

*Francisco Colomer*¹

Jesús Gómez-González¹

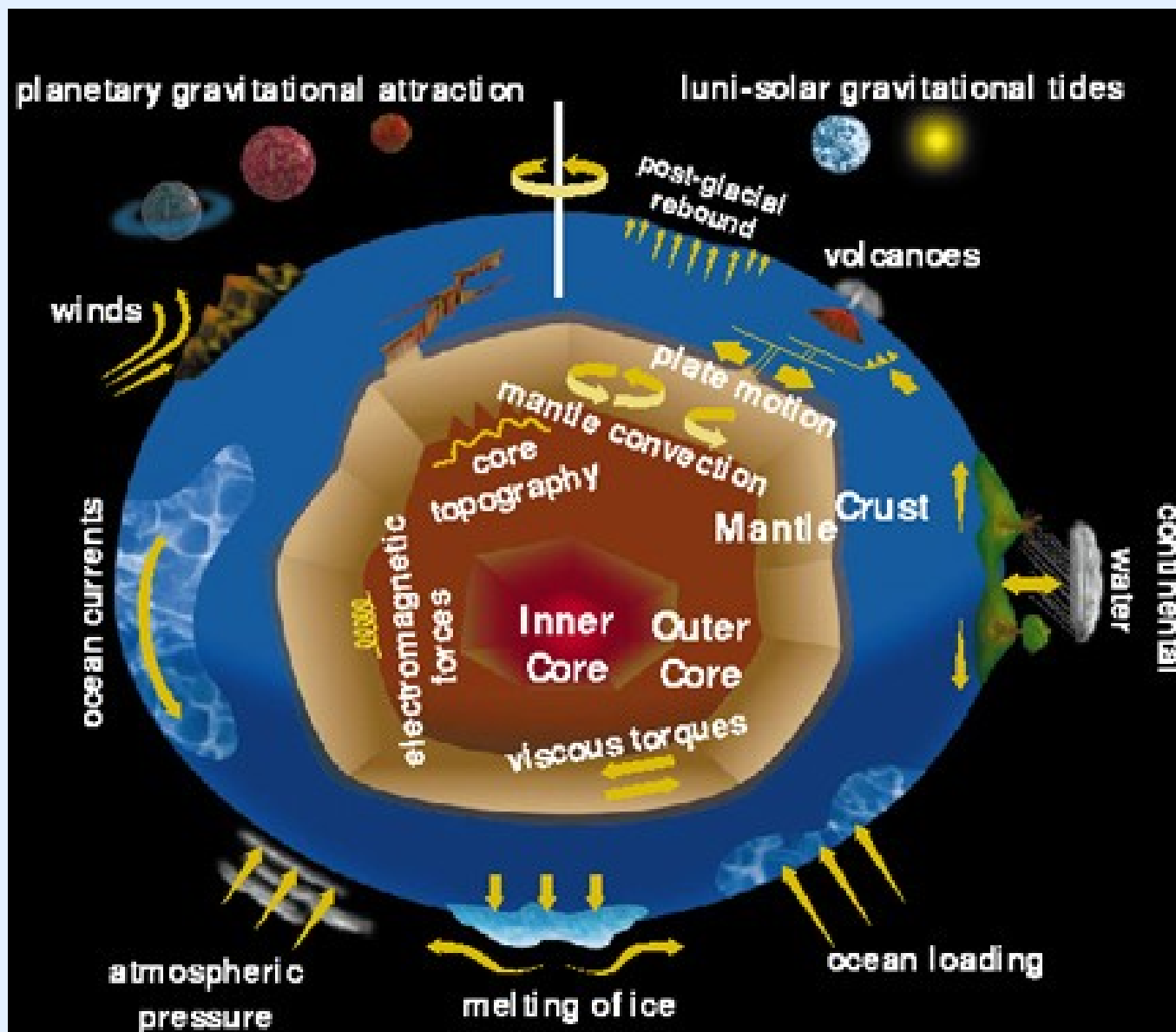
Marlene C.S. Assis²

José Antonio López-Fernández¹

¹IGN, Spain & ²SRCTE, Portugal

<http://www.raege.net/>





GGOS

Global
Geodetic
Observing
System

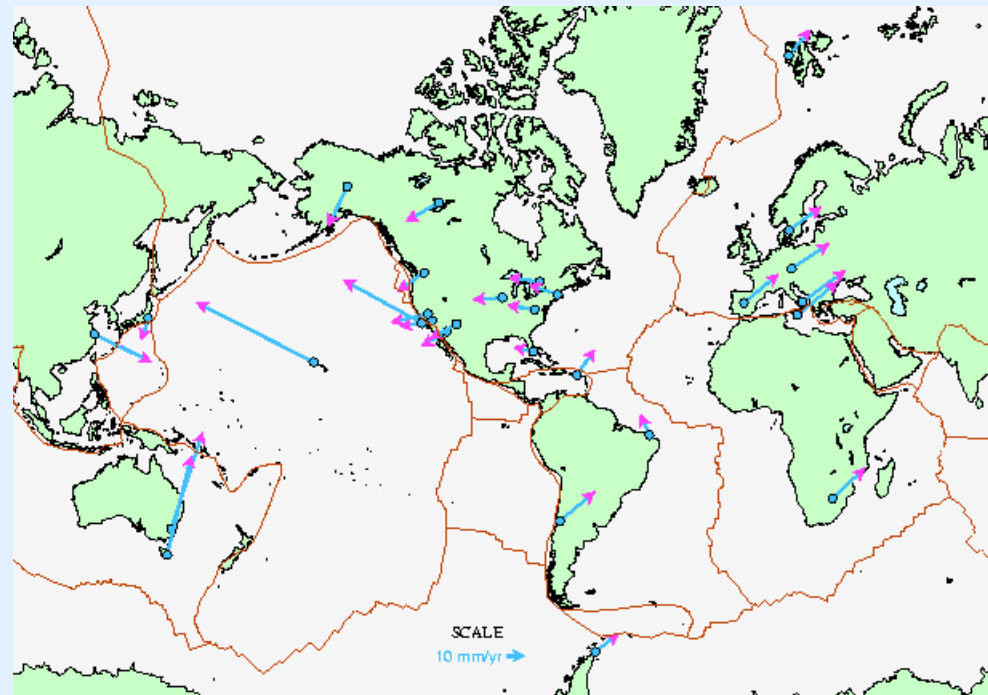
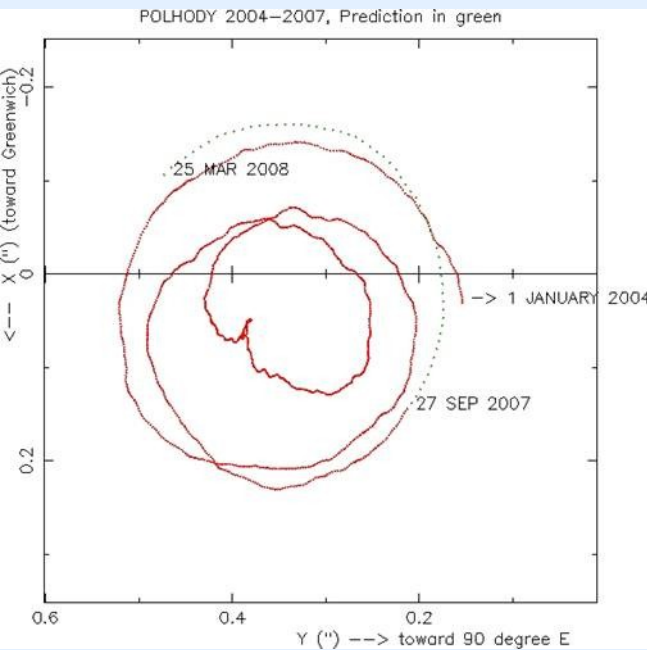
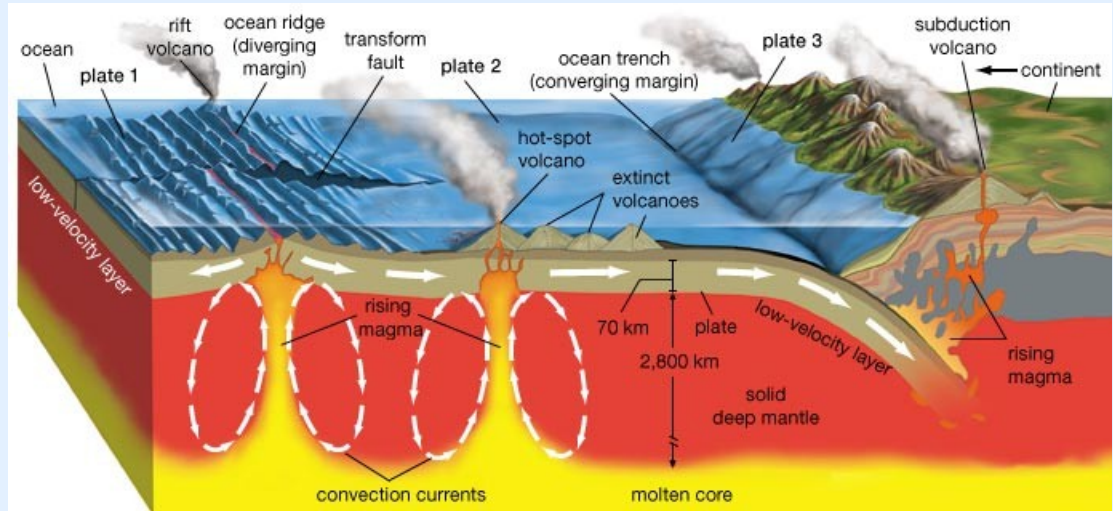
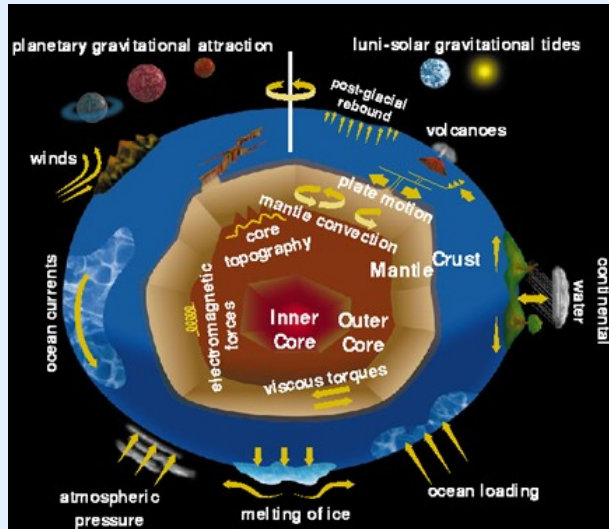


