986,
CHAMP (CHAllenging Mini Satellite Payload)	Germany 2000.

This group of dedicated satellites includes some which were used during the first years of the satellite era for the establishment of geodetic datum connections (e.g. SECOR ANNA-lB (1962)). All satellites which are dedicated to a given observation technique will be treated in detail together with this technique.

Keywords: Satellite, Geodesy, navigation, GPS, remote sensing.

INTRODUCTION

The orbital height of a satellite is mainly determined by the purpose of the mission.

A satellite used for gravity field determination should have a rather low orbit (about 300 to 500 km), and it must carry highly sophisticated instrumentation. A satellite used for precise position location should have a rather high and stable orbit, and could be much simpler, from the technical point of view. This is why dedicated missions for the mapping of a fine structured Earth gravity field have only been realized recently, or are in the final stage of realization. In order to separate gravitational and non-gravitational forces the satellites must be carefully designed. One possibility is to select a favorable mass/area relation, which minimizes the forces acting on the satellite surface. In another solution the surface forces are compensated by a thrusting system. This keeps the satellite centered on a "proof mass" which is shielded from the satellite surface forces.

A frequently used distinction for the purposes of subdivision is passive and active satellites. Passive satellites are exclusively used as targets. They have no "active" electronic elements, and are independent of any power supply. Their lifetime is usually extremely long. Active satellites in most cases carry various subsystems like sensors, transmitters, receivers, computers and have a rather limited lifetime. Table1.1 gives an overview of the most important satellites that are in use, or have been used, in satellite geodesy.

Table 1. Satellites used in geodesy

Passive Satellites	Active Satellites	
ECHO-1 ETALON-1	ANNA-I B	ERS-2
ECHO-2 ETALON-2	GEOS-3	TOPEX/POSEIDON
PAGEOS GFZ-l	SEASAT-1	GFO (Geosat Follow On)
STARLETTE	NNSS satellites	CHAMP
STELLA	NAVSTAR satellites	JASON
LAGEOS-1	GLONASS satellites	ENVISAT
LAGEOS-2	GEOSAT	GRACE
EGS (AJISAI)	ERS-1	

Another possible subdivision is into:

- Geodetic Satellites
- Earth Sensing Satellites,
- Positioning Satellites, and
- Experimental Satellites

Geodetic satellites are mainly high targets like LAGEOS, STARLETTE, STELLA, ETALON, ASIJAI, and GFZ which carry laser retro-reflectors. They are massive spheres designed solely to reflect laser light back to the ranging system. The orbits can be computed very accurately, because the non-gravitational forces are minimized.

Earth sensing satellites like ERS, GFO, TOPEX, JASON, ENVISAT carry instruments designed to sense Earth, in particular to monitor environmental changes. Many of these satellites carry altimeters. The satellites are rather large with irregular shape, hence drag and solar radiation forces are also large and difficult to model. Most are equipped with an orbit determination payload, e.g. PRARE, GPS, and/or DORIS.

In addition most satellites carry laser reflectors to facilitate precise orbit determination. Positioning satellites are equipped with navigation payload. To this class belong the former TRANSIT, GPS, GLONASS, and future GALILEO satellites. Some of the spacecraftscarry laser reflectors (e.g. GPS-35, -36, and all GLONASS satellites). The satellites are arranged in constellations of up to 24 and more to provide global or regional coverage.

Experimental satellites support missions with experimental character. They are used in the development of various other kinds of satellites, to test their performance in real space operations. A large number of experimental satellites have been launched for communication technology. Experimental satellites of interest to geodesy are mostly irregularly shaped and fly in low orbits. Precise orbit determination (POD) is supported by laser cube corner reflectors and/or a navigation payload like) GPS. Examples include TiPs (Tether Physics and Survivability), and Gravity Probe B.

RESULTS AND DISCUSSION

Discussion:

In this research some satellites and subsystems are described that are in use or have been used for different observation techniques in satellite geodesy.

GEOS-3

The third satellite of the GEOS series was launched by NASA on April 9, 1975. The initial orbital elements and some physical parameters are:

period	102 minutes,
apogee height	844 km,
perigee height	837 km,
inclination	115°,
weight	340 kg,
diameter	132 cm, and
length	81 cm.

The antennas are orientated toward Earth using a 19.5 m gravity gradient boom and a 45 kg boom end mass. Figure 1 shows the configuration of the spacecraft and its main elements.

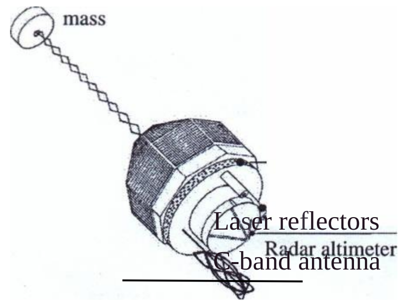

Figure 1. GEOS-3 spacecraft

The experiment package consists of the following:
- Radar Altimeter for the satellite-to-ocean surface height measurements 5.7 GHz; precision ±60 cm,
- C-Band Transponder, providing for range, range-rate and angle measurements in conjunction with appropriately equipped ground stations.
- S-Band Transponder, for satellite-to-satellite tracking experiments.
- Laser Retroreflector Array with 264 quartz cube corner reflectors; designaccuracy ± 10 cm.
- Doppler System, dual frequency (162 and 324 MHz), providing the determination of positions and position changes from ground stations.

