Radio Amateurs efforts in Ionospheric studies

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ABSTRACT

Radio-amateurs have always been involved in research on ionospheric propagation. Amsat-Italia developed a space based programme to contribute to the international research effort on Space Weather and Ionosphere. This programme is divided in three sub-projects: Skywave, Ionosfera and RATS which are discussed in this paper.

INTRODUCTION

Amsat-Italia since the end of the year 2000 initiated a space-based programme aiming to contribute to the international research effort on space weather and ionosphere. The programme is divided in three sub-projects: Skywave mission, Ionosfera and RATS.
The Skywave mission is the space segment of the programme [1], it is based on a small satellite that will carry one or more scientific instruments that will be used to investigate ionosphere, the satellite will also carry at least one transponder to allow radio-amateurs to communicate.
Ionosfera is the ground based segment of the entire mission. It is basically a web site that should keep the international community informed on the state of the mission; by a free registration any user can access to several services also related to the prediction and radio propagation analysis, moreover it allows users to obtain information on the current state of propagation through ionosphere and space weather. The data required data to perform predictions and analysis, available on the web site, will be collected mostly by Skywave and its payloads, radio-amateurs will contribute with their collections of radio-link achieved in their activities.
At last, RATS, it is the (main) scientific payload proposed to be embarked on SkyWave and also planned to be developed within radio-amateur community.

SKYWAVE

Project Skywave was started at the end of 2000 by Amsat-Italia and the mission is intended to be a contribute to the amateur community and hopefully also to the scientific community.
Our idea is to give an additional instrument and data that should allow a better understanding of radio propagation through ionosphere.

In order to define the satellite mission and to be able to put its capabilities within a broader programme on Ionosphere study, we collected and analyzed a large amount of information on similar missions dedicated to terrestrial services [2], this work allowed us to better understand already proposed mission concepts.

Reference space mission related to Ionosphere were analyzed in order to obtain information about orbit of interest, the kind of instruments useful to this mission and what else should be integrated aboard the spacecraft.
By our study we noticed that most of them were based on small satellite, such information is valuable to us for initial sizing.

Considering all of this, our first result was that satellite should weight be between 50 kg and 125 kg, this weight makes Skywave to be a microsat class satellite. This class of satellite is familiar to the radio amateur community, in fact amateurs have built and orbited not few satellites of this kind and experiences made on those spacecrafts gives radio-amateurs a good background on the subject.

To determine the better compromise for the mission we investigated different activities that could be performed aboard Skywave. Among various options proposed initially, we finally decided to (develop and) implement a Topside Sounder as scientific payload for SkyWave (see RATS section below), that lead us to design our, completely dedicated, Radio Amateur Topside Sounder (RATS) whose preliminary tests will be introduced in a following section.

To be an amateur satellite, Skywave mission, has also to meet amateur radio typical interests, to achieve the better compromise we designed an orbit that provide global coverage of Earth to allow all radio-amateurs to access satellite, such an orbit will make us able to collect data for the entire ionosphere.

In brief, orbit specifications are as follows:

- Circular orbit at about 1000 km height.
- Inclination will be such to have a polar orbit (it doesn't have to be necessarily sun-synchronous [3].)

IONOSFERA

It is a web site intended to provide services aiming to predict and analyse radio-propagation through the ionosphere [4] for the radio-amateur community. The operational data collected in (and retrievable from) the Ionosfera website could serve the interested Radio-amateurs and Scientists to study this phenomena with a data source distributed all over the world.

The Pilot Project Ionosfera (http://esa-spaceweather.net/sda/ionosfera/index2.htm), proposed by AMSAT-Italia and selected by ESA, aims at supporting the Radio-amateurs and the Scientists in their activities relating to the Ionosphere.

The Ionosphere indeed is a direct product of the Sun-Earth interactions (hence a Space Weather topic), used by Radio-amateurs to achieve long-range radio-communication links.

However, Radio-amateurs in their daily (and nightly) activities face the major problem of link success unpredictability: because its dynamic behaviour is still not thoroughly understood, radio-propagation through Ionosphere refraction is still not reliable nor secure enough for practical use in applications such as for example, emergency communications in case of disasters.

