Lares System: a successful example of low cost high science mission

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In 1992 ASI launched with the IRIS launch system on board STS 52 the LAGEOS-2.

It has a diameter of 60 cm, mass 405 kg and orbits earth at 5900 km. Those are perfect parameters for Geodesy and also provide some indications on relativistic effects, but is non what is needed for reach the necessary accuracy for an exact determination of the Lense–Thirring effect.
From LAGEOS 2 to LARES

- The LAGEOS limitations for fundamental physics had lead already in mid 90’ the team guided by Prof I. Ciufolini and Prof A. Paolozzi to developed a specific design for a Laser Relativity Satellite: LARES
- The satellite should have some specific characteristics: it was to be small and very heavy in order to reduce the so called non-gravitational forces

- LARES principal Parameters
- Mass 386.8 Kg
- Diameter 36 cm
- Mirrors 92 CCR
- Orbit 1450 Km, 69.5°
- Goal: measure Lense-Thirring effect with an accuracy of 1%
In 2008 ASI agreed with ESA to embark on board the VEGA maiden flight a scientific payload.

This opportunity was recognized should need a design to cost approach strictly tailored with the scope of the scientific mission and the risk of a maiden flight.

The original contract foresaw a launch in 2009.

The following elongation of the Vega program allowed to modify the design in order to host on the LARES System other payloads: 9 CubeSats + Almasat.
Lares System

Lares Platform
Lares satellite
Almasat
Cubesats

The Lares System provides also additional Vega environmental data and images of the flight and satellites separations.
LARES VS. LAGEOS
Science: The frame dragging

- Any mass induces a deformation in the Space-Time frame
- If the mass rotates then also the ST frame co-rotates and a mass in this frame will be dragged
- This effect, predicated by Einstein theory is called Lense–Thirring effect
- The accurate measure will provide benefit to the studies on relativity and also on current applications as GPS

Gravity Probe results

<table>
<thead>
<tr>
<th></th>
<th>Measured</th>
<th>Predicted</th>
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<tbody>
<tr>
<td>Geodetic precession (mas)</td>
<td>6602 ± 18</td>
<td>6606</td>
</tr>
<tr>
<td>Frame-dragging (mas)</td>
<td>37.2 ± 7.2</td>
<td>39.2</td>
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**LARES: a satellite of records**

1. The orbiting object with the highest mean density in the solar system
2. The heaviest tungsten alloy piece ever manufactured
3. The orbiting artificial object with the lowest surface-to-mass ratio
4. The satellite body with the lowest number of parts: 1
5. Satellite built in 4 years and 1 week
6. Among the longest incubation period 1984-2008 (24 years)
Design to cost approach

- Low cost: less than 6.5 M€ = 1/5 of the launcher cost
- Extensive use of COTS elements
- Spin-in from High-Tec commercial small industry
- Strong cooperation between Industry and University
**LARES Mission organigram**

**ASI - Italian Space Agency**

**ESA – European Space Agency**

- **Vega Maiden Flight**

**Industrial Contract**

**OHB-CGS – Compagnia Generale Spazio**

**Scientific Contract**

**Salento University**

- **Principal Investigator: Prof. Ignazio Ciufolini**

**Sapienza University**

**INFIN**

**Sapienza University**

- Satellite design;
  - Satellite Breadboard design, construction, tests;
  - MGSEs design, construction, tests.

**RHI**

- Separation System manufacturing

**Sapienza University**

- Separation System design;
  - Separation System breadboards design construction and test.

**S.A.B. Aerospace**

- Support System

**Marotta Advanced Technologies**

- Support System

**TEMIS**

- Telemetry

**OMPM**

- Supplier
Lares System Success Criteria

C1 - To deploy:
  a) Lares satellite
  b) Almasat
  c) Cubesats

C2 - To acquire:
  a) images of the VEGA and satellites separations
  b) Vega Flight environmental data
Lares System Results

LARES Classical Orbit Elements
Time (UTC): 14 Feb 2012 16:49:15.828
Semi-major Axis (km): 7818.315676
Eccentricity: 0.000344
Inclination (deg): 69.449
RAAN (deg): 236.403
Arg of Perigee (deg): 261.623
True Anomaly (deg): 149.111
Mean Anomaly (deg): 149.091

AVUM Classical Orbit Elements
Time (UTC): 14 Feb 2012 16:49:15.828
Semi-major Axis (km): 7233.161548
Eccentricity: 0.000862
Inclination (deg): 69.458
RAAN (deg): 235.881
Arg of Perigee (deg): 45.822
True Anomaly (deg): 343.507
Mean Anomaly (deg): 345.992

C1

C2 - [a) VEGA, b) All...

b) All Sensor data acquired
Signal correctly acquired four days after launch
Lares Program

All Criteria Met!
Science Phase on going