SALLESAT-I PROJECT

www.sallesat.org

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Building a satellite is a real challenge. Further to the technological capacities needed to reach the mission' objectives, the satellite must have all the necessary elements that would allow it survival in space. For example, how to get enough energy from the sun, get the antenna pointed to Earth, resist the enormous temperature changes and survive to cosmic radiation.

From the educational point of view, building a satellite can be an important way of promoting higher interest in communications, as well as a new learning challenge, and quite specially, it can be the best way to get the solid integration of a whole experimenters' team, thanks to the large quantity of educational branches involved.

This is one of the main development and working lines of the Sallesat Project: supplying ideas for licensing projects on the Technologic University and being at the same time a good motivational tool that improves interest in Science and in new careers to First and Secondary level students. Sharing this effort in common and checking its economical cost must be useful to all society members.

Leadership

From the 90s, Radio Club La Salle (RCB) has been a meeting place for people interested in experimenting and studying technical subjects related to the development of the Amateur Radio service, as well as a place to promote radio-electrical investigation, electronics and telecommunications.

The RCS web is the main member's communication tool between members that mainly come from within their own university students and sometimes from other universities. Quite often, secondary level students coming from other centers can participate in this research work too.

Coordination and management of the RadioClub is handled by several University's teachers, formers students and other external specialists.

The club is registered as a legal association on the Direcció General de Drets and Entitats Jurídiques of the Generalitat de Catalunya. At the same time, the Radio Club owns a collective license for the use of an amateur radio station, with the call sign EA3RKL, registered on the Ministerio de Industria y Turismo.

Esquema directivo actual

The main working areas of the Club are the following: Radio astronomy, meteor detection and observation, and satellites.

Further to the first two areas, since the course 2003/04, RCS has decided to promote a greater interest on the satellite area, in order to increase motivation and participation in space communications, not only from

the technical point of view, but in divulgation of new professional careers. Since this date, Sallesat-I has become the main project of the RadioClub.

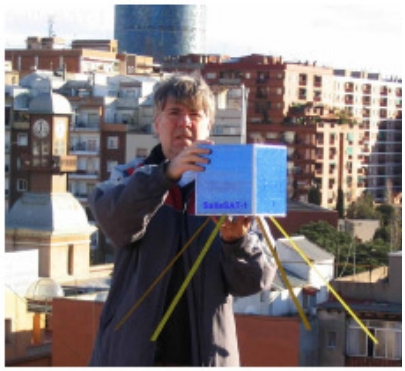
Sallesat-I is a picosatellite for radio amateur communications and scientific research, that pretends increasing the students interest on space and, at the same time, to be a good approach to the world of radio communications in primary schools, secondary level schools and other technical universities.

The business plan has been designed to be adapted to the organization model of the university, taking as much as possible elements from the university resources, as well as technological human ones: students, designers, scholarship holders, teachers and cooperators.

The SalleSat-I design has been structured in several different subprojects, made by the students themselves as projects and tasks that will allow them to reach their final degree, being coordinated by a supervisor committee formed by people specialized in several different areas of the satellite design, but in such a way that they do not lose the global vision of the project any time.

SalleSat-I project

As a new project for the university, it'll be fundamental the knowledge acquired by the organizations and universities involved, specially those that are already working in the satellite design area, comparing problems and solutions to find a solid starting point. In any way, the first steps were the get the whole design of the satellite from our own experiences without any previous interchange of ideas and experiences. This phase took a full scholar year (22203/2004).



In getting more information coming from other organizations with the same objectives, specially after a meeting with Mr. Jordi Puig-Suari, professor in the Aerospace Engineering School in the California Polytechnical State University in San Luis Obispo (Calpoly), where we were presented the Cubesat Project. In knowing that other 40 universities from all continents were working with it, this gave a new direction to the Sallesat Project, in order to join the standardized satellite experimental model called Cubesat.

