• Early SLR satellites (Beacon B/C, GEOS ½, Diademe C/D were primarily satellites of opportunity
  • Co-located with Navy Doppler, C-band, S-band, GRARR, flashing lights (for Cameras)
  • Begin path toward more accurate geodetic products (networks, gravity field, polar motion, etc.)
• Around the time of the Williamstown Conference in 1969 (Kaula, The Terrestrial Environment: Solid-Earth and Ocean Physics, April 1970) the “SLR Space Geodesy Community” recognized that it could move from static geodesy to dynamics if we could:
  • Improve SLR ranging (cm accuracy)
  • Deploy a Global Network
  • Launch the right kind of target in space
• Improvement in LLR technology (LURE team/Apollo 11)
• Improvement in SLR by GSFC
Initial Concept for LAGEOS

• Proposed to NASA by SAO/George Weiffenbach (October 1970)
  • Original satellite called “Cannonball”
  • The Smithsonian Earth Physics Satellite (SEPS) Definition Study; NASA Technical Memorandum TM X-64632
  • Passive, high mass-to-area ratio ball uniformly covered with retroreflectors
  • Applications, mechanical and optical design, retro issues, signal link analysis, orbital acquisition, etc.
  • Lots of effort on the design and specification of the retro array
  • Orbital considerations
  • General design that could be scaled to different sizes
• Final Report to NASA by SAO/George Weiffenbach (April 1973)
  • “Use of a Passive Stable Satellite for Earth-Physics Application”s, NASA Grant NGR 09-015-164
  • Subcontract to ADL for Thermal - Optical Studies (based on design work they did on the Lunar Array)
• The plan for the Saturn launched Skylab provided a possible opportunity for a space segment;

• Early safety concerns for the astronauts led to consideration of having a fueled rescue Saturn vehicle ready to go in case there was trouble - the problem was “what can we do with the vehicle if it isn’t needed?”

• A solution was a heavy payload that was cheap and relatively easy to load, and ready to go.

• George Weiffenbach and Tom Hoffman adapted the concept design to an 8000 lb “Cannonball Satellite” with a depleted Uranium core (very heavy);

• NASA subsequently decided that the rescue vehicle was not needed;

• BUT the idea was geminating;
• LAGEOS Mission was accepted by NASA in 1973;

• Configuration was scaled to a Delta launch (no Uranium);

• Designed, built at Marshall Space Center; Bendix did the optical design work;

• Design included 4 Germanium Cubes for 10.6 micron studies at the request of Prof. Charles Towns

• Finally launched in May 1976

• LAGEOS was not the first passive, spherical satellite covered with retroreflectors; the French launched the Starlette satellite in early 1975.
SAO developed the orbital acquisition plan for NASA.

The orbital acquisition Plan was based on:

- Radio Beacon on the apogee kick motor that was to separate slowly from the LAGEOS; the battery operated beacon would last a few days;
- The SAO Baker Nunn Camera network would photograph it;
- Air Force radars would track;
- All of the sources of data would be merged at SAO and used to continuously update the SLR predictions;

Near real-time communication.
Baker Nunn Camera

- Global Network
- f/1 Schmidt Camera
- Az-Alt mount
- Mechanized film tracking transport
- 55 mm Film
- See down to 14 - 15 magnitude
- Main source of data for the early SAO Standard Earth Models
- Basis for satellite acquisition and predictions for SLR
- With 4th stage apogee kick motor
- 12 - 13 magnitude
- May 4, 1976

LAGEOS AND AKM TAKEN 3 HOURS AFTER LAUNCH
• Bi-Static, Az-Alt System
• Ruby oscillator/amplifier
• Day and Night Time Tracking
• 4 - 30 ppm
• 20 - 5 nsec pulse width
• Sites at Mt Hopkins, Arequipa, Natal, and Olifontsfontein/Orroral Valley
Camera and laser provide on site co-location
**First LAGEOS SLR Data**

* First Passes:  
  * Mt Hopkins  May 7, 1976  23 hours 43 - 51 minutes (UT)

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* Data from Launch through July 10, 1976 (2 months)

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The Mt. Hopkins camera-laser crew (plus two Cambridge visitors) pose in Amado after receiving awards for participation in the LAGEOS program; from left, Joe Delgado, John Gregory, Chad Poland, Jake Wohn, Don Patterson, Jim Peters, Al Almazan, and Station Manager Steve Criswell.
Fig. 3. Plot of range residuals versus time for 741 Lageos observations taken with the GSFC laser on 23 May 1976.
# First Year Data Yield

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SLR Stations that have tracked LAGEOS (entire history)

- Geographically dense in some regions
- Many spatial and temporal gaps
• Data built up as more stations were added
• Data quality HAS improved with the technology
• SLR (ILRS) Standard
• Now added LARES
• Still room for more LAGEOS Satellites