Status of the Establishment of the Yebes Laser Ranging Station (YLARA)

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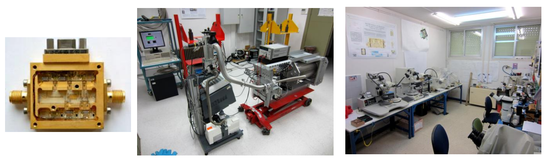
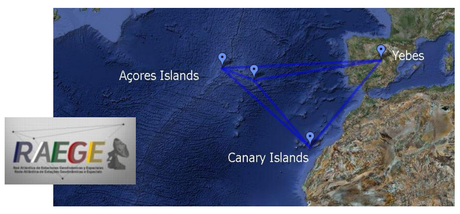
European Regional Development Fund
Investing in your future

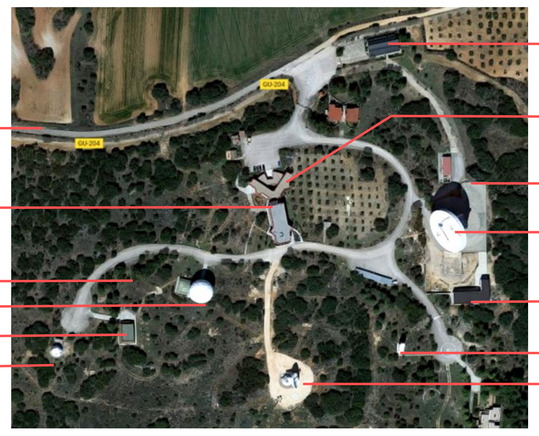


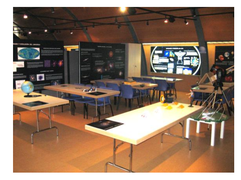
State of art laboratories: cryogenic receivers, low noise amplifiers, up/down converters, mechanical workshops...



Establishment of an Spanish-Portuguese **Network of Geodynamical and Space Stations (RAEGE)** by the installation and operation of **4 geodetic stations provided** with VGOS radio telescopes in Yebes (1), Canary Islands (1) and Azores Islands (2)

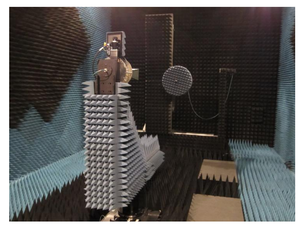
YEBES OBSERVATORY OVERVIEW





Outreach pavilion

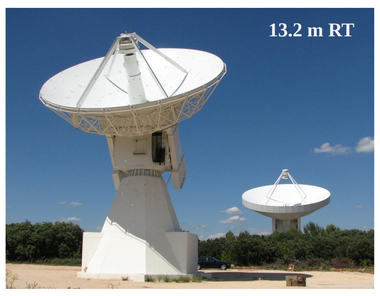
40 m RT. Geodesy and astronomy observations. From 2 to 120 GHz

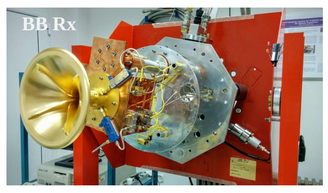


Anechoic Chamber
Planar and spherical near field systems

CORE SITE STATUS - AVAILABLE TECHNIQUES

13.2 m VGOS Radio Telescope





- **Broadband Receiver (from 2 to 14 GHz)**
  - Dual lineal polarization, noise temperature under 25 K
  - Using a quadruple-ridged flared horn (QRFH) from Caltech
  - Installed in February 2016 for VGOS Broadband observations
- Yebes Low Noise Amplifiers: broadband for VGOS
- Signal conditioning modules for backends (Yebes design)
- Phase and noise calibration modules (Yebes design)

GNSS Receivers

Spanish Network ERGNSS

EUREF Permanent Network

Local tie

- The complete network is composed by 24 vertex including on it the radio telescopes and the GNSS antennas.
- Pillars are made of concrete and iron and compose by a 30 cm diameter cylinder inside a protector tube
- Network accuracy below 1 mm

Gravimetry pavilion

- Seven pillars for instrument installation and intercomparisons
- Two absolute gravimeters (A10 & FG5)
- OSG Superconducting gravimeter (Feb - 2012)
- Participation in IGETS - International Geodynamics and Earth tide Service
- One SILEX Accelerometer

YLARA SPECIFICATIONS AND GOALS

<u>Phase 1. Observations to satellites equipped with retro-reflectors</u> (fulfilling the requirements of the GGOS project)

Laser / Telescope subsystems: Classical Design

- Pulsed Solid State Laser
  - Repetition rate ≥ 1000 Hz (adjustable)
  - Pulse width < 25 ps
  - Wavelength 532 nm (Nd:YAG – Nd:Van)
  - Energy 0,5 - 5 mJ
- Biaxial telescope, AZ-EL mount
  - Receiving system 50-80 cm
  - Transmitting system 7-15 cm
  - Beam pointing accuracy 1-5”
  - High slew rate

We need advice

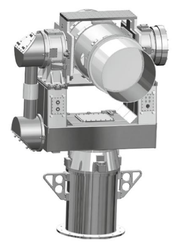
Laser / Telescope subsystems: Current Trends