RAEGE – RED ATLÁNTICA DE ESTACIONES GEODINÁMICAS Y ESPACIALES

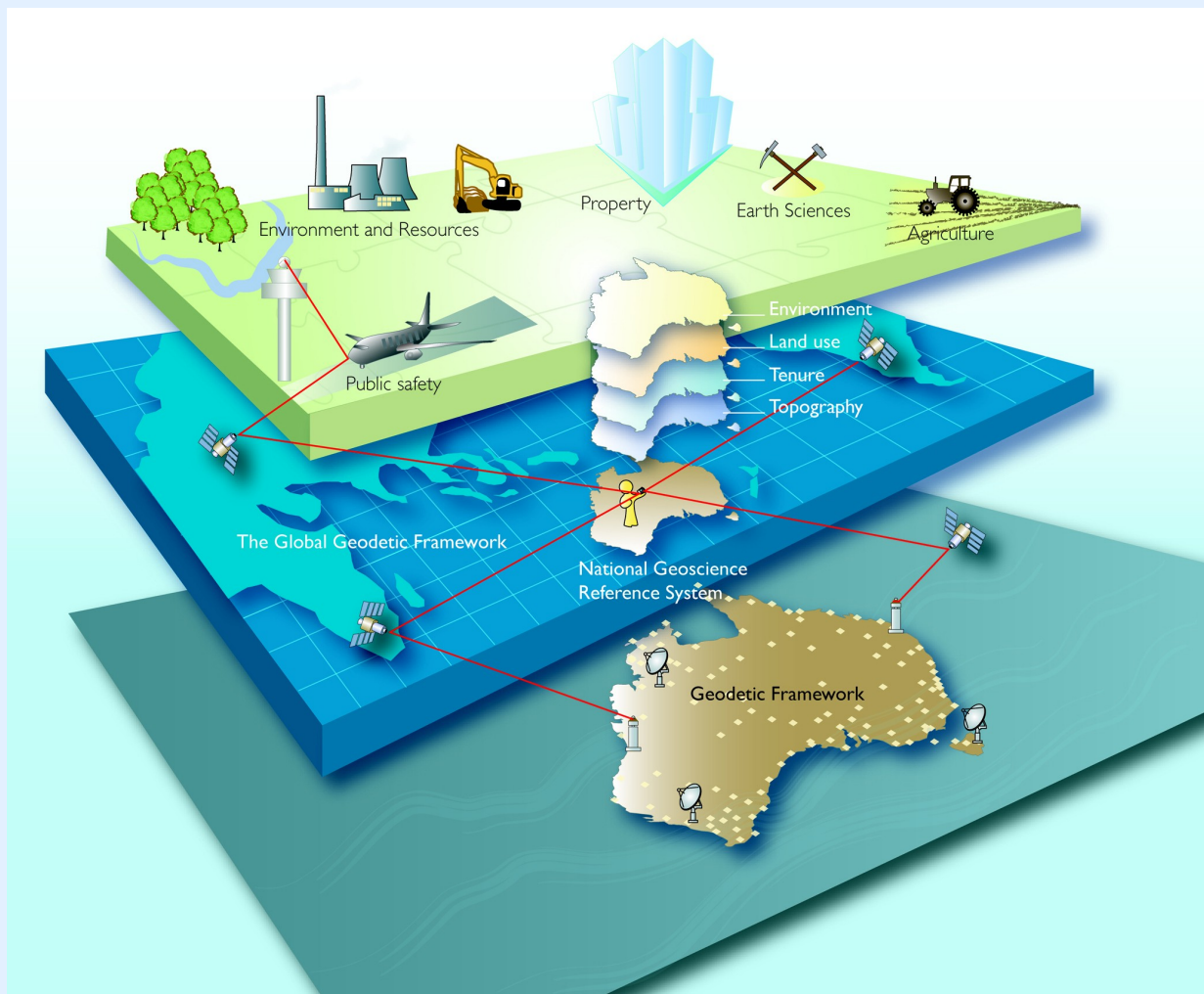


GOBIERNO DE ESPAÑA

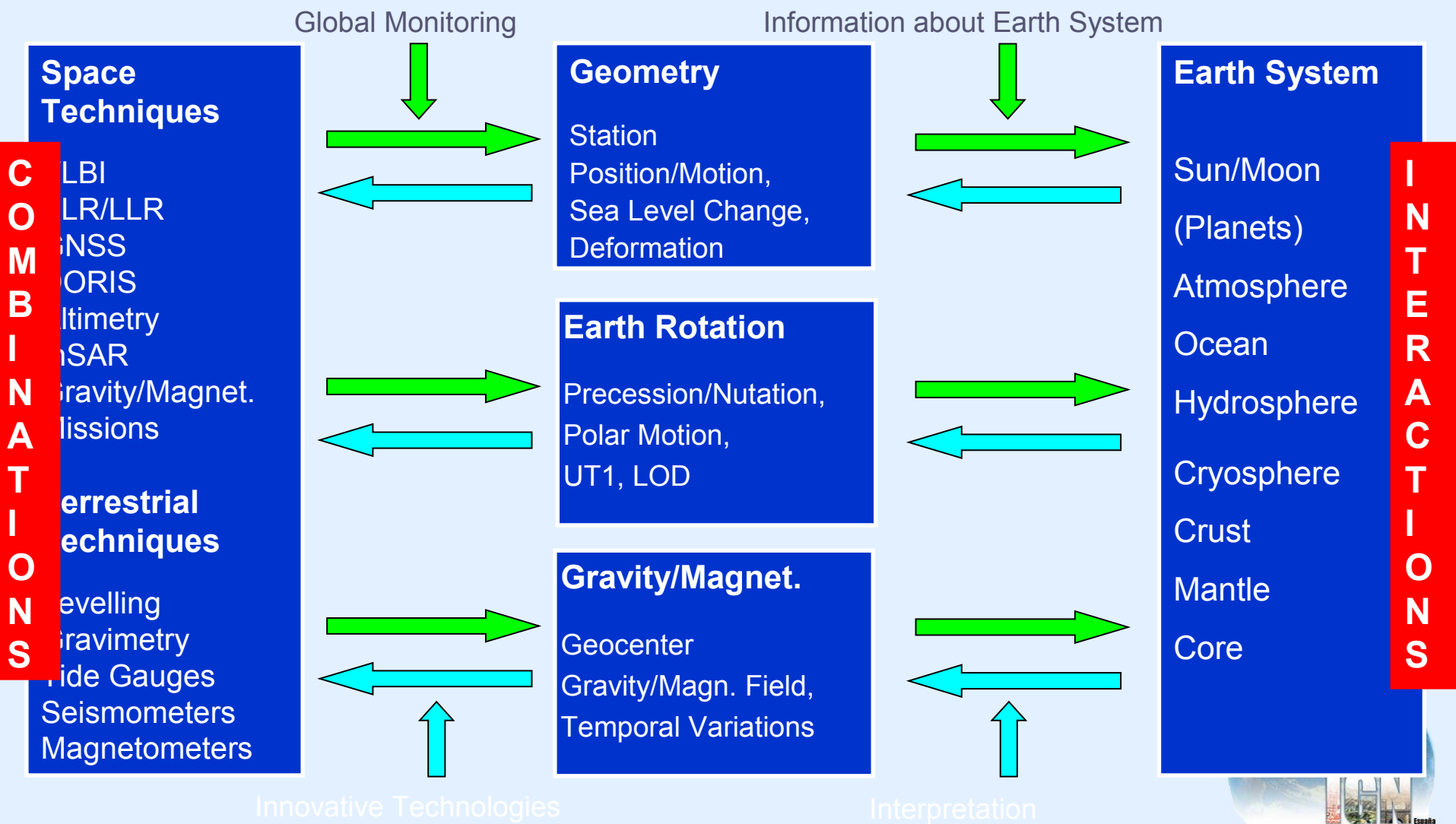
MINISTERIO DE FOMENTO



Spatial Data Infrastructure & Reference Frames



Reference frames: highest accuracy and long-term stability



Geometry

IERS: International Earth Rotation and Reference Systems Service

IGS: International GNSS Service

IVS: International VLBI Service

ILRS: International Laser Ranging Service

IDS: International DORIS Service

IGFS: International Gravity Field Service

BGI: Bureau Gravimetrique International

IGeS: International Geoid Service

ICET: International Center for Earth Tides

ICGEM: International Center for Global Earth Models

IDEMS: International Digital Elevation Models Service

PSMSL: Permanent Service for Mean Sea Level

IAS: International Altimetry Service (in preparation)

BIPM: Bureau International des Poids et Mesures

IBS: IAG Bibliographic Service

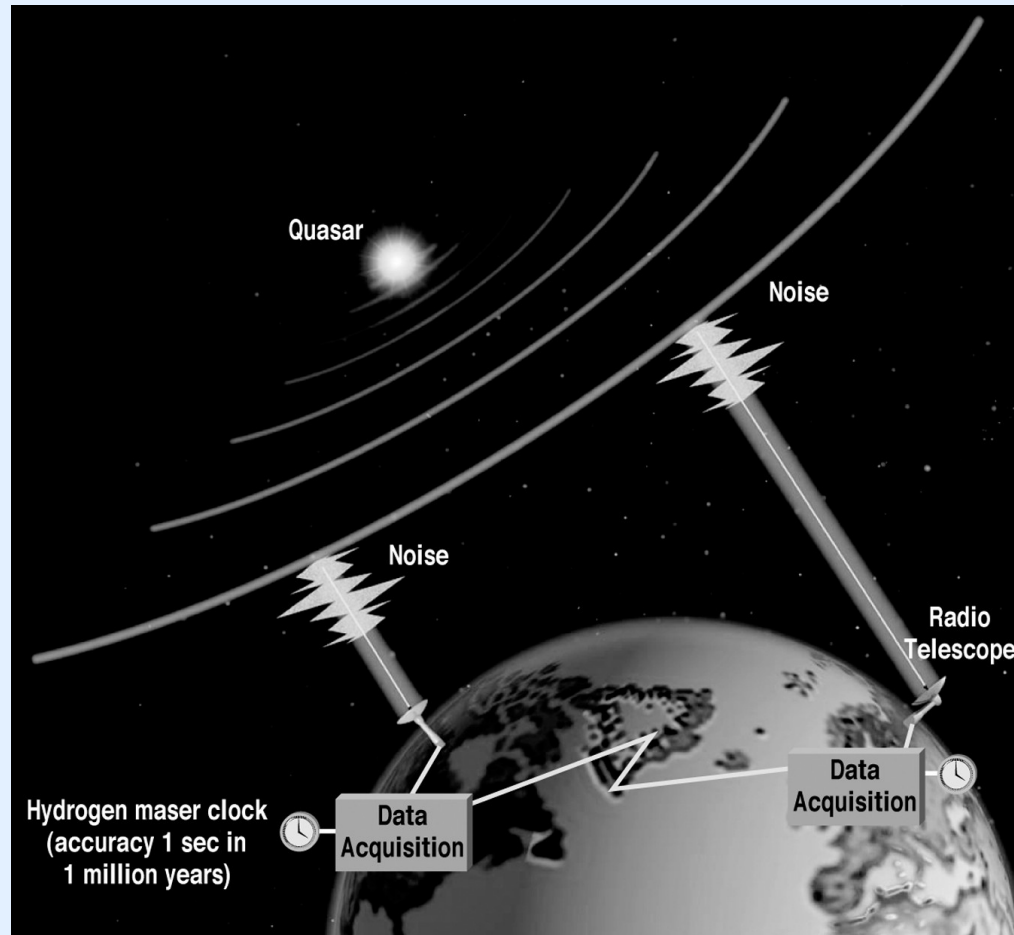
Gravimetry

Ocean

Std



Very Long Baseline Interferometry (VLBI)



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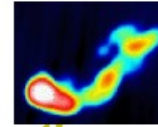
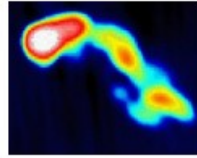