GEOS-3, because of the well-equipped experiment package, became the geodetic satellite "par excellence". Many problems from science and practice could be solved with GEOS-3 data. The most important subsystem from the geodetic point of view was the radar altimeter. It was in operation for more than three years until the end of 1978, without any considerable interruptions. The laser-reflector array can still be used.

SEASAT-J

The oceanographic satellite SEASAT-1 was launched on June 26,1978, with an orbit similar to that ofGEOS-3, namely a period of 109 minutes, an altitude of 800 km, and an inclination of 108°.

The spacecraft carried several sensors for use in oceanography, and a radar altimeter with a ±10 cm resolution, which exceeded by far the design-accuracy of the GEOS-3 altimeter. Due to a break-down in the power system, SEASAT-1 only delivered altimeter data for five months. However, because of the much higher data rate, the size of the SEASAT-l data set is similar to the GEOS-3 data set. The results of the SEASAT mission have contributed considerably to the progress of geodesy.

ERS-J, ERS-2

The designation ERS-J stands for the First European Space Agency (ESA) Remote Sensing Satellite. It was launched on July 17, 1991. ERS-l flies in a sun-synchronous orbit at an altitude of about 800 km and an inclination of 98.5 degrees. The mission had the following main objectives.
- monitoring of the global oceans,
- observing polar and sea ice,
- monitoring regionally the land surface, and
- supporting geodetic research.

From the geodetic point of view the two on-board systems of greatest interest were the radar altimeter (RA) and PRARE. The radar altimeter is a single frequency Ku-band (2 cm waves) instrument of the SEASAT type with an anticipated height-resolution of 0.1 m over sea and 0.4 m over ice. PRARE should have been used for precise orbit determination at the 10 cm accuracy level. Unfortunately the PRARE system could not be activated after launch. ERS-l is also equipped with laser retro- reflectors providing the primary tracking of the spacecraft.

The remote sensing objectives of the mission were covered by a large variety of instruments, such as an Active Microwave Instrument (AMI) including a Synthetic Aperture Radar (SAR) and an Along Track Scanning Radiometer (ATSR), providing information on sea state, winds and waves.

A very powerful tool for geodetic deformation studies developed with the interfereometric use of the SAR antenna, the Interferometric SAR (InSAR).

ERS-2 was the follow-on mission to ERS-l. It was launched on April 21, 1995 into an orbit similar to ERS-l. It carries similar instruments to ERS-l, as well as the Global Ozone Monitoring Experiment (GOME). Precision orbits were determined with PRARE and SLR. For a period of time, both satellites flew in the combined tandem mission.

ASIJAI (EGS)

The Japanese Experimental Geodetic Satellite (EGS) was launched on August 12, 1986. The unofficial name is AJISAI (water-snake). The spacecraft is well suited for laser ranging and for photographic camera observations. It is polyhedron- shaped with an effective diameter of 2.15 m. It carries 318 mirror elements and 120 reflector assemblies for laser right (Figure 2) The total weight amounts to 685 kg. The nearly circular orbit has an inclination of i = 50° and a period of 115.7 minutes.

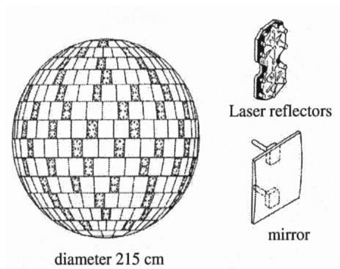

Figure 2. AJISAI (EGS), Japan

TDRSS

The Tracking and Data Relay Satellite System (TDRSS) provides tracking and data communication between low Earth orbiting (LEO) spacecrafts and ground-based control and data processing facilities. The space segment consists of seven Tracking and Data Relay Satellites (TDRS) located in geosynchronous orbits. The constellation provides global coverage. The system is capable of transmitting to and receiving from the spacecraft over 100% of their orbit. The ground segment is located near Las Cruces, New Mexico. The system has worked successfully since 1983 and supports a large number of scientific missions. Among these are the

- Hubble Space Telescope,
- Space Shuttle,
- Landsat,
- Ocean Topography Experiment (TOPEX),
- Earth Observing System (EOS),
- Space VLBI,
- International Space Station (ISS), and
- JASON.

Conclusion:

The satellites which were exclusively, or primarily, launched for geodetic or geodynamic purposes are:
PAGEOS, STARLETTE, GEOS, LAGEOS, AJISAI, GFZ-1, CHAMP Geodetic satellites are Mainly high targets which carry laser retro-reflectors.

They are massive spheres designed solely to reflect laser light back to the ranging system. The orbits can be computed very accurately, because the non – gravitational forces are minimized.

REFERENCES

Gunter S. 2003. satellite geodesy, 2nd completely and extended edition, Berlin, New York pp. 134–152
http://www.iau.org/
http://hpiers.obspm.fr/icrs-pc/icrf/icrf.html
http://www.iers.org/IERS/EN/Home/home_node.html
http://igscb.jpl.nasa.gov/
http://www.gaithersburgmd.gov/about-gaithersburg/city-facilities/international-latitude-observatory
http://adsabs.harvard.edu/full/2000ASPC..208..147Y
http://www.ngs.noaa.gov/PUBS_LIB/Geodesy4Layman/TR80003D.HTM
http://www.scopus.com/
http://www.sciencedirect.com/