

Satellite Laser Ranging Tracking Through The Years

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Abstract

Satellites equipped with retroreflectors have been tracked by laser systems since 1964. Satellite laser ranging supports a variety of geodetic, earth sensing, navigation, and space science applications. This poster will show the history of satellite laser ranging from the late 1960's through the present and will include retro-equipped satellites on the horizon.

Satellite Tracking History

Initial laser ranges to a satellite in Earth orbit took place in 1964 with the launch of Beacon Explorer-B (BE-B), the first satellite equipped with laser retroreflectors. Since that time, the global network of laser ranging sites has tracked over eighty satellites including arrays placed on the Moon. Satellite and Lunar laser ranging continue to make important contributions to scientific investigations into solid Earth, atmosphere, and ocean processes. SLR also provides Precise Orbit Determination (POD) for several Earth sensing missions (e.g., altimetry, etc.), leading to more accurate measurements of ocean surface, land, and ice topography. Several of these missions have relied on SLR when other radiometric tracking systems have failed (e.g., GPS and DORIS on TOPEX/Poseidon, PRARE on ERS-1, GPS on METEOR-3M and GFO-1) making SLR the only method for providing the POD required for instrument data products. A list of satellites equipped with retroreflectors (past, current, and future) and tracked by SLR is shown in Table 1. The table summarizes the data yield (approximate through 2014) and includes a list of any co-located instrumentation (e.g., GNSS, DORIS, or PRARE). Figure 1 shows this rich history in graphical format, as well as future plans, from mid-1960 through 2017. The satellite missions supported by laser ranging are shown in four categories: geodetic, Earth sensing, navigation, and space science or engineering applications.

The data generated by the laser ranging stations tracking these satellites, as well as products derived from these data, are available from the Crustal Dynamics Data Information System (CDDIS, <http://cddis.nasa.gov>). The CDDIS is NASA's active archive and information service of space geodesy data and products and currently serves as a key global data center for the ILRS. For over 30 years, the CDDIS has provided continuous, long term, public access to the data and product sets required for many interdisciplinary studies of the global Earth Science community. The CDDIS archives and distributes GNSS, currently GPS, GLONASS, Galileo, Beidou, and others, laser ranging, VLBI, and DORIS data for an ever-increasing international user community. In addition to the ILRS, the CDDIS serves as a global data center for the International GNSS Service (IGS), the International VLBI Service for Geodesy and Astrometry (IVS), the International DORIS Service (IDS), the International Earth Rotation and Reference Systems Service (IERS), and the Global Geodetic Observing System (GGOS).

Table 1. ILRS Satellite Tracking Information

Satellite	Start Date	End Date	No. of Years	No. of Passes	Co-Located Instrument	Comments
<i>Current and past satellites:</i>						
ADEOS	1996-10-15	1997-08-18	2	756		
ADEOS-2	2002-12-14	2003-01-22	2	175		
AJISAI	1986-08-13		29	240,306		
ALOS	2006-08-14	2006-08-31	1	106		Restricted
ANDE-Castor	2009-08-04	2010-08-01	2	719		
ANDE-Pollux	2009-08-04	2010-03-16	2	313		
ANDE-RR Active	2007-01-12	2007-12-07	1	444		
ANDE-RR Passive	2007-01-12	2008-05-15	2	663		
BE-C	1976-01-02		27	106,481		
BLITS	2009-09-24	2013-03-05	5	10,254		
CHAMP	2000-07-17	2010-09-04	11	17,574	GNSS	
COMPASS-G1	2012-04-28		3	857	GNSS	
COMPASS-I3	2012-04-27		3	1,177	GNSS	
COMPASS-I4	2012-10-14	2012-10-15	1	2	GNSS	
COMPASS-I5	2012-07-06		3	1,749	GNSS	
COMPASS-M1	2008-12-04	2012-06-29	5	5,540	GNSS	
COMPASS-M3	2012-07-11		3	2,147	GNSS	
CryoSat-2	2010-04-20		5	21,005	GNSS	
DIADEM-1C	1997-04-21	1997-11-02	1	2,433		
DIADEM-1D	1997-04-22	1997-11-01	1	2,654		
Envisat	2002-04-10		13	60,525	DORIS	
ERS-1	1991-07-17	2013-10-18	10	26,639		
ERS-2	1995-04-24	2014-09-23	19	85,989		
Etalon-1	1989-01-26		26	34,392		
Etalon-2	1989-07-13		26	32,636		
ETS-8	2007-03-10	2010-07-29	4	778		
FIZEAU	1995-06-13	1998-10-16	4	4,837		
Galileo-101	2011-11-30		4	4,871	GNSS	
Galileo-102	2011-11-29		4	4,724	GNSS	
Galileo-103	2012-11-07		3	3,103	GNSS	
Galileo-104	2012-11-07		3	3,391	GNSS	
Galileo-201	2014-12-05		1	34	GNSS	
GEOS-3	1998-10-15	1999-05-13	2	2,225		
GFO-1	1998-04-22	2008-11-07	11	46,339	GNSS	GPS failure
GFZ-1	1995-04-19	1999-06-08	5	5,227		
GIOVE-A	2006-05-11		9	5,017	GNSS	
GIOVE-B	2008-05-20	2012-07-24	5	3,608	GNSS	
GLONASS (64 sats.)	1994-12-28		21	181,205	GNSS	
GOCE	2009-03-31	2013-11-02	5	4,118	GNSS	
GP-B	2004-07-07	2006-06-05	3	3,170	GNSS	Restricted
GPS-35	1993-10-18	2013-05-07	21	10,097	GNSS	
GPS-36	1994-04-21	2014-04-18	21	11,865	GNSS	
GRACE-A	2002-03-18		13	39,118	GNSS	
GRACE-B	2002-03-18		13	38,808	GNSS	
HY-2A	2011-10-02		4	13,794	DORIS	