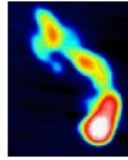
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INSTITUTO GEOGRÁFICO NACIONAL

IGN

Level 5:
Quasars



Level 4:
Moon, Planets

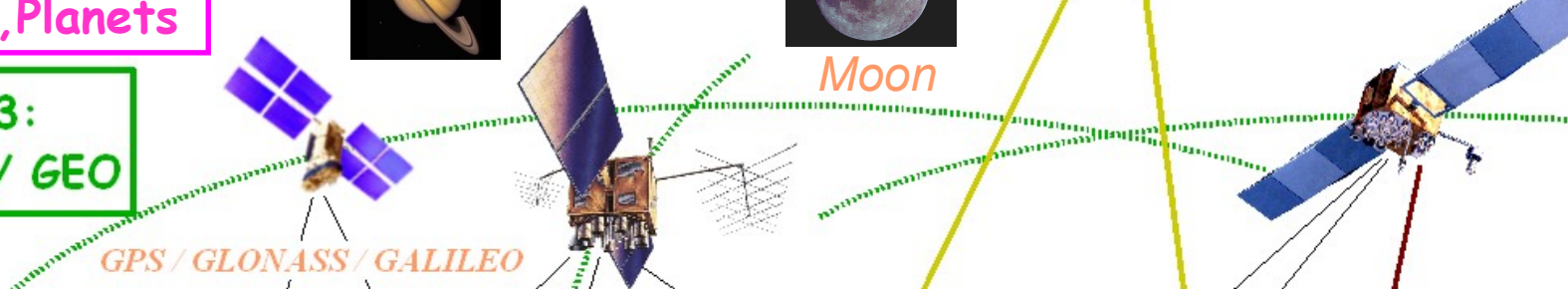


Planets

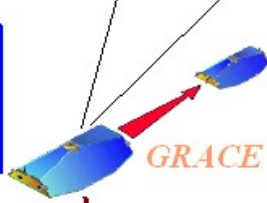


Moon

Level 3:
MEO / GEO



Level 2:
LEO



GRACE



CHAMP



Jason-1

LAGEOS



Level 1:
Stations



VLBI



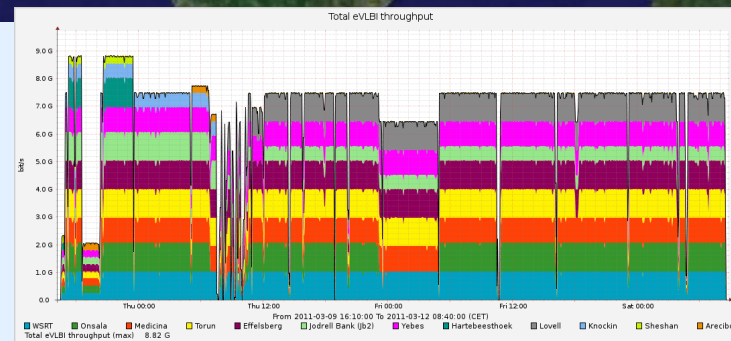
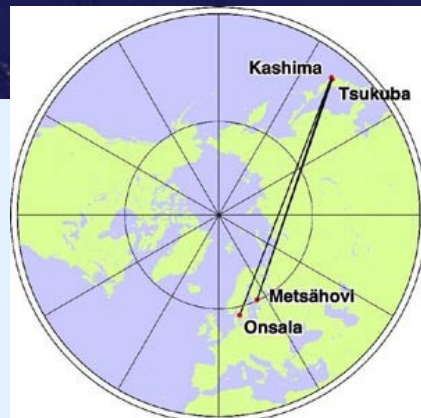
Level 1: Core Network (~ 40 Stations):

- 2-3 VLBI telescopes for *continuous* observations
- SLR/LLR telescope for tracking of all major satellites
- At least 3 GNSS antennas and receivers (controlled equipment changes)
- DORIS beacon of the most recent generation
- Ultra-stable oscillator for time and frequency keeping and transfer
- Terrestrial survey instruments for permanent/automated local tie monitoring
- Superconducting and absolute gravimeter (gravity missions, geocenter)
- Meteorological sensors (pressure, temperature, humidity)
- Seismometer for combination with deformation from space geodesy and GNSS seismology
- Additional sensors: water vapor radiometer, tiltmeters, gyroscopes, ground water sensors, ...