Ionosfera is in the frame of ESA's Space Weather Pilot Projects, will then provide two kinds of (free-of-charge) services:

• The provision of operational data on Radio-amateur communications and on Space Weather RF effects. Such information could be used later on by Scientists to consider the Ionosphere from another point of view and to improve, by integrating it with other available data, their scientific models.

• A radio-communication prediction service based on several tools (number and complexity will be decided during the project development) allowing to predict/understand (maybe in real-time) long-range radio-communication links.

In addition to the above, Ionosfera proposes itself to increase public awareness on Space Weather thematic and on the other Pilot Projects.

Ionosfera will obviously be focussed on Radio-amateurs needs and expectations but will also attempt to create a European (hopefully worldwide) network of motivated persons participating to and taking benefit from the Project (you are warmly invited to contact us, if this is your case!).

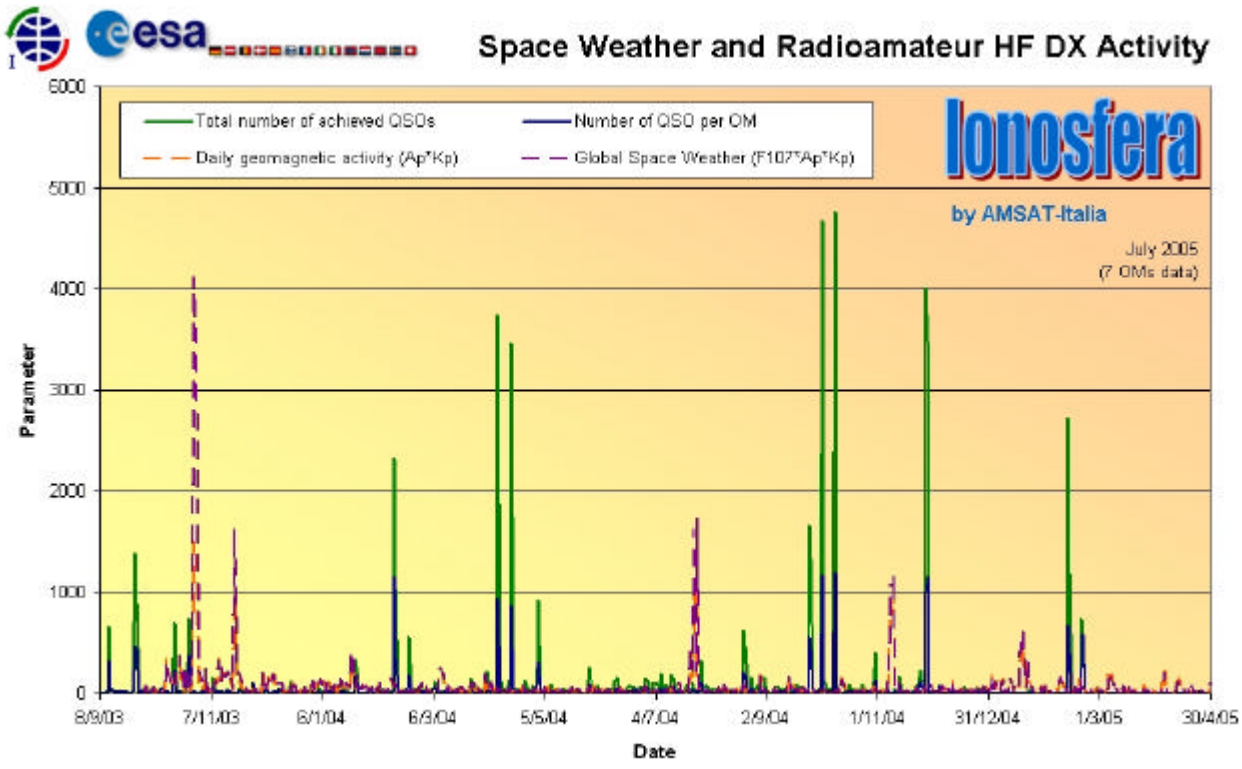

Fig. 1. Prelimanary results obtained from Ionosfera web site

Figure above shows the latest (but still preliminary) results from Ionosfera analysis on the received logs (about 60.000 from seven radio-amateurs). A clear de-correlation can be seen between HF DX activity (number of contacts or QSOs) and Space Weather conditions.

RATS

RATS stand for Radio-Amateur Topside Sounder. It is meant to become the Scientific payload onboard SkyWave as a replica (upgrading when possible and/or required) of the swept-frequency portion of the ISIS Topside Sounder.