This represented for us a whole change of the external parameters of the satellite. If the first prototype size was a cube of 30 cm side, the new one must be adapted to a size of only 10 cm side and a mass not greater than 1 kilogram. In compensation, it could be easier to get it placed in orbit, thanks to the standardized size and the lower cost of launching a Cubesat.

The next phases fore sided to develop the final flight model are the following ones:

- 2005-2006 Design
- 2006-2007 Assembling
- 2007-2008 Permits and financing
- 2008-2009 Launching
- 2009-2012 SalleSat-II

SalleSat-I satellite design

The predicted satellite orbit is a LEO type (Low Earth Orbital Satellite) that makes it flight between 400 and 1000 Km height. At this distance, lower power is required to be heard, allowing lower energy needed in the satellite thanks to the lower size of the solar panels.

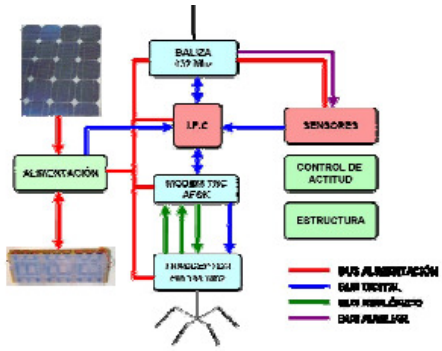
Functions:
432 MHz Identification and telemetry beacon coded in Morse (CW = Continuous Wave)
144 MHz Telemetry emission by APRS frames in AFSK at 1200 bps
144 MHz Packet repeater coded in APRS format in AFSK at 1200 bps
144 MHz Advanced teleordering in AX25 protocol

Blocks diagram:

Vital support: Energy caption and power supply
Attitude control and sensors

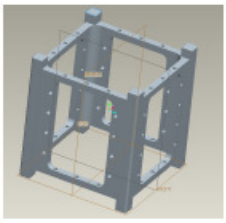
Communications: FM transceiver with 1 W power output
CW Beacon

Payload: Fujitsu CPU
Flash memory
RAM memory
Software



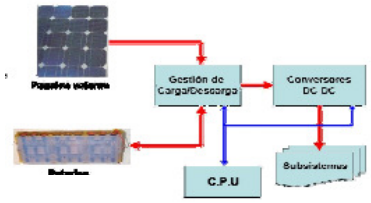
Structure:

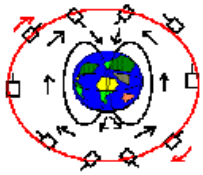
Cubesat standard picosatellite
Size: 10 x 10 x 10 cm
Mass 1 Kg



Vital Support:

Solar panel on six faces of the cube
Two antennas in two opposite faces
Ni-M-Hdr batteries
Charge/discharge CPU controlled
DC-DC converters for voltage control



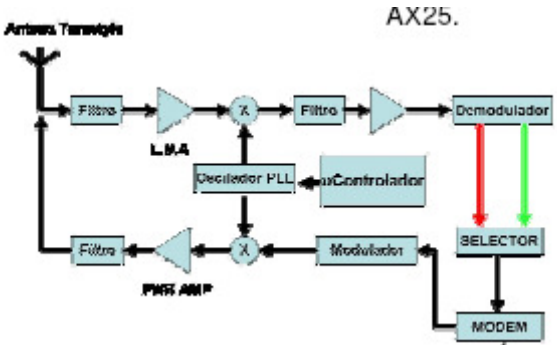


Passive magnetic attitude control
Magnetometer sensors, accelerometers and temperature sensors

Payload:

Hardware I.F.C. and flying software
CPU Fujitsu
Flash memory for program
RAM memory for application running

Software Remote control: telemetry processing and digipeater
Telemetry: APRS packets in AX.25 format. Analog and digital channels
Remote Control: AX.25 packets connection oriented
Packet digipeater with storing and retransmission of APRS packets



