UNESCOsat: The United Nations' First Satellite

Donald Platt
Florida Institute of Technology
2280 Pineapple Ave
Melbourne, FL 32935; 321-243-4633
dplatt@micro-a.net

ABSTRACT

An international effort is underway to produce the first satellite in the history of the United Nations. The idea of the preparation and launch, with the endorsement of the UNESCO branch of the United Nations, of an international satellite to promote science education, public awareness of science, and international co-operation in the basic sciences, was presented by the National Commission of the Russian Federation for UNESCO to the UNESCO basic sciences committee. The General Conference of UNESCO at its 35th session in October 2009 approved an amendment to the UNESCO draft Programme and Budget for 2010-2011 concerning the project. The launch vehicle and a 100 kilogram satellite platform will be provided by Russia. Payloads will be provided on the basis of international cooperation including several from American universities. Available payload mass is approximately 30kg. Anticipated goals of the project include opportunities to inform and inspire younger students and the public about space missions and the benefits they bring to the world; assist in science technology, engineering and mathematics (STEM) education in the developing world; provide international student payload opportunities; and to highlight the benefits and importance of satellites and space for the general public. Student groups are being sought from around the world to assist in developing payloads, education programs, developing ground stations and other associated areas. One payload, defined thus far, is a remote sensing system to assist students in understanding resource management, science opportunities from space and crop health in their own regions of the world. Images will be able to be requested by participating student groups and then downloaded by their own ground stations or the internet. These images can be used both for educational programs and also to assist in food production and Earth resource management locally. Activities to provide information on the project to a wide range of institutions, partner organizations and sponsoring agencies that may be interested in cooperation are currently underway. A second payload will be a microbial experiment to subject extremophiles to the environment of space and determine their viability.

INTRODUCTION

Surprisingly, in the history of the space age, the United Nations has never had their own sponsored satellite. This is about to change with the approval of the UNESCOsat small satellite project. This satellite, conceived by the Russian delegation of the UNESCO basic sciences committee, will be a 100 kilogram-mass satellite with educational outreach and basic science goals. Russia is providing the 100 kg satellite bus and launch vehicle with participation from around the world. Payloads are being provided on the basis of international collaboration among educational institutions. Available payload mass is approximately 30kg.

The space sciences and space systems departments at the Florida Institute of Technology in Melbourne, Florida are managing the American effort to gain student involvement in the project and student payload development. This paper summarizes these efforts and encourages project involvement from interested organizations around the world.

OBJECTIVES

Anticipated goals of the project include opportunities to inform and inspire younger students and the public about space missions and the benefits they bring to the world; assist in science technology, engineering and mathematics (STEM) education in the developing world; provide international student payload opportunities; and to highlight the benefits and importance of satellites and space for the general public. Student groups are being sought from around the world to assist in developing payloads, education programs, developing ground stations and other associated areas.

Student groups can be involved from any area of the world with specific interest being in developing areas. These students may not have been exposed previously to a space-based research project. They will be able to

request images of their home region or village, send the request to command the satellite, receive the data either through a ground station they have built with UNESCOsat project assistance or the internet and analyze the data. They could perhaps work with local authorities to monitor crops or land use, contributing to their local communities.

Other student payloads can also be flown on the satellite answering other space-based research questions and stimulating interest in STEM education.

POTENTIAL PARTICIPANTS

It is anticipated that project participation be open to any educational group with an interest in accessing science data or using the satellite as a teaching tool in the STEM areas.

If a group becomes involved by developing a ground station from a "kit" under development, they can have access to the science data being provided by the satellite including the opportunity to command the satellite to image areas of the Earth of their interest.

Students are welcome to submit proposals for use of the satellite as well as payloads that may be near completion at this time.

PAYLOADS UNDER DEVELOPMENT

The Russian ISS-Reshetnev Space Company's Yubileyniy small satellite platform will be used as the bus for UNESCOsat.[1] Launch will occur using the Rokot launch vehicle. Figure 1 shows the satellite configuration with the envelop available for payloads.

Russia will provide payload integration assistance and launch. On-orbit operations will be conducted from a Russian control center in Moscow. Requests for data from participating educational organizations can be submitted from around the world. Upon approval the satellite will be commanded to collect data. This data can then be downloaded either through a locally-built ground station or over the internet.

Assistance in data analysis and curriculum suggestions will be provided by UNESCO. It is hoped that groups in developing areas of the world such as Africa and Small Island states will be involved using the freely available data collection capability and assistance from UNESCO.

This is an excellent opportunity for international cooperation in a space research project. Future space exploration will require international collaboration and the UNESCOsat can start future generations of space explorers off in the spirit of cooperation for the entire world.