General Characteristics: highly automated, 24-hour/365 days, latest technologies



Real time data transfer and correlation (e-VLBI)



Components of the International VLBI Service for Geodesy and Astrometry (IVS)



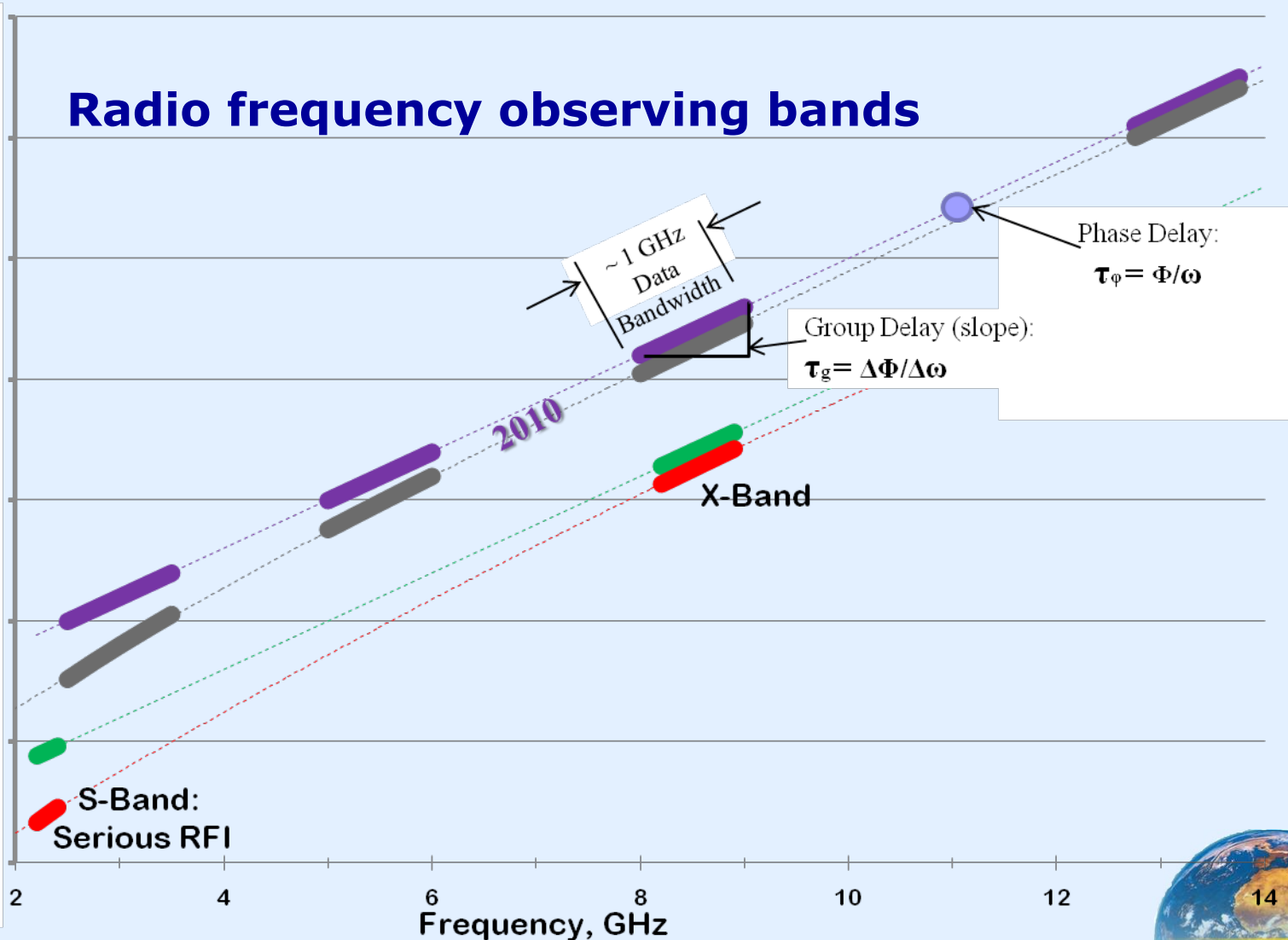
Present and future IVS goals

Products	Specification	Status 2002	Goals (VLBI2010)
Polar Motion (x_p, y_p)	accuracy product delivery resolution frequency of solution	$x_p \sim 100, y_p \sim 200 \mu\text{as}$ 1 – 4 weeks – 4 months 1 day 3 days/week	25 μas 1 day 10 min – 1 h 7 days/week
UT1-UTC (DUT1)	accuracy product delivery resolution	5 – 20 μs 1 week 1 day	2 μs 1 day 10 min
Celestial Pole ($d\varepsilon; d\psi$)	accuracy product delivery resolution frequency of solution	100 – 400 μas 1 – 4 weeks – 4 months 1 day ~ 3 days/week	25 μas 1 day 7 days/week
TRF (x, y, z)	accuracy	5 – 20 mm	2 mm
CRF ($\alpha; \delta$)	accuracy frequency of solution product delivery	0.25 – 3 mas 1 year 3 – 6 months	0.25 mas improve. for more freq. bands 1 month



Radio frequency observing bands

PHASE(Arbitrary Units)

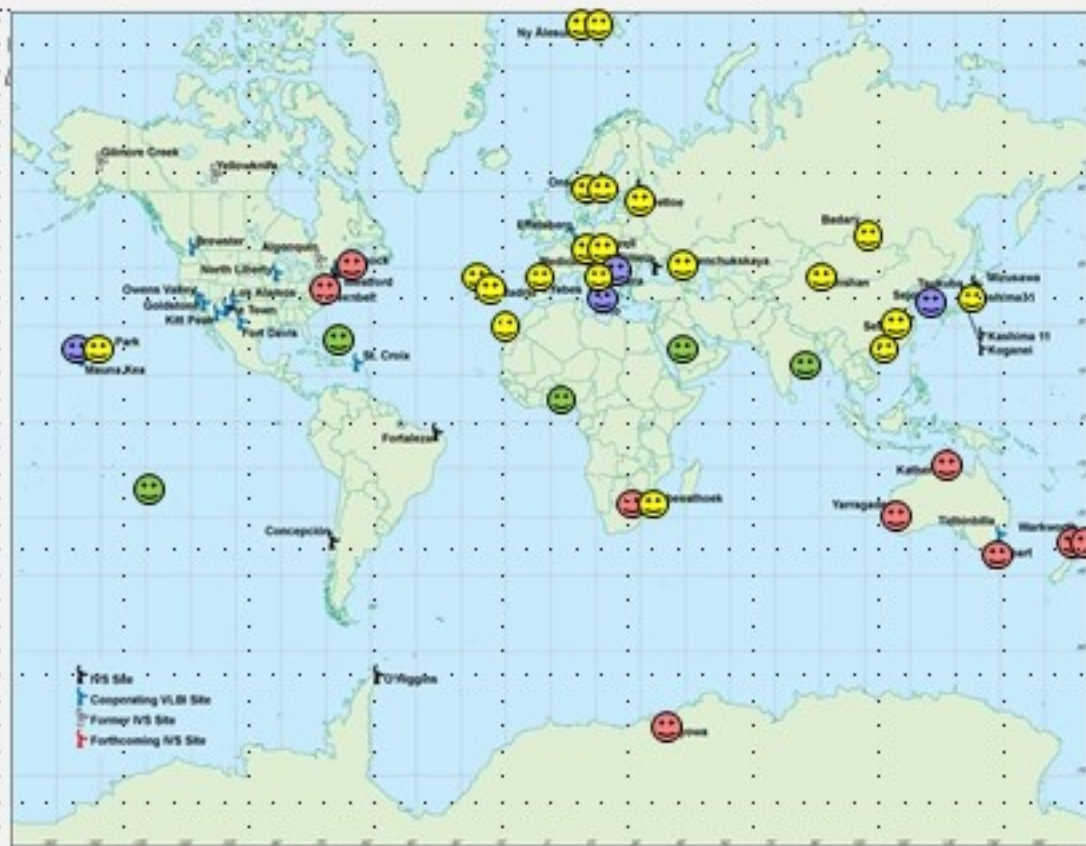


VLBI2010 System Characteristics

	Current	VLBI2010
antenna size	5–100 m dish	~ 12 m dish
slew speed	~20–200 deg/min	≥ 360 deg/min
sensitivity	200–15,000 SEFD	≤ 2,500 SEFD
frequency range	S/X band	~2–15 (18) GHz
recording rate	128, 256 Mbps	<u>8–16 Gbps</u>
data transfer	usually ship disks, some e-transfer	<u>e-transfer, e-VLBI,</u> ship disks when required