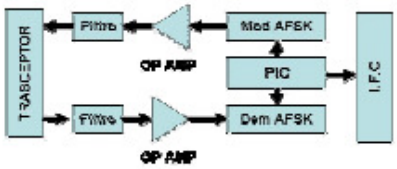
Communications:

144 MHz FM transceiver PLL controlled working in the 145.800-146 MHz segment band with 0.5 to 1 W output
One channel transmitter sharing APRS frames with telemetry frames in APRS
TX modulator with 4,5 kHz maximum shift at 1200 bps in AFSK modulation
RX demodulator in 15 kHz wide band
Remote control decoder in a wide band of 50 kHz
430 MHz beacon in CW with 100 mW output and self functioning

RX-Channel 1 receiving APRS frames. RX-Cannel 2 receiving control frames
Second receiver having higher priority than the first

Modem:

AFSK modulation at 1200 bps
Semiduplex operation
PIC controlled connecting CPU with TX
TNC with full autonomy



Antennas:

430 MHz monopole antenna with L/4
144 MHzz four elements turnstyle antenna, circular polarity

Satellite tracking

In parallel with SalleSat-I design and construction, we are working on a terrestrial station for tracking and control of the satellite. The actions that are to be done could be divided in two branches: Technical ones and those that must become an educational project in new technologies.

RCS has already a automatic station for LEO satellite tracking. The station has been working since the participation in an internal project developed on the Spanish astronaut Pedro Duque to the ISS (International Space Station).

The station has already been designed by students that were working at the RadioClub. The software that will track the satellite is a RCS propriety. It could be discharged[4] and used with all its working modules in free way by non professional users.

Another designed element that has been developed as a final licensee project is a motorized control interface for moving the tracking antennas. The right combination of the proprietary software and hardware (motorized control) allows a complete and automatic satellite tracking.

In the 2006/07 academic course, two 5º course students from the Universidad de Deusto in Navarra acting in conjunction with La Salle University have been developing a licensee final project that will allow us a full remote control of another tracking remote station of the RadioClub. That station will be placed at the other end of the university, in the top of the highest building of the university, to be controlled by any authorized internet connected terminal computer.

During the present scholar year, we have been developing an intensification[5] process that has to reach the design of several antennas prototypes for omnidirectional reception of the satellite and the ISS (International Space Station). The construction and design of these antennas must be based in quotidian materials and, when possible, in low cost and recyclable materials. The construction has been thought as an exercise of experimental scholar activity and it has to be done and tested by primary and secondary level students.

The terrestrial station for satellite tracking must have the following elements:

- A directional antenna system for each of the communications band that have enough gain to assure the uplink and downlink connections in each band to be used.
- A motorized tracking system for keeping the antennas pointed to the right ascension and declination of the satellite at any time.
- Another complementary omnidirectional antenna system for each of the bands used.
- A good software program capable of determining the actual position of the satellite at any time, especially the present coordinates height and moving direction.
- Transceivers for each of the bands in use. These rigs must be doubled for greater security in each of the bands.
- A software program capable to record all the signals and decode and translate all of them.
- For the best signal quality, low noise preamplifiers are needed, because they will allow an improvement of the low level signals on each of the antennas.

Administrative processes

The launching in orbit of a satellite must get the concerning government authorization and the world entities that control the radioelectric space.
The Ministerio de Industria, Turismo y Comercio or the future Agencia Española de Radiocomunicaciones (AER) must authorize and grant a license and a call sign to the satellite.

As opposed to the general radioamateur licenses that allow the use of the whole band available and assigned, the satellites beacons and transmitters need a license for specific frequencies that are being world wide coordinate by the IARU (International Amateur Radio Union)[8].

Further to this, the IARU checks the following parameters:

- Checking of the right levels of the uplink and downlink signals
- Antenna gain, size, placement, spreading and pointing precision.
- Transmitter power, modulation types used and encoding (open except for remote control)
- Receiver design, sensibility, passband and interference capability supported.
- Power output and stored energy that is supplied by solar panels and batteries.