G. Kirchner, et al. Concept of a modular / multi-laser / multi-purpose SLR station (2016)

- Pulsed Solid State Lasers
  - Transmitting system
  - For GNSS: 15μJ / 2 kHz / 1ns (SP-DART values)
  - Precise SLR: 300-400 μJ / 1 kHz / 7-10 ps
- Astronomy telescope, AZ-EL mount
  - <u>No Coudé path</u>
  - Receiving system 50-80 cm
  - Pointing accuracy 1-5”

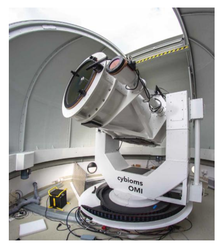
Other Specifications

- Satellites observations from 400 - 42000 km (night and day)
- Minimum tracking elevation 10 - 15º
- Detector package (telescope location):
  - CSPAD (QE 30%) + Other options
- Adapted optic to 532 and 1064 nm (laser wavelengths)
- Range Gate Width 50-1000 ns
- Field of View 10-60”, daylight filter bandwidth 0.15-0.5 nm
- Frequency Standard: Hydrogen-maser. Time reference: GNSS
- Event timer (precision < 10 ps, resolution ~ 1 ps)
- Highly automation system, remotely controllable (full automated system under study)
- Aircraft safety systems compatible with other geodetic systems at Yebes: ADS-B and FLARM receivers, all sky cameras, etc.
- Complete weather station



NASA’s SLR systems
Cobham gimbal and telescope assembly (monostatic design)
J. F. McGarry, et al., 2018

SP-DART CONCEPT
Tracking up to Geostationary Satellite with 15 μJ Laser and 70 cm Astronomy Telescope. P. Wang, et al, 2016



Metsähovi kHz SLR system
Bistatic telescope 50/10 cm
Classical Design
Näränen & Raja-Halli, FGI-2016

<u>Phase 2. Space Debris observation capacity</u>

- To be determined:
  - Single station / multi-static ranging
  - Laser system characteristics (power, color, repetition rate, etc.)
  - Optical detectors according to the laser wavelength
  - Adapted software
  - EU - SST Sensor

ERDF FUNDS – ICTS INFRASTRUCTURES

- **Yebes Observatory is one of the Singular Scientific and Technological Infrastructures (ICTS)** in Spain, and the only one in the Castilla-La Mancha Region
- The ICTS are facilities, resources, equipment and services, unique in its kind, and dedicated to cutting edge high quality research and development, to promote transfer, exchange and preservation of knowledge, technology and innovation

Infraestructuras Científicas y Técnicas Singulares

⇒ **ERDF Funds, Operational Programme Smart Growth 2014-2020 - Ministry of Economy, Industry and Competitiveness of Spain** (FICTS1420-11-12)

⇒ **Operation:** Development Infrastructures and Laboratory Activities for Space Geodesy at Yebes Observatory (YDALGO)

- The Economic and Technical ERDF Memory establishes the next preliminary work schedule for the construction of the YLARA system:

YLARA station working plan	2018			2019				2020				2021				2022-23
Building and infrastructure				X	X	X	X	X	X	X	X	X	X	X	X	Possible schedule extensions
Telescope and dome				X	X	X	X	X	X	X	X	X	X	X	X	
Optic System					X	X	X	X	X	X	X	X	X	X	X	
Measurement System								X	X	X	X	X	X	X	X	
Software package and security systems			X	X	X	X	X	X	X	X	X	X	X	X	X	
System Engineering and Integration							X	X	X	X	X	X	X	X	X	
Project Management and Quality Assurance					X	X	X	X	X	X	X	X	X	X	X	
Promotion			X	X	X	X	X	X	X	X	X	X	X	X	X	
Staff (2 engineers + 2 technicians)			X	X	X	X	X	X	X	X	X	X	X	X	X	

CURRENT PROJECT STATUS

- **Study of worldwide SLR stations**. For the establishment of the YLARA station basic specifications, a detailed study about characteristics and performance of the most relevant SLR stations has been made (operative and under construction stations).
- Yebes Observatory staff **training** about the systems and techniques required in an SLR station (through attendance to workshops, stays and visits to different SLR stations).
- **Selection of the station location**. The following figure shows the chosen location for the future SLR station at Yebes Observatory. The selection of this location has been carried out after analyzing the different possibilities, looking for an optimal location from the point of view of the station (visibility, access, soil quality) as well as its influence on other observatory facilities (local tie, radio telescopes, gravimetry pavilion, GNSS receivers). Geotechnical drillings will be performed by the end of 2018.
- **Station building pre-design**. Taking as reference different stations visited by Yebes engineers.

Future YLARA Station Location

- **Market study** of the main subsystems suppliers **(in progress)**: laser system, telescope, dome, detectors, time and frequency systems, security systems, weather station, control software…
- Preparation of **initial acquisitions** regarding to safety and time and frequency systems: event timer, GNSS timing source, all-sky camera, FLARM air traffic awareness system and cloud sensor.
- New **professional** staff under the YDALGO project (co-financed with FEDER funds): software engineer and electronic engineer.