Regulatory aspects of small satellite remote operations in radio amateur bands

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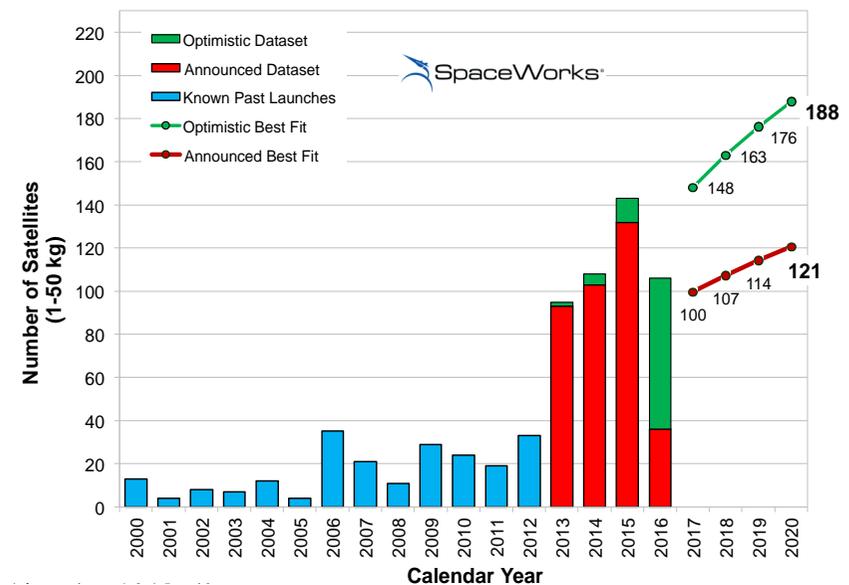
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Capacity Building:

- **Cubesat standard:**
  - In 1999, CALPOLY and Stanford University developed the specifications.
  - Originally, educational, now also commercial and governmental.
  - Provide hands-on experience to students.
  - Typically, 1-2 years mission life.
 - Low cost (hardware < 50 K€)

- **Number of Cubesats in orbit:**
  - As of 15/03/2015, 330 cubesats have been launched.
  - 136 from Universities.
  - Number of launches has surpassed the most optimistic prediction.

REVOLUTIONARY MINDS
BOB TWIGGS + JORDI PUIG-SUARI
Changing the state of **the cost of science**

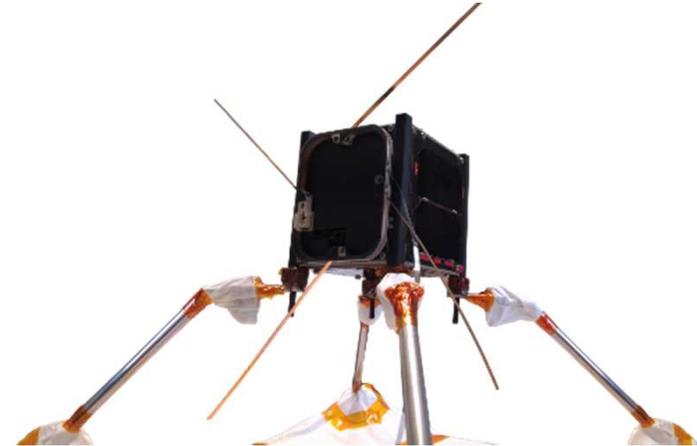# Spanish Cubesat Missions

- **Xatcobeo (Uvigo):**
  - First Spanish University Cubesat (1 Kg).
  - Developed following space quality standards (ECSS).
  - Launched by ESA on 13-02-2012 and re-entered on 31-08-2015.
  - 100% Successful mission.