IVS network by 2017



VLBI2010 very fast

radio telescope

twain radio telescope

VLBI2010 fast

radio telescope

upgrade legacy

radio telescope

potential new site

radio telescope

[Hase et al., 2011]



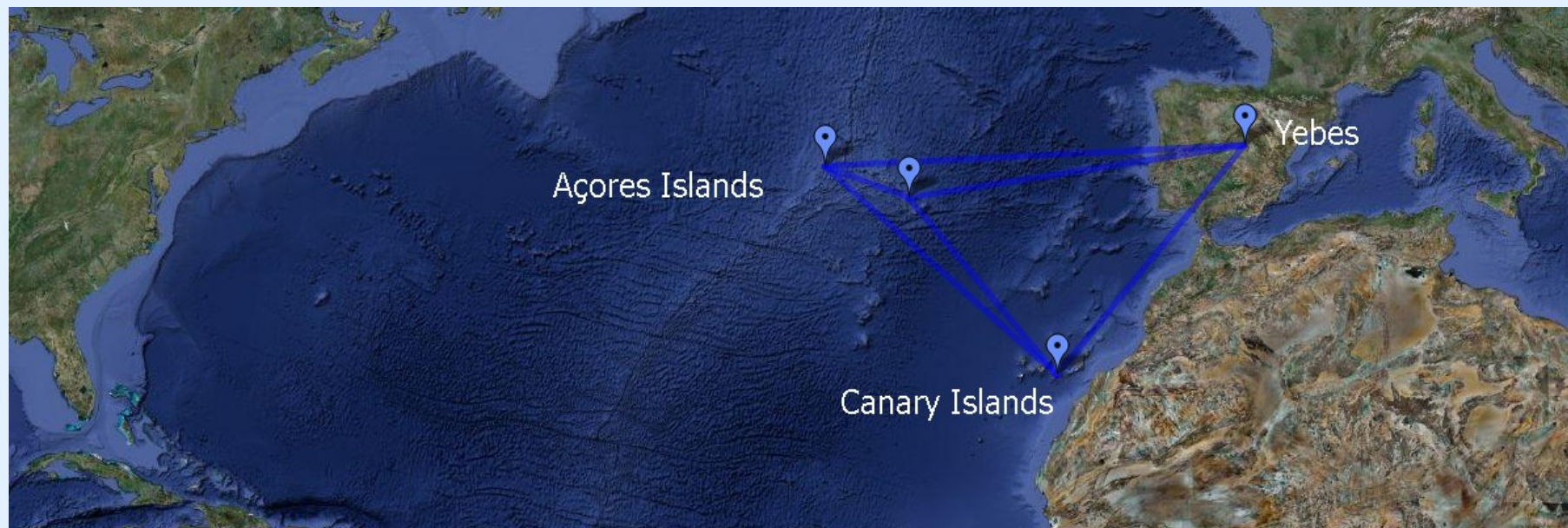
RAEGE workshop – Madrid, January 2009



The RAEGE project

Establishment of an Spanish-Portuguese **Network of Geodynamical and Space Geodesy Stations** (*RAEGE*) by the installation and operation of **four fundamental geodetic/astronomical stations** provided with radio telescopes fulfilling the VLBI 2010 project specifications: Yebes (1), Canary Islands (1) and Açores Islands (2).



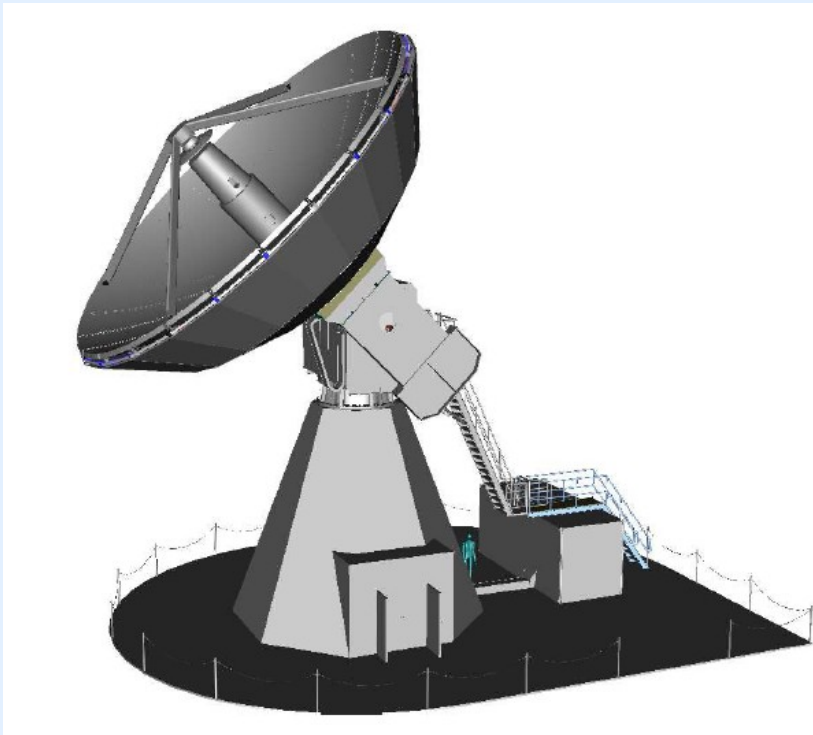


Baselines:

- Yebes – Tenerife : 1800 km
- Yebes – Santa María : 2000 km
- Yebes – Flores : 2400 km
- Tenerife – Flores : 2000 km
- Santa María – Flores : 540 km



New VLBI2010 RAEGE radio telescope by MT Mechatronics including geodetic capabilities set by IGN

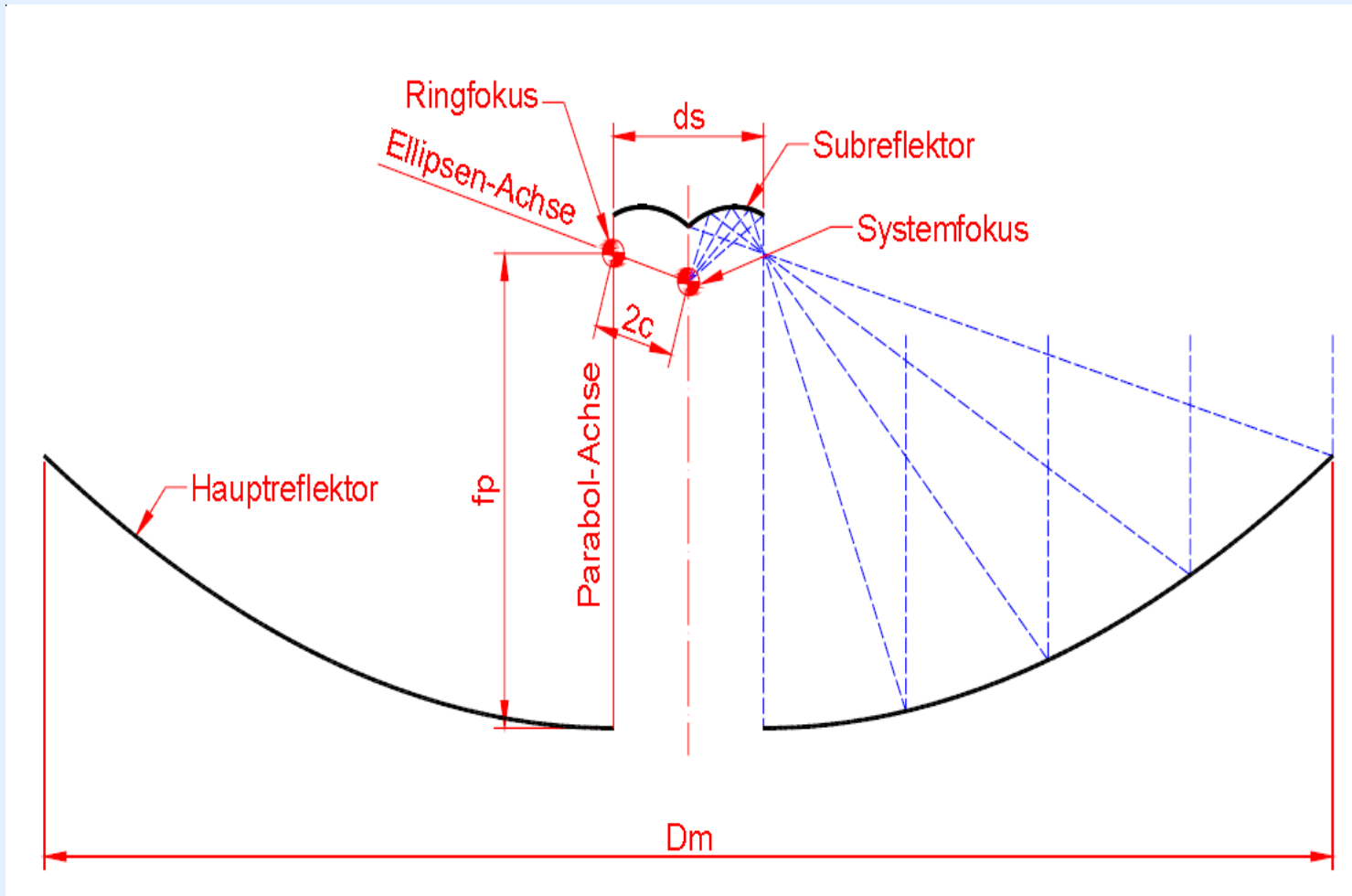


Characteristics:

