Paper

Summary of SSETI Express satellite mission – gained experience

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Abstract— In the following paper we present the results of our input in the first of SSETI space missions: SSETI Express, the predecessor of ESEO mission, which we are currently working on, the experience we have gained from this project and how it can benefit us during the upcoming ESEO mission.

Keywords— spaceborne patch antennas, students satellite, SSETI.

1. Introduction

We represent a group of students from Wrocław University of Technology participating in the SSETI association. Student Space Exploration and Technology Initiative (SSETI) is a non-profit organization founded by the Education Office of the European Space Agency (ESA). Its objective is to create a network of students in order to design, build, launch and operate satellites and spacecraft.

This paper will focus on our team's commitment to SSETI Express satellite space mission, which is one of educational programs operated under the SSETI association, the experience we have gained through participating in this project and how the lessons learnt can benefit us during future missions.

2. The mission

The idea of SSETI Express mission came out from another project European Students Earth Orbiter (ESEO). As the students participating in SSETI projects are regular full time students who have their own classes and finals, working on SSETI projects is something they do after hours. The point is that making the ESEO satellite mission happen was taking so long that there has been an uncertainty whether the students working on this project will ever see the results of their work. Besides, there has been a need for testing of specific designs and concepts for the ESEO mission. And that is how the idea of SSETI Express came out.

One of the priorities of SSETI Express mission was speed – the plan was that the SSETI Express satellite will be made ready for launch out of the components we already had for ESEO mission, in the shortest time possible. But of course fast could not mean not-precise. There have been also several goals set for SSETI Express that were different from the ESEO mission. Besides the educational part, main goals of SSETI Express mission included:

- taking pictures of the planet Earth and sending them back to Earth;
- providing connectivity for radio amateurs in the UHF band and most significantly, because SSETI Express would be the first satellite ever to do it;
- taking up into space on its own board three other satellites – so called "cube-satellites" to be released later, when SSETI Express in space:
  - XI-V, designed by University of Tokyo (Japan);
  - UWE-1, by University of Würzburg (Germany);
  - Ncube-2, by Andoya Rocket Range (Norway).

The basic schedule outline of the SSETI Express mission was as follows:

- February/March 2004: start of the project;
- July 2004 – March 2005: building a test model (fit-check) and flight model integration;
- April – May 2005: testing of the satellite;
- July 2005: SSETI Express ready for shipment to Plesetsk space center;
- 27th of September 2005: launch date.

Our task in SSETI Express mission was to design a telecommunication subsystem for the satellite along with AMSAT UK. In particular, we were responsible for the following components:

- low gain antennas (LGAs) for S-band shown in Fig. 1, including:
  - internal back shielding boxes, protecting other electronic devices onboard the satellite against electromagnetic interference caused by antenna back radiation;
  - external protective caps for the antennas;
- transceiver enclosure with integrated microwave antennas divider (Fig. 2);
- microwave cabling with clamps holding the cables inside satellite structure (Fig. 2).

During the testing phase carried out in Poland as well as in ESTEC (European Space Technology and Research Center, Noordwijk – The Netherlands) and in Saab Ericsson

a) b)

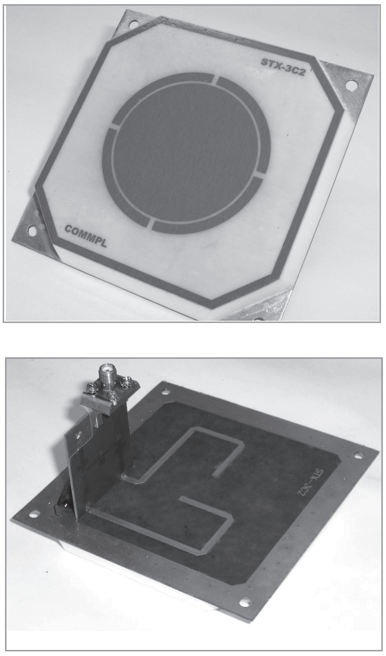

Fig. 1. The antenna: top (a) and bottom (b) views.

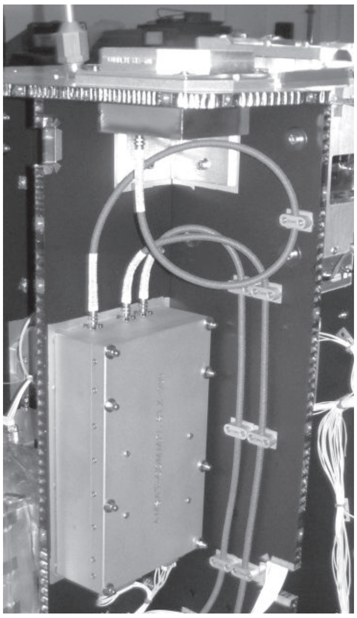

Fig. 2. Transceiver enclosure with power divider and fixed microwave cables.