- **GENSO** (Global Education Network for Satellite Operation) **(ESA & Uvigo)**
  - Worldwide network for satellite Operation.
  - Uvigo selected by ESA as European Operation Node.
  - Uvigo led the software development.
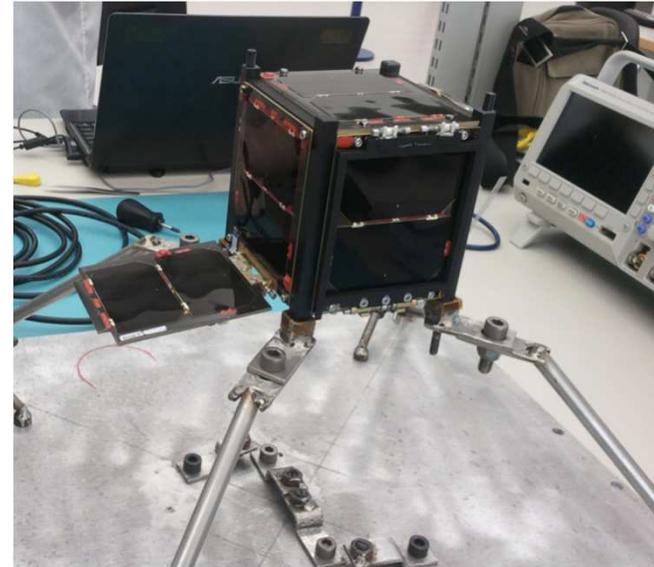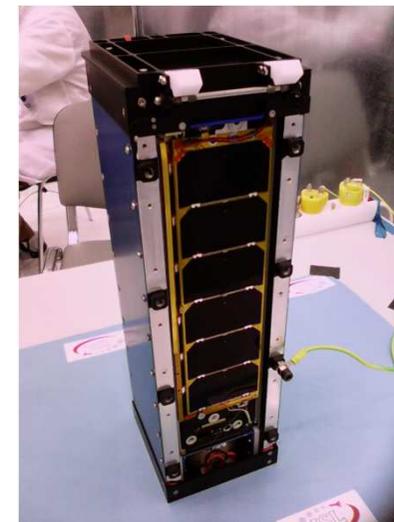
Spanish Cubesat Missions

- **HUMSAT-D (Uvigo)**
  - First satellite of the HUMSAT mission carried out under the Basic Space Technological Initiative of OOSA.
  - It receives, storages and re-transmits information collected from worldwide in-situ sensors.
  - Redundant and parallel reception up to 4 simultaneous sensors.
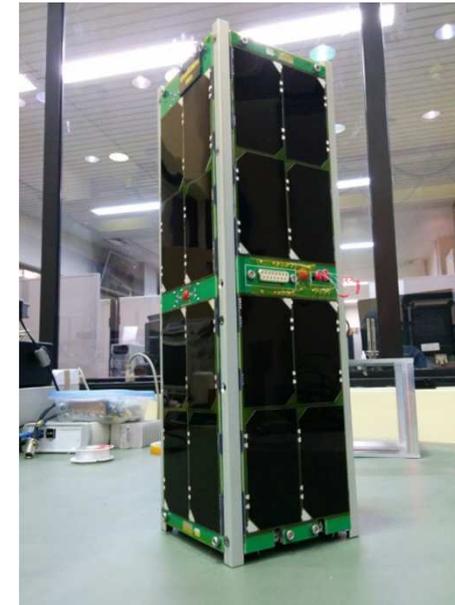 - Successfully launched by DNPER on 21-10-2013: 100% mission objectives

- **Optos (INTA):**
  - Technological demonstrator.
  - 3U Cubesat.
  - Launched by DNPER on 21-10-2013.
 - 100% mission objectives.

Spanish Cubesat Missions

- **SERPENS: (Brazilian Space Agency & UVIGO):**
  - Cooperation Brazil & Spain.
  - 3U Cubesat (3.5 Kg).
  - Second HUMSAT satellite.
  - Scheduled launch 3Q2015 from ISS.

- **SATNET (CALPOLY & UVIGO)**
  - Worldwide network for satellite Operation.
  - Open Source software.
  - Network architecture compatible with federal deployments and distributed cloud computing.
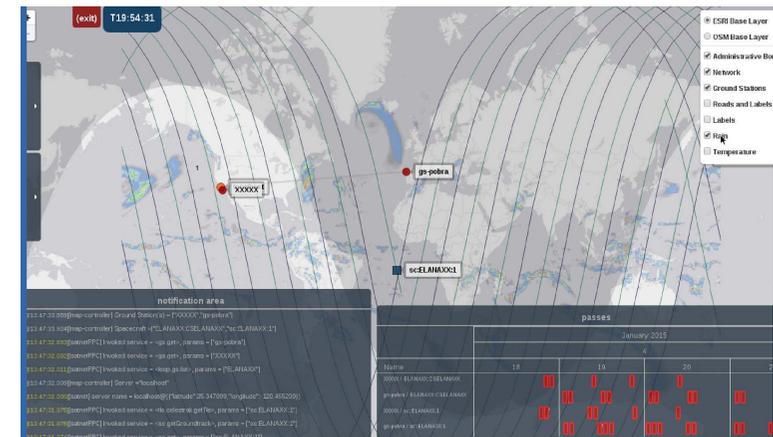
Small Satellite Regulations (I)

- Small satellites under international space law

  - Cubesats and all other smallsats are **space objects** under the UN Outer Space Treaties.

    - Art. VI OST: State parties are **responsible for all national activities in outer space** > including smallsats

    - Art. VII OST & 1972 Liability Convention: launching States are **liable for any damages** caused by the smallsat while in orbit (no damages caused on earth, as they usually burn up in the atmosphere during reentry).