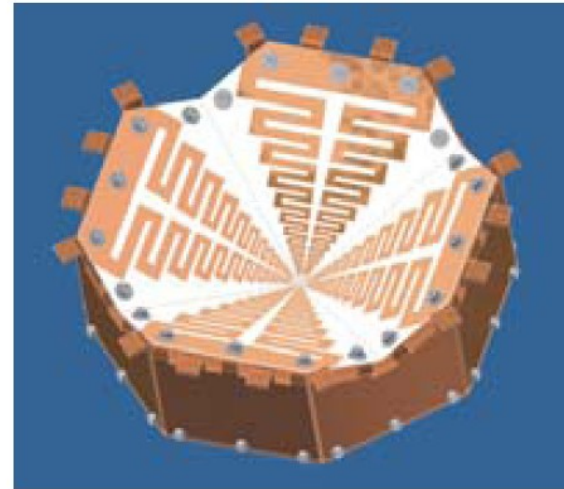
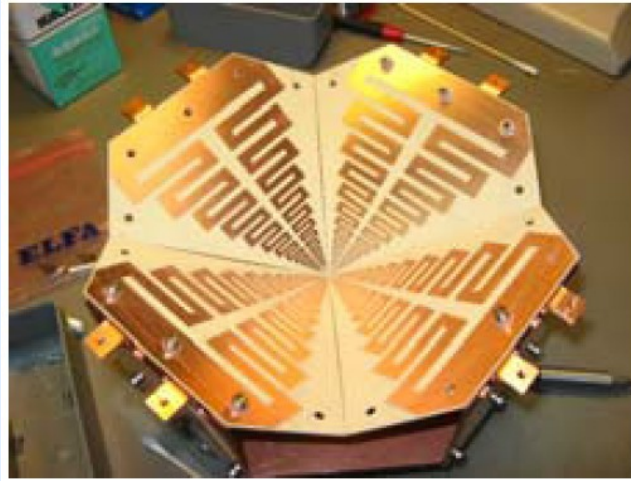
- 13.2 m RT, ring focus, $\nu \geq 45$ GHz (90 GHz)
- S/X and (future) wide band feeds
- $12^\circ/\text{sec}$ (az) & $6^\circ/\text{sec}$ (el) slew speeds



Radiotelescope optics: ring focus



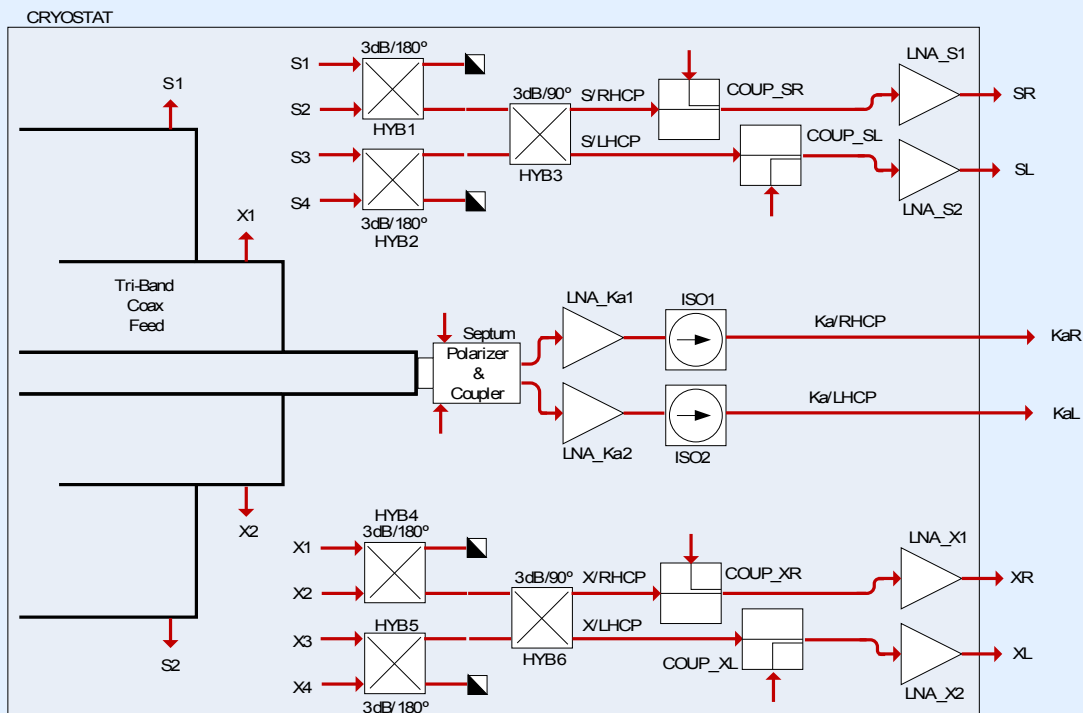
VLBI2010 radio feed



ELEVEN feed:

- Developed at Chalmers University (Sweden) by Per-Simon Kildal.
- To operate in 2-14 GHz band.
- Coolable, but challenges to the mechanical construction.

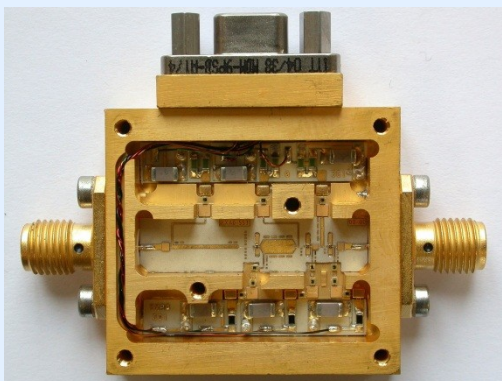
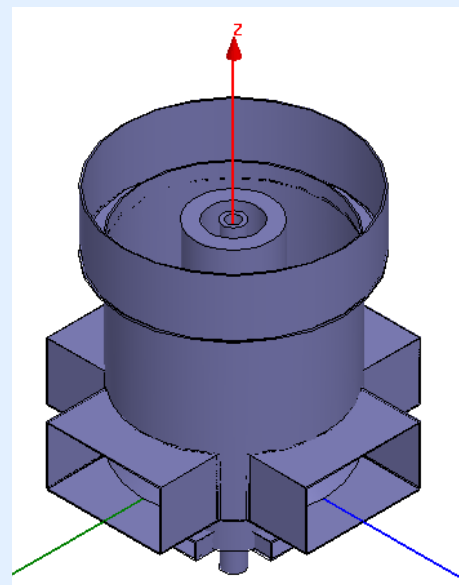




VLBI2010 developments

- Receivers

- Optics and feeds (S/X/Ka)





Present status and 2011 work programme



RAEGE station in Yebes (Guadalajara, Spain)