Any similar project that could produce wide world consequences must receive cooperation[9] from other entities for coordination, expansion or financing at least. All involved parts must get the maximum circulation and motivation, in order to look for the best economical profits as well as scientific and educational ones. Thanks to the actual wide spread that gives Internet access, the information can move more quickly in an efficient and precise way, making possible the supply of continuous information of the event and get the valuable collaboration of thousands of people interested in radio communication.

The Cubesat Project of the Calpoly University (California Polytechnic University)
This University has developed and *standard* to provide an easy launch of radio amateur satellites from all the world, as well as get more people interested in new technical professions and increase the students knowledge in telecommunications and space techniques. At the present moment 40 Universities have already participated in this program.

The Calpoly standard

- A deployment system called P-POD (Poly Orbital Deployer)[10].
- Calpoly will be in charge of all documentary and licenses coordination
- Calpoly will give access to a laboratory for previous testing
- Takes charge of the shipment of the satellite to the launching place
- Makes the checking of all the remote control commands and telemetry at launch path.
- Has established a physical standard strucre of 10 x 10 x 10 cm, with a layout and design that must be strictly followed.

Tests to be passed at Calpoly

- Checking that the sizes and structure complies with the established requirements
- To pass a thermal resistance and vacuum test previous to a degasification process of the model, with a furnace test during 2 hours at 60º and 1 hour at 70 º.
- To pass a vibration test with 20 to 2.000 Hz in 7 frequencies segments
- To pass a test of antennas deployment and remote control

Educational project

A project like that cannot be justified if it does not supply a good knowledge management tool that uses the enormous educational possibilities it has, awaking greater interest in space and helping in some way to develop an educational project at all levels.
The knowledge of space and all aerospace sciences has an educational impact that must be exploited as a motivational element and is an excellent interdisciplinary tool for all theses processes, further to awake a professional interest in them and showing another catalog of new professions as well.

Educational actions to be made

At the University

Final licensing projects
Allow new variable credits (Intensifiers)
Terrestrial station: tracking and control activities
Cooperation in other University projects
Specific training in the implied technology

At the higher courses

Training activities at group class
Final cycle works
UNIES = La Salle University and School Program

At basic education

Divulgation actions at class groups
Training of future trainers

Developing and designing new projects that will allow the educational centers to get access to these technologies
These projects are all addressed to help investigation and supply instrumental tools or equipment to people or other entities interested in a cooperation or participation in SalleSat-I project.

- VHF receiver assembling kit
- Control interface for antenna rotors that make tracking
- Tracking satellite software
- VHF-UHF antenna system design
- Pedagogical papers

Activities to be made by the Radio Club

The Radio Club' main activity is the developing of its own project, as well as other specific activities in the ambit of radio amateur communications.

- Activities around satellite communications
- Calibrated activities in knowledge and experiments
- Radio Club participation in the ARISS project. Supplying help to other interested schools.
- Terrestrial tracking station
- Creation of an special team for new educational activities
- Teachers training
- Web management by RCS as a main information point: *www.sallesat.org*

1st presentation date and SalleSat-I project debate
The last 1st July 2006 was a day dedicated to the presentation of SalleSat-I in CaixaForum Barcelona. At this act, where students, University teachers, radio amateurs and AMSAT-EA members were present in it, the responsible committee presented the present situation of project SalleSAt-I and the future action lines.

NOTES
1 www.radioclub.salleurl.edu
2 Download assigned frequency. This frequency is the most easy to use for the signals involved.
3 Being in study
4 www.salletracker.com
5 Free election course
6 International Space Station
7 144/5 and 430/440 MHz
8 Entity in charge of coordinating frequencies for all radio amateur satellites
9 URE: Unión de Radioaficionados Españoles. AMSAT-EA: Amateur Satellite association in Spain
AMSAT-USA: Amateur Satellite Association that finances and spreads world radioamateur activities interested in satellite communications.
10 http://polysat.calpoly.edu/earthstation/status/index.php