Our effort on design and development of RATS basic functions was started on the master RF signal generator.

We choose a new approach, using Direct Digital Synthesis (DDS) techniques to generate, control and command the carrier frequency necessary for sounding. With this approach, we intend to make reliable and very precise and stable signals for transmit and receive block of RATS.

Our effort was primarily devoted to verify feasibility of simple circuit for transmitter part, and next to apply same parts to receiver (for conversion master oscillator).

For test we have designed and built a first single, simple board, in order to check and validate our ideas; a single DDS chip from Analog Devices was used, to generate a carrier from 0.1 and 20 MHz. This board was controlled externally by PC with parallel port, and was capable to generate a good spectral signal around entire range of interest. [Board visible on figure 2]

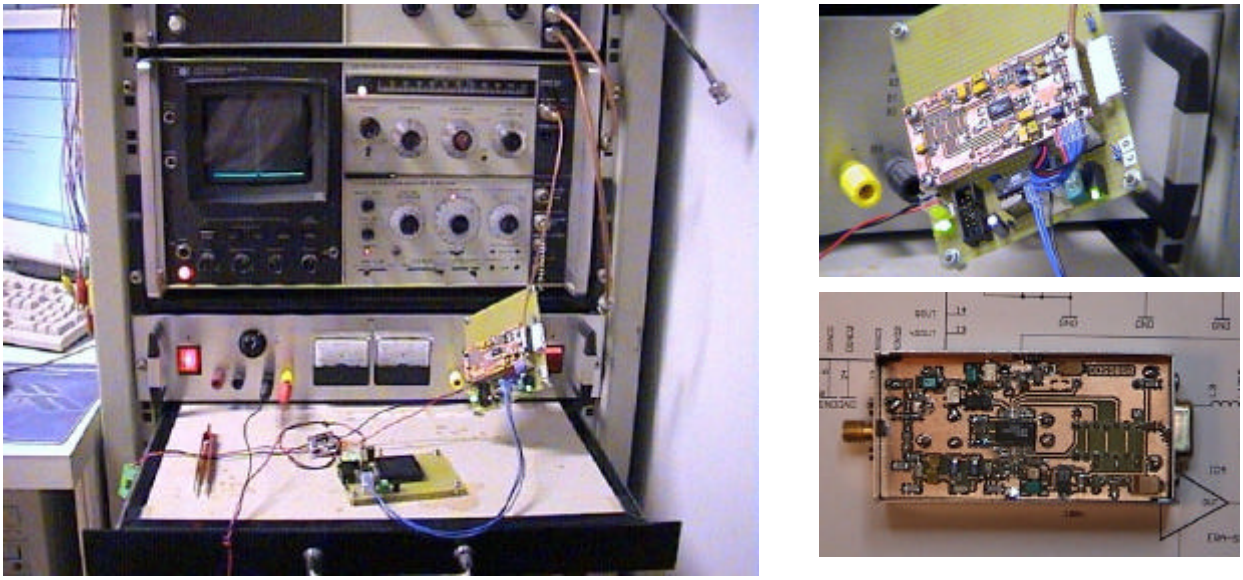

Fig. 2. Boards and first tests on RATS

On another board, we used a small microcontroller (from Atmel) for frequency settings of DDS, checking speed and settling time; next we reloaded the software for production of BPSK signal at various data rate [board visible on figure 2].

Some PRN sequence was next used to verify the produced spectrum and all tests were ok.
On all boards and test made, we can set the frequency with accuracy below 1Hz, with more than 70dB of spurious product down. [Spectrum visible on figure 2]

For RATS we have to produce a sweep signal (not only fixed), so the following step was to test this purpose. With our boards, we have a step-sweeping capability (change of DDS frequency in discrete step) with some time limitations (max speed for frequency programming) so a new chip was selected in order to obtain more linear performance.

This new chip is more powerful with dual (quadrature) output; this will be extremely useful for receiver section, as feed of rejection mixer. During last weeks, we have received some sample from Analog Devices, and a new board design is started for new tests.

FUTURE PLANS

We plan to develop and launch SkyWave for the 50th anniversary of the launch of Alouette-1 in 2012. For that date, ways to implement SkyWave in support to the Olympic Games (in London) will be investigated and proposed very soon.

REFERENCES

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