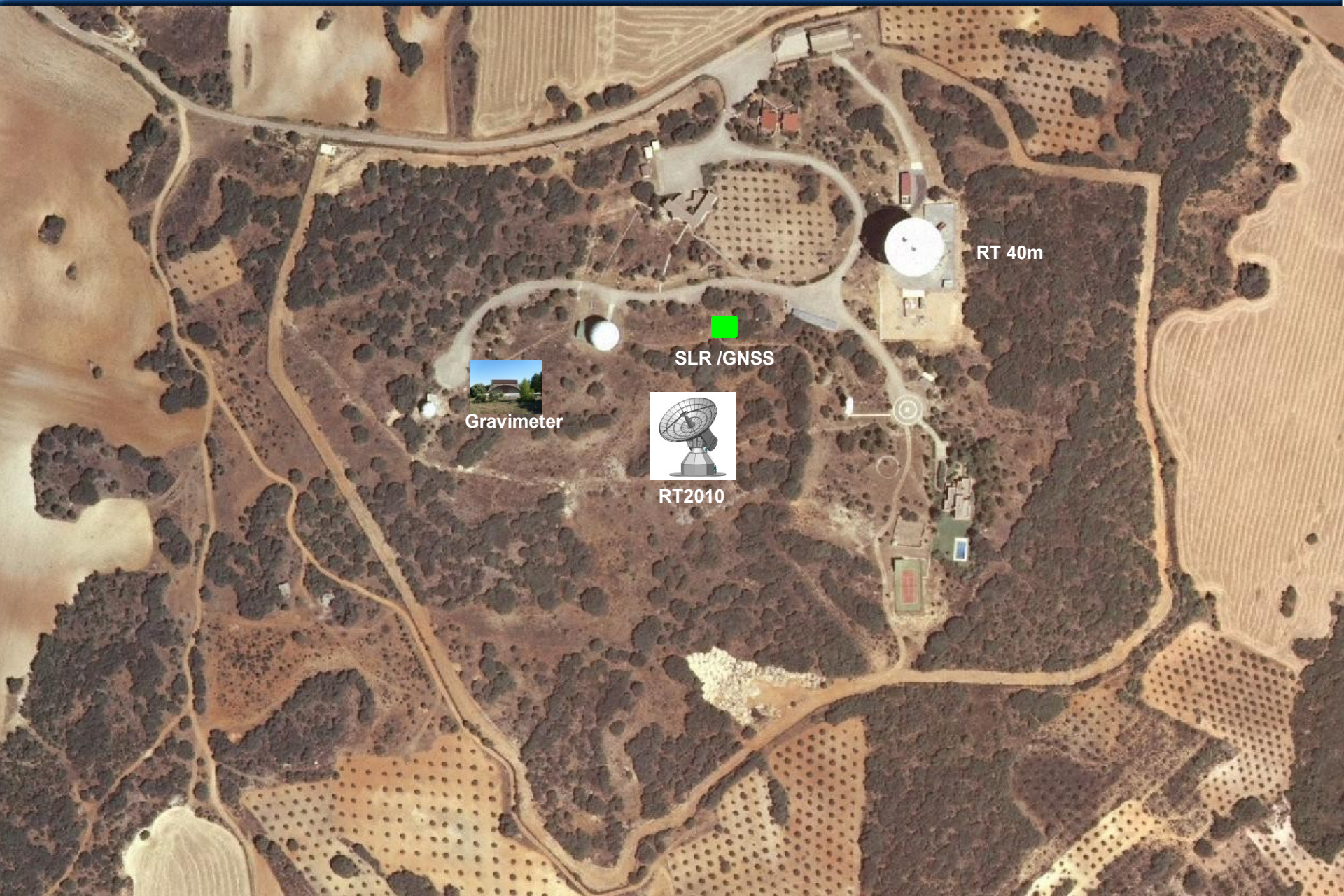
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Gravimeter building and equipment at Yebees:

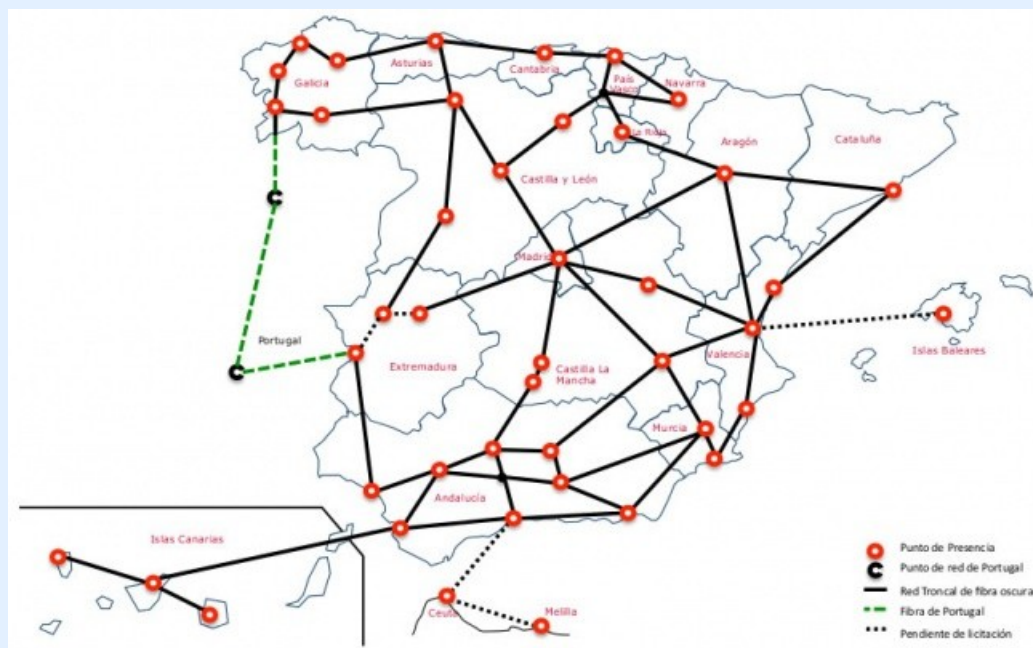


- Seven pillars for instrument comparison
- Two absolute gravimeters (A10 & FG5)
- One new superconducting gravimeter (GWR, May 2010)



Connectivity status

- Currently connected at 1 Gbps
- Expecting dark fiber from RedIris-NOVA (2011)





RAEGE station in Canary Islands (Spain)

To be equipped with:

- one radiotelescope
- one GNSS receiver
- one gravimeter

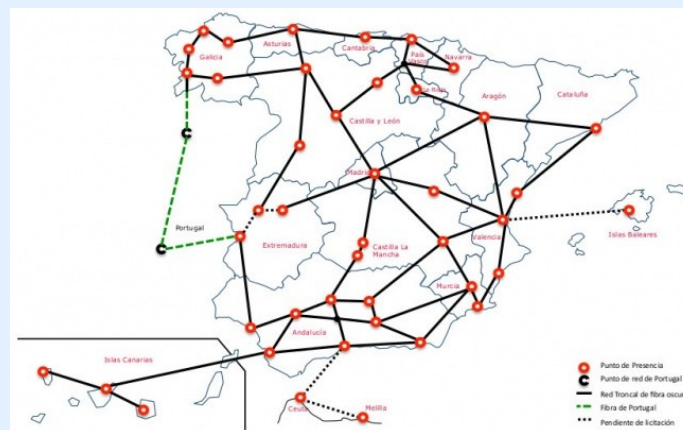
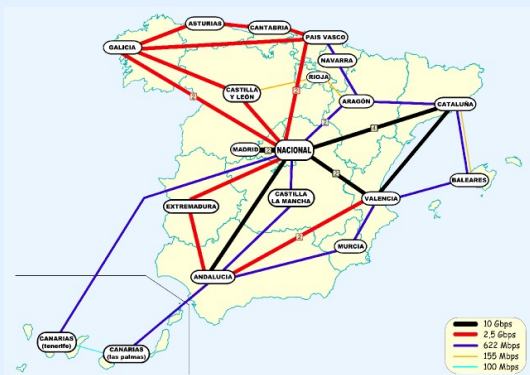
Possible location:

Tenerife



Connectivity status

- Currently connected at 622 Mbps
- Dark fiber with RedIRIS NOVA by the end of 2011.

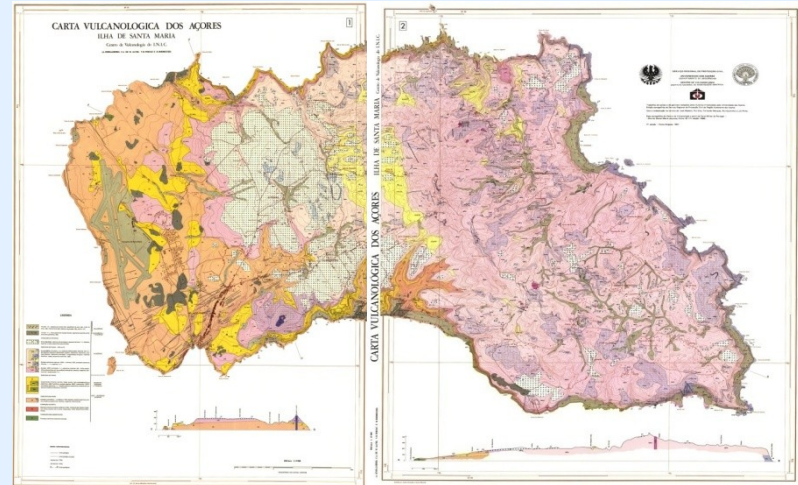
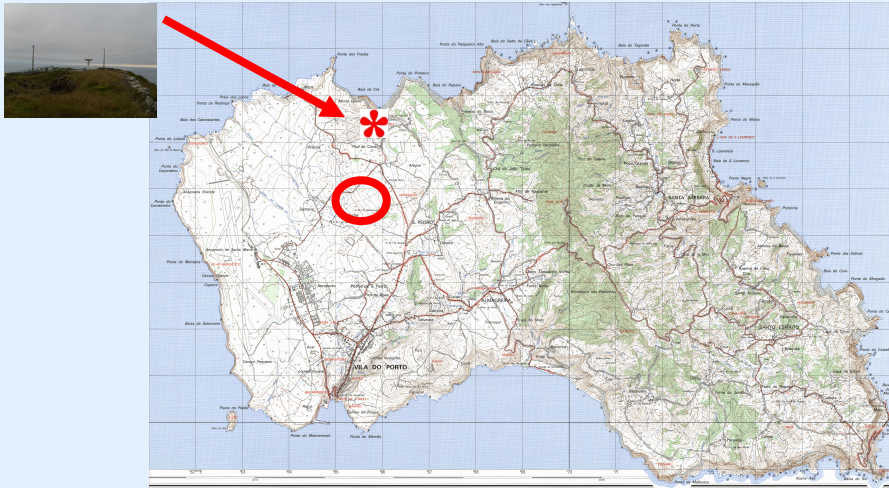