Space (Sweden) it turned out that our components attained good characteristics and values of specific parameters. LGAs which weighted only 46 g ($100 \times 100 \times 10$ mm) each had 7 dBi of gain, while exhibiting an excellent right handed circular polarization (RHCP) values in wide range of elevation angle. Return loss of each antenna stayed above 25 dB in the operating band.

Our microwave divider delivered superior values of its parameters as well: return loss above 20 dB and isolation above 25 dB – over the full operating band in both cases.

Besides that, members of our team have built our own ground station for the purpose of receiving signals from the SSETI Express satellite. The ground station is capable of operating in both SSETI Express satellite bands: UHF – 437.250 MHz and S-band – 2401.835 MHz. Currently after the failure of the electrical power subsystem of the SSETI Express satellite, the ground station is receiving signals from cube-sats that SSETI Express has taken up into space on its board.

3. Lessons learnt

While working on the SSETI Express project we had an undisputed opportunity to improve our skills in several fields, pertaining to both technical issues and interpersonal skills. In particular, we can say that the most important issues are related to:

- team work,
- managing of work,
- cooperating on the international level,
- exchange of information.

In order to achieve success as a team it is critical that all the individuals working on the project should understand they should put aside their personal ambitions and realize what a team work is in order to be effective.

First of all, responsibilities and tasks should be clearly defined and assigned to specific members of the team, so it is clear who is responsible for what, in case somebody falls behind.

Since it is a student project and people come and people go it is important that the rotation of people be balanced – fresh brains mean new ideas, however it takes time before newbies gain necessary knowledge and it takes time to pass on the knowledge from the more experienced team members. Information flow is the key. Especially because it is an international project we have noticed that for work to be more efficient it is critical that there is a flawless flow of information both between members of one team and between teams from different universities.

When it comes to technical issues, we would mention the following:

- Internal communication must be clearly described to avoid protocol incompatibilities between onboard subsystems of the satellite. The entire telecommunication subsystem shall be described in a single, separate document (i.e., this approach protects from data type incompatibilities during the process of exchanging the data between systems).
- Housing – high frequency chain should be always very well separated from other chains to avoid interference of any kind.

- Redundancy can significantly increase device reliability, if the design is done in a proper way. A method of detecting malfunctions and switching algorithms must be prepared with the highest attention. We find important that the redundancy systems are not overbuilt and too complicated.
- Receiver – both primary and secondary receivers should work simultaneously because their switching in case of a failure of the active one would be impossible.
- Transmitter – redundancy of the transmitter should also be ensured in case of a failure. Switching could be realized on command from the ground station.
- Planning of placement of cables should be arranged in close collaboration with people responsible for harnessing, to let us choose the optimal solution.
- All connectors should be checked in detail with appropriate cables before applying them for temperature cycles, pressure and vibration tests to avoid disconnection.
- Electronic devices aboard satellite must be resistant to effects caused by ionizing radiation (i.e., hopping of bits) and electrostatic discharges. Also they should work in a wide range of temperatures.

We took our lesson from the SSETI Express mission and we try to apply what we have learnt to the ESEO project we are currently working on.
In addition, we put bigger emphasis on communication between teams, trying to work out every single detail and issue. We make sure that every team is being represented during all the chats that we hold on regular basis. To improve communication and information flow we also decided to go for additional chats – specific subjects and subsystems oriented.
As for the internal group improvements, we decided – again for a better information flow which is the key – that every new member of our team will from now on have his own individual tutor to guide him and introduce him to the project and the particular tasks he will be working on, from the general view to the very details.
We meet more often in person to discuss details of proposed technical solutions.
We also pay more attention to previously considered maybe not so relevant details while working on the documentation, since it is the main source of information about our subsystem for the other groups.
Since there had been problems with overheating of the S-band transmitter during the SSETI Express mission we now pay way more attention to temperature-related specifications and issues related to overheating of devices. So now, while working on ESEO we have even invited a group of heat dissipation specialists to help us solve possible overheating problems.
And finally we try to develop our whole telecommunication subsystem according to standards set forth by The Consultative Committee for Space Data Systems (CCSDS) that guarantee a proper functioning of devices that have been used.
Concluding, we hope that we will benefit from the experience gained throughout the SSETI Express mission and that it will help us in designing better telecommunication subsystems for the ESEO mission that we are currently working on and the upcoming European Student Moon Orbiter (ESMO) mission.

References

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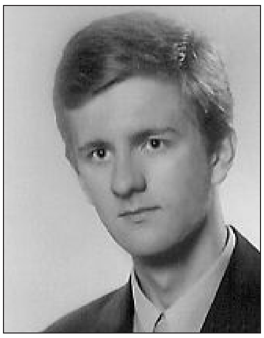

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