Pearlman, M.R., Appleby, G.M., Kirchner, G., McGarry, J., Murphy, T., Noll, C.E., Pavlis, E.C., Pierron, F. (2010), Current Trends in Satellite Laser Ranging, *Eos Trans. AGU, 91*(26), Meet. Am. Suppl., Abstract G13C-07.

Abstract:

Satellite Laser Ranging (SLR) techniques are used to accurately measure the distance from ground stations to retroreflectors on satellites and the moon. SLR is one of the fundamental techniques that define the International Terrestrial Reference Frame (ITRF), which is the basis upon which we measure many aspects of global change over space, time, and evolving technology. It is one of the fundamental techniques that define at a level of precision of a few mm the origin and scale of the ITRF. Laser Ranging provides precision orbit determination and instrument calibration/validation for satellite-borne altimeters for the better understanding of sea level change, ocean dynamics, ice budget, and terrestrial topography. Laser ranging is also a tool to study the dynamics of the Moon and fundamental constants. Many of the GNSS satellites now carry retro-reflectors for improved orbit determination, harmonization of reference frames, and in-orbit co-location and system performance validation. The GNSS Constellations will be the means of making the reference frame available to worldwide users. Data and products from these measurements support key aspects of the GEOSS 10-Year Implementation Plan adopted on February 16, 2005. The ITRF has been identified as a key contribution of the IAG to GEOSS and the ILRS makes a major contribution for its development since its foundation. The ILRS delivers weekly additional realizations that are accumulated sequentially to extend the ITRF and the Earth Orientation Parameter (EOP) series with a daily resolution. Additional products are currently under development such as precise orbits of satellites, EOP with daily availability, low-degree gravitational harmonics for studies of Earth dynamics and kinematics, etc. SLR technology continues to evolve toward the next generation laser ranging systems as programmatic requirements become more stringent. Ranging accuracy is improving as higher repetition rate, narrower pulse lasers and faster detectors are implemented. Automation and pass interleaving at some stations is already expanding temporal coverage. Web-based safety keys are allowing the SLR network stations to range to optically vulnerable satellites. Some stations are experimenting with two-wavelength operation as a means of better understanding the atmospheric refraction and with very low power laser to improve eye-safety conditions. New retroreflector designs are improving the signal link and enable daylight ranging. Dramatic improvements have also been made with lunar ranging with the new APOLLO Site in New Mexico, USA and the upgraded lunar station "MEO" in Grasse,

G13C-07

Current Trends in Satellite Laser Ranging

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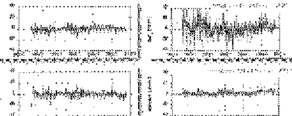
Abstract

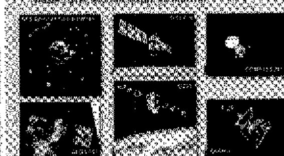
The Laser Ranging Technique and Science/Applications of SLR

SLR and the Terrestrial Reference Frame

- SLR is one of the key space technologies that contribute to the development of the ITRF:
  - An accurate, stable set of station positions and velocities.
- The unique contribution of SLR to ITRF is the link of its origin to the center of mass of the Earth system
- SLR contributes also in maintaining a stable scale for the ITRF, in equal parts with VLBI
- The ITRF Requirements of GGOS are:
  - <1 mm reference frame accuracy
  - < 0.1 mm/yr stability
- The primary science driver is the measurement of sea level change
- The GGOS goal requires a factor of 10-20 improvement over current ITRF performance demonstrated below for ITRF2008.

ITRF2008 Origin and Scale Variations from SLR





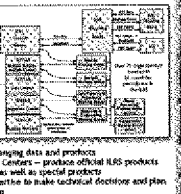
The International Laser Ranging Service and its Support of Missions through Laser Ranging

The International Laser Ranging Service (ILRS), founded by the International Association of Geodesy (IAG) in 1998, organizes and coordinates Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR) to support programs in geodetic, geophysical, and lunar research and provides the International Earth Rotation and Reference Frame Service (IERS) with products important to the maintenance of an accurate International Terrestrial Reference Frame (ITRF).