Table 1. ILRS Satellite Tracking Information (continued)

Satellite	Start Date	End Date	No. of Years	No. of Passes	Co-Located Instrument	Comments
ICESat	2003-03-05	2010-08-02	8	9,358	GNSS	Restricted
IRNSS-1A	2013-09-05		2	566	GNSS	
IRNSS-1B	2014-05-09		1	284	GNSS	
IRNSS-1C	2014-11-14		1	22	GNSS	
Jason-1	2012-01-01	2014-05-15	14	89,392	GNSS, DORIS	
Jason-2	2008-06-24		7	59,816	GNSS, DORIS	
KOMPSAT-5	2013-09-09		2	1,929	GNSS	
LAGEOS-1	1976-05-10		39	230,362		
LAGEOS-2	1992-10-24		23	155,962		
LARES	2012-02-17		3	23,837		
LARETS	2003-11-04		12	48,683		
LRE	2001-12-17	2002-03-28	2	78		
LRO-LR	2009-07-03	2014-09-30	6	4173.6 min		Restricted
METEOR-3	1994-01-25	1995-11-11	2	6,395		
METEOR-3M	2001-12-19	2006-03-03	6	1,809	GNSS	GPS failure
Moon	1996-06-05		21	6,299		
MSTI-2	1994-06-21	1994-10-10	1	38		
OICETS	2006-04-18	2009-04-15	3	521		
PROBA-2	2010-03-16	2011-02-11	2	585		
QZS-1	2010-11-30		5	1,811	GNSS	Restricted
RadioAstron	2011-11-15	2012-10-25	2	18		
Reflector	2001-12-21	2012-09-17	5	3,730		
RESURS	1995-12-25	1998-10-14	4	2,031		
SARAL	2013-03-04		2	7,770	GNSS, DORIS	
SOHLA-1	2009-03-06	2009-03-26	1	163	GNSS	
SpinSat	2014-12-11		1	50		
Starlette	1976-01-03		39	194,174		
STARSHINE-3	2001-10-03	2003-06-01	3	50		
Stella	1993-09-30		22	102,533		
STPSat-2	2013-04-02	2014-11-16	2	462		
STSAT-2C	2013-03-29		2	247		
SUNSAT	1999-05-07	2001-05-09	3	1,806		
SWARM-A	2013-11-26		2	2,109	GNSS	
SWARM-B	2013-11-27		2	2,485	GNSS	
SWARM-C	2013-11-25		2	2,102	GNSS	
TanDEM-X	2010-06-21		5	16,654	GNSS	
TerraSAR-X	2007-06-16		8	25,961	GNSS	
TIPS	1996-06-21	1997-10-15	2	1,851		
TOPEX	1992-01-01	2005-12-15	14	109,763	GNSS, DORIS	GPS, DORIS failure
WESTPAC	1998-07-23	2014-05-08	11	5,615		
ZEIA	1997-03-29	1997-07-29	1	148		
ZY-3	2012-07-05	2014-05-14	2	155		
<i>Future launches</i>						
ICESat-2	Launch 2017				GNSS	
Jason-3	Launch 2015				GNSS, DORIS	
Sentinel-3A, -3B	Launch 2015, 2017				GNSS, DORIS	