RAEGE stations in Azores (Portugal)

North American plate



Santa Maria: Saramago

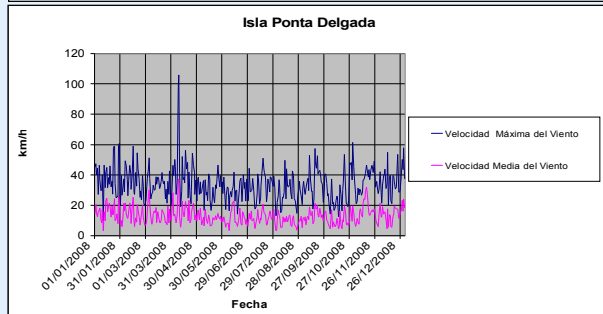
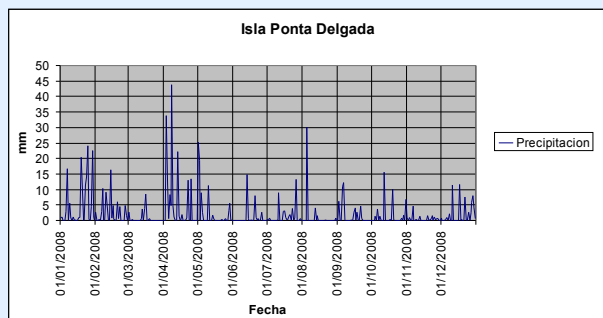
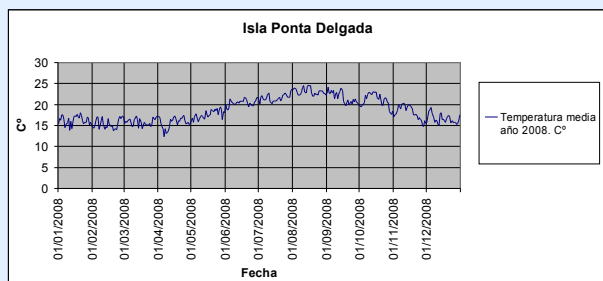


Aluvi3n
Conglomerado
Basaltos

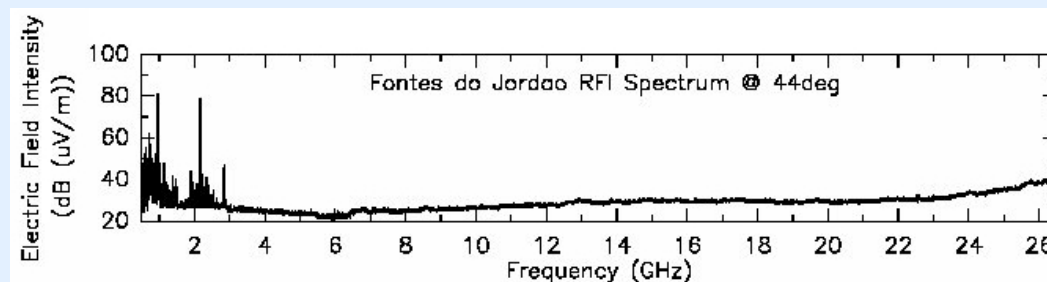


Meteorology and RFI

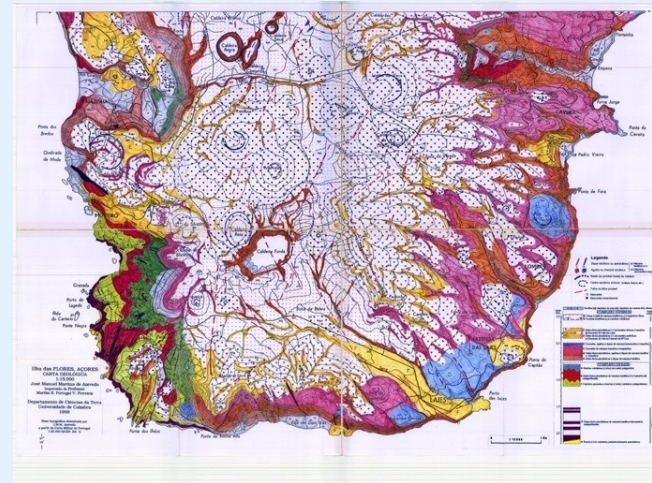
Temperature / Rain / Wind (San Miguel)



RFI measurements (1–26 GHz) (Santa María)



Flores: Lajes

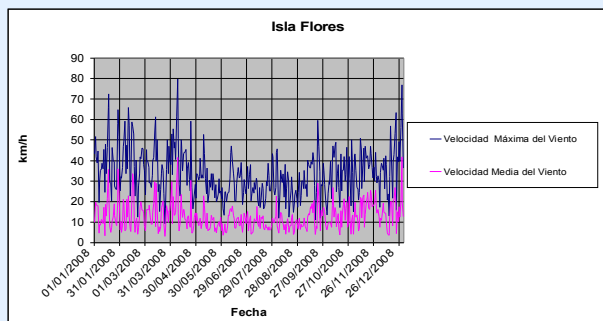
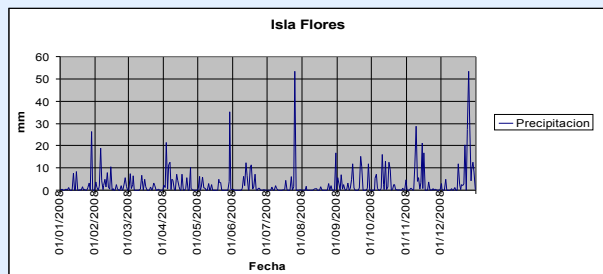
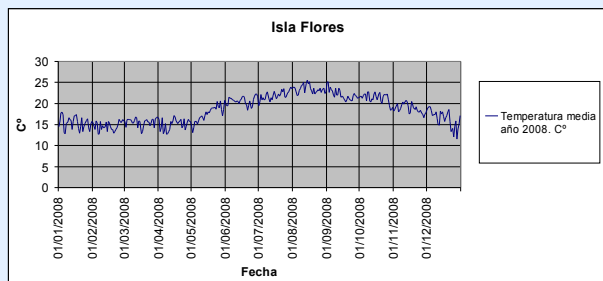


Aluvión
Conglomerado
o
Basaltos

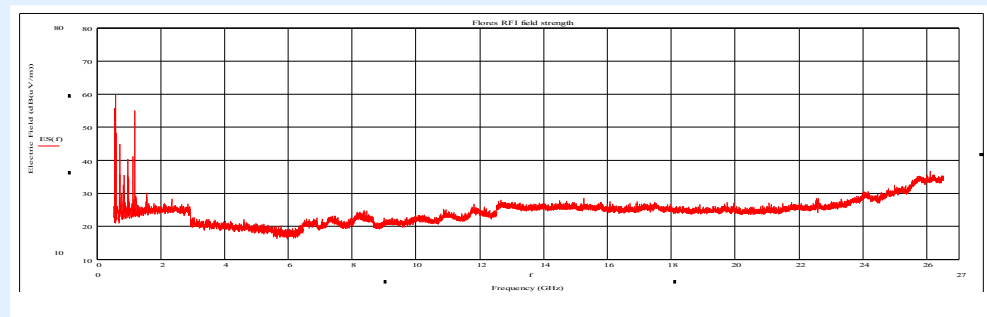


Meteorology and RFI

Temperature / Rain / Wind



RFI measurements (1–26 GHz)



Connectivity status

- COLUMBUS-III network hosts 20 Gbps



Final comments

- IGN has contracted the first three RAEGE antennas (Yebees, Santa María, and Tenerife) to MT Mechatronics.
- Construction of antennas is started.
- First RAEGE radio telescope (Yebees) installed in 2012.
- Fiber optics infrastructure for network control and data transmission in real time (16 Gbps/station).
- More:
 - INGRID 2011 (Santander)
 - IVS GM 2012 (Madrid) – <http://www.oan.es/gm2012/>