    - Art. VIII OST & 1974 Registration Convention: 1) The launching State must **register** any object launched into earth orbit or beyond; 2) **the State of registry will retain jurisdiction and control** over the space object.

Small Satellite Regulations (II)

- **Small satellites under national space law**
  - States should implement all these international obligations at the domestic level:
    - By assuming responsibility over smallsats procured by their non-governmental / private entities, and by accepting the role of launching State.
    - By imposing an obligation to obtain a license to launch and operate non-governmental smallsats.
    - By registering non-governmental smallsats, both at national and international level.
    - By establishing an adequate supervision of this kind of space activity.

Small Satellite Regulations (III)

Additional int'l regulations for small satellites

- Art. IX OST: duty not to interfere with the space activities of other States.
  - Minimize the creation of space debris > the 25 year rule
  - Avoid harmful interference with other radiocommunications
- ITU Regulations > smallsats must comply with the ITU Radio Regulations (RR), and same as all other satellites:
  - Must follow the RR, both for the frequencies (radio-spectrum is a limited natural resource) and for the associated orbits
  - Must follow ITU coordination procedure whenever necessary
  - Coordination of smallsats constellations with pre-existing satellite networks (GEO, etc) is particularly challenging

Small Satellite Regulations (IV)

UN-OOSA Basic Space Technology Initiative

- Goal is **to provide advice on regulatory and technical aspects** (frequency registration, inclusion on the UN Register) with regard to smallsats.

- **ITU-T Resolution 757 (WRC-12):** there are no specific smallsats characteristics relevant from a frequency management perspective. As a consequence, ITU Radio Regulations (Article 9 & 11) remain untouched and in force for small satellite missions.

- ITU 2015 symposium approved the **Prague Declaration** urging the small satellite community to adhere to international regulations and to continue with capacity-building workshops on regulatory and legal aspects.

General ITU Regulatory Framework

- There are many non-GO small satellites operating in frequency bands not falling under ITU Article 9 (ITU coordination procedure).

- University cubesats typically operate in radio-amateur satellite bands:

  - Only suitable for non commercial applications.

  - Most common frequency bands:
    - VHF:144-146 MHz (primary service)
    - UHF: 432-438 MHz (secondary service 5.282)
    - S band: 2300-2450 MHz - (secondary service 5.282)

- For non RA small satellites, other frequencies are available → same ITU regulation than other NGO satellites

Earth Station – Satellite Radio Amateur

- Any satellite operator shall set up an earth station to ensure that they will be capable of switching off the transmissions from the satellite (25.11) .

- The station has to be operated by an operator with a valid amateur license (1.56, 1.57 and 25) and callsign (19)

- Remote earth Stations have to be located inside notified service areas of the satellite.

  - Service area "XVE-visible earth" for a worldwide service area.
  - No extra fee to include & update additional service areas.

Earth Stations Networks

- For LEO orbits: typically 5 or 6 passes of 8-12 minutes of duration over the local Earth Station.

- Thus, 90% time not used in a single satellite mission operated by its own ES.

- Ground Stations Networks:

  - Extend the satellite access time.

  - Select the best moment to operate the satellite based on the housekeeping telemetry.

  - Increase dramatically the mission data budget.