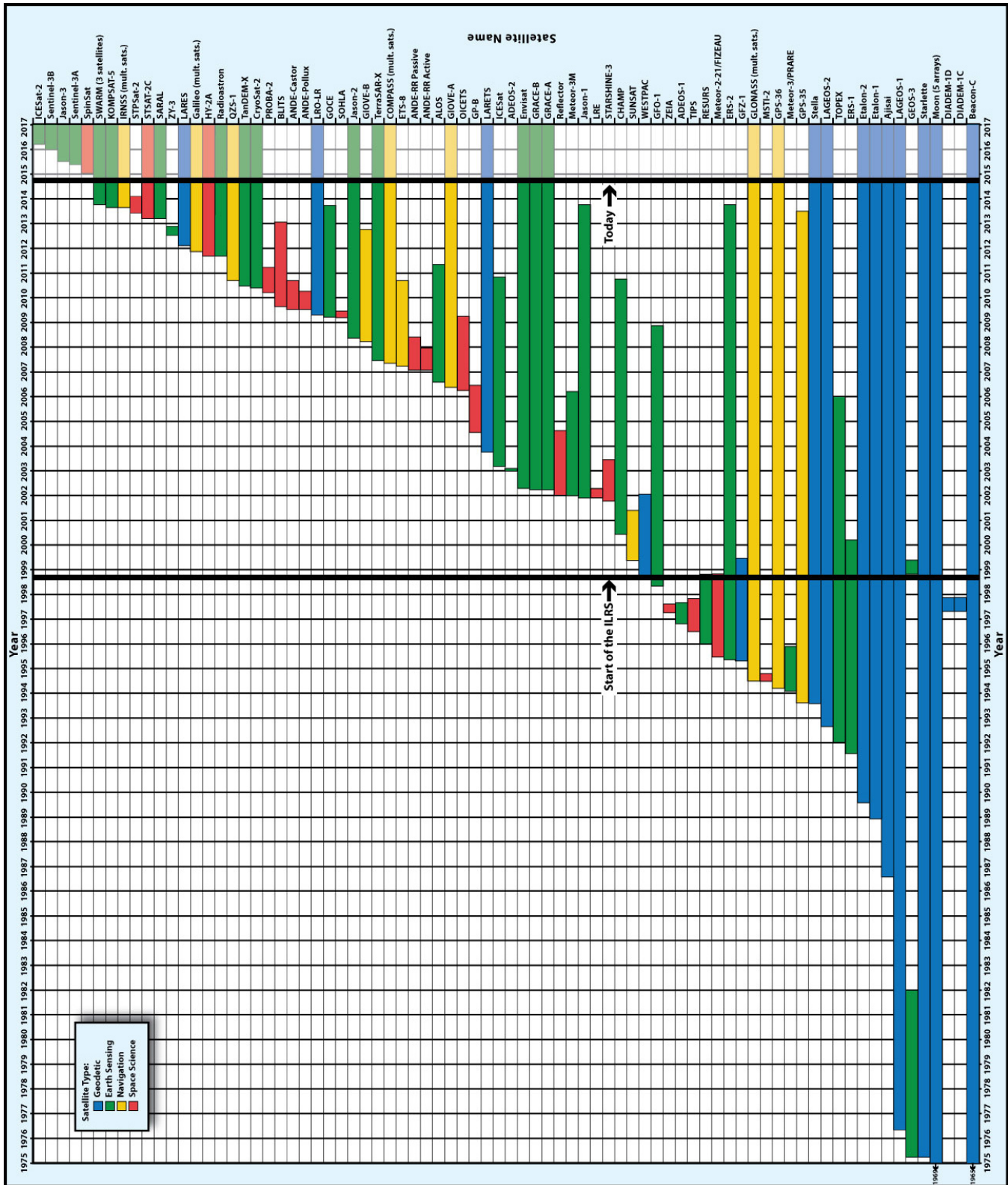


Figure 1. Satellite and Lunar Laser Ranging Tracking History