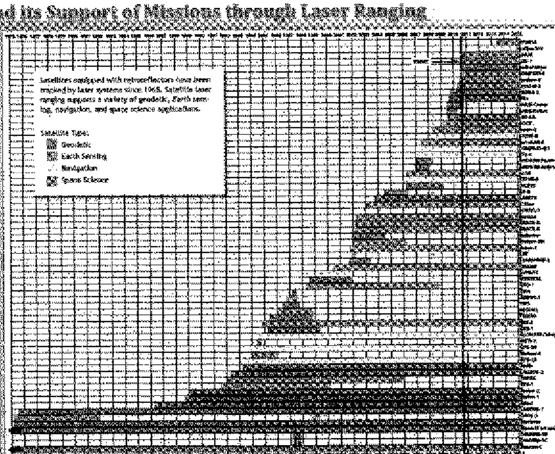
The ILRS produces quality-assured scientific results from the SLR and LLR data including:

- Satellite ephemerides
- Earth orientation parameters
- Position and velocity of the ILRS tracking stations
- Time-varying geocenter coordinates
- Static and time-varying coefficients of the Earth's gravity field
- Fundamental physical constants
- Lunar ephemerides and librations
- Lunar orientation parameters

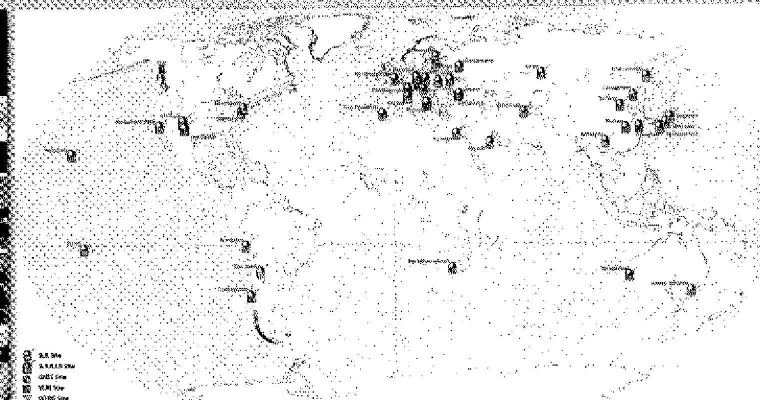
The ILRS accomplishes its mission through the following components:



- Tracking Stations and Subnetworks — range to the approved constellation of artificial satellites and the moon
- Operations Centers — collect, QC, merge data from tracking sites and transmit to data centers
- Data Centers — archive laser ranging data and products
- Analysis and Associate Analysis Centers — produce official ILRS products (station coordinates and EOP) as well as special products
- Working Groups — provide expertise to make technical decisions and plan programmatic courses of action
- Central Bureau — coordination and management of ILRS activities
- Governing Board — responsible for general direction of service and defines official ILRS policy

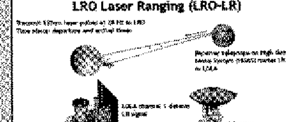


Current SLR/LLR Network

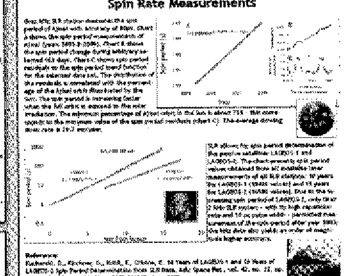


New Technology and Developments

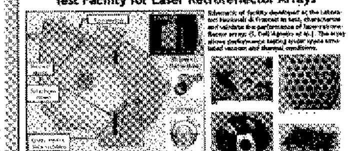
LRO Laser Ranging (LRO-LR)



Spin Rate Measurements

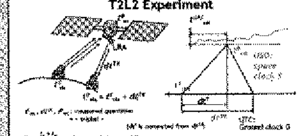


Test Facility for Laser Retroreflector Arrays



Courtesy of: Simone Dell'Agnello
Istituto Nazionale di Fisica Nucleare (INFN), Roma, Italy

T2L2 Experiment



NASA's Next Generation SLR (NGSLR)