  - But impact on power budget.
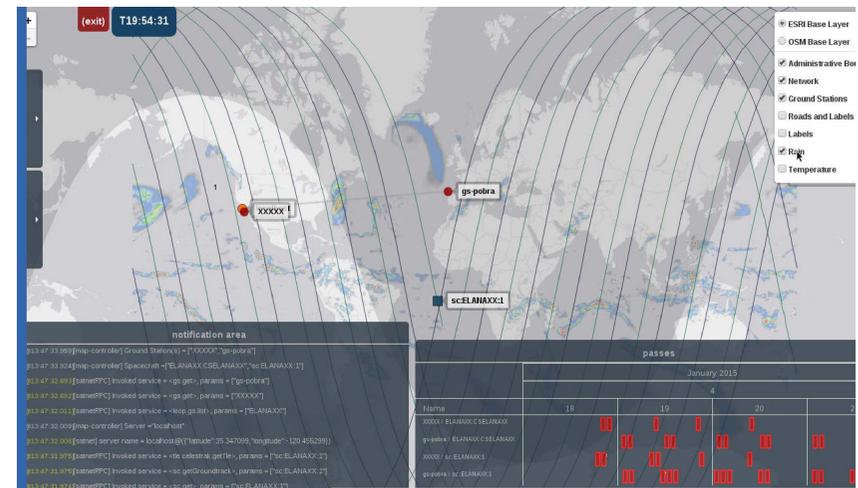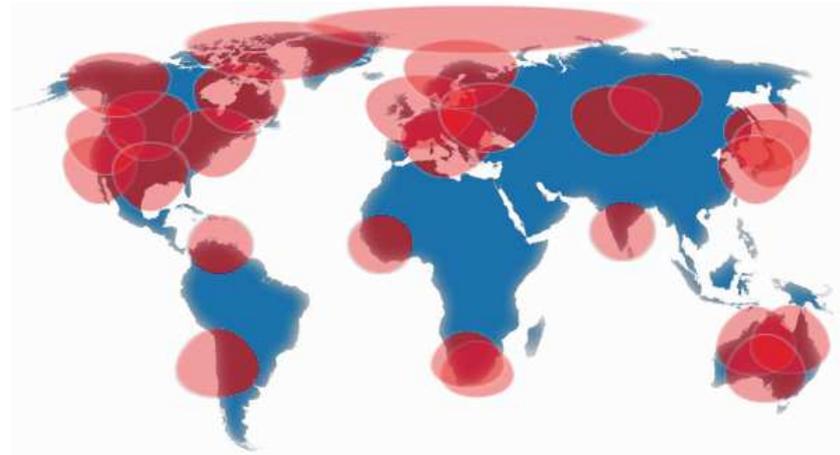
Earth Stations – Satellite Radio Amateur

- Downlink remote satellite operation
  - Possible to automatically receive passive downlink and retransmit the received data by internet to the control centre.
    - Some national regulations do not allow interconnecting ES to internet.
  - No local operator needed in the remote ES.

- Uplink remote satellite operation
  - Operator shall be present in the remote ES, supervising the transmissions and controlling the PPT TX/RX.
  - Potential problems for an automatic remote operation without the presence of an operator in the federated ES -> Legal Liability!

- NOTIFY SPECIAL EARTH STATIONS UNDER ITU RES-642

SERPENS: Example of remote operation

- 3U Cubesat Satellite.

- International cooperation under UN BSTI program.

- Scheduled launch in 3Q2015 by ISS.

- API submitted by the Brazilian administration.

- Service Areas: Brazil & Spain.

- Remote Operation by SATNET software

- Imminent notification under RES-642
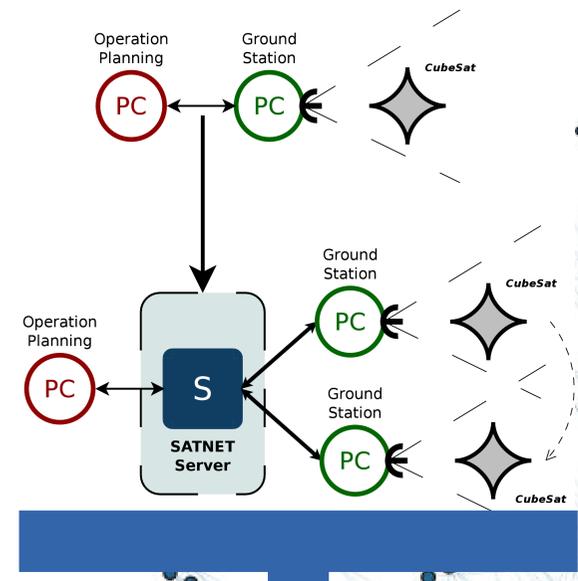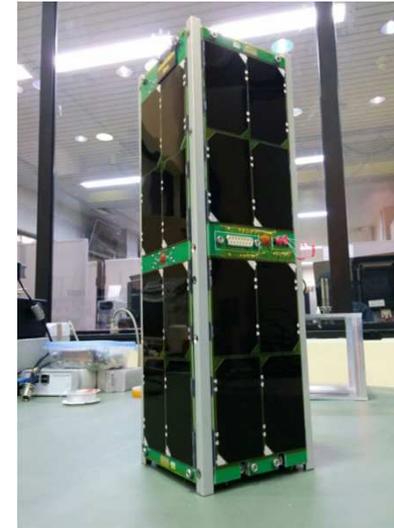
Conclusions

- Cubesats hands-on experience in real satellite missions.

- Increasing number of small satellite missions.

- Smallsats must comply with international space law.

- University satellites frequently use satellite radio amateur bands.

- Earth Station Networks can   dramatically increase the mission return.

- ITU regulation framework:

  - Define properly the service areas

  - Downlink automatic remote operation

  - Uplink supervised remote operation.

- NOTIFY SPECIAL EARTH STATIONS UNDER ITU RES-642

HUMSAT MISSION