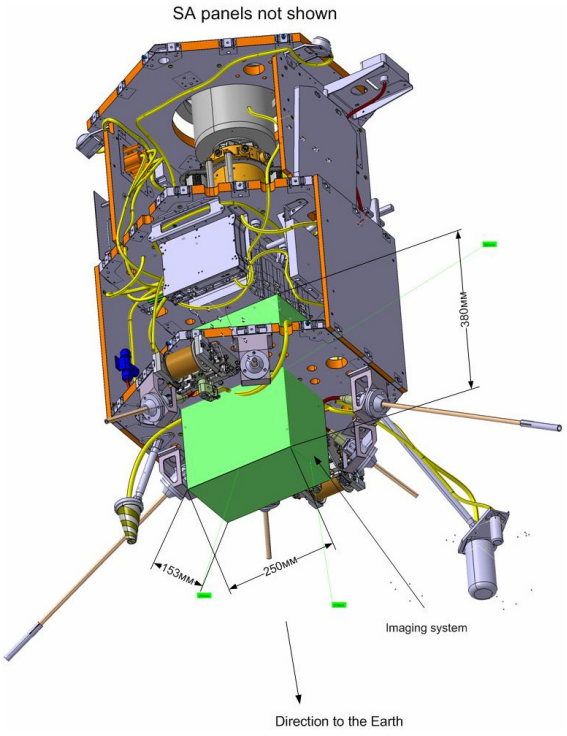

Figure 1 UNESCOsat satellite based on the ISS-Reshetnev Yubileyniy platform. The green box is the available payload area.

Imaging Payload

The Florida Space Institute (FSI), a consortium of a series of Florida colleges and universities, is developing an imaging payload that will collect five photographic images of the Earth (unfiltered, blue-, green-, red-, and near infrared-filtered) and then downlink the data to a requesting ground station. The data will be analyzed as part of a Geographical Information System (GIS) for land-cover classification, both spatially and temporally. Over time, trends will show changes in land use, and agricultural yields.

These images will be from the following wavelengths of the electromagnetic spectrum:

- Band 1: 0.45-0.52 (μm) - blue
- Band 2: 0.52-0.59 (μm) - green
- Band 3: 0.62-0.68 (μm) - red

- Band 4: 0.77-0.86 (μm) - near infrared
- Band 5: Unfiltered called - visible
- Band 6: blank - default position

A filter wheel will select the various bands.

Orbital altitude will be between 800 and 1500 km, depending upon launch opportunity. It is hoped that to improve resolution of the 5 inch-diameter imaging system, the orbit will be as low as possible.

If the satellite is operating at an altitude of 1500 km, the circular swath radius is 9.6 km. Spatial resolution is 17.6 m X 17.6 m (at 1500 km). If the spacecraft were to be placed in an 800 km altitude orbit the spatial resolution on the Earth improves, with an equivalent square area of 9.4 m X 9.4 m.

A CCD camera system will take images and data will be collected for transmission to Earth through a PC-104 computer system. The communication will use the Russian provided small satellite communications system.

At this time, there are 25 students from the Florida Institute of Technology (FIT) and the University of Central Florida (UCF) involved in this program – 1 non-degree seeking student, 3 freshmen, 6 sophomores, 7 juniors, 6 seniors, and 2 graduate students. Various disciplines are represented, including physics and space science, aerospace engineering, mechanical engineering, computer engineering, materials science, computer science, and industrial engineering. Weekly meetings have been initiated to facilitate communication and monitor work assignments. Students are assisting in imaging system optical design, component machining including CAD drawings and final machining, electronics system design and software development.

In particular, a PhD student in conservation biology at the University of Central Florida (UCF) is working with wildlife agencies in Ghana to reduce the impact of bush-meat hunting and firewood gathering on the local resources, among other impacts. The imagery from the UNESCO satellite will provide spatial data regarding land cover classification and, over time, changes in land cover. As part of a Geographic Information System (GIS), this data will be used to evaluate changes in land use by the people of Ghana located near the protected resources.

Microbial Payloads

Two separate microbial payloads are being developed by students at the Florida Institute of Technology. One has a goal of examining the effects of Shewanella MR-1 in a microgravity environment to determine if they could be used on future long term space missions. The second experiment will study the viability of extremophile bacteria in the microgravity and radiation environment of space. It will verify the operation of an instrument with potential astrobiology applications. Both experiments will be mounted within the electronics enclosure on the side of the imaging payload.

Shewanella MR-1 is bacteria that can function both in an aerobic and anaerobic environment. However, when in an anaerobic environment and in the presence of an electron receptor, MR-1 will donate the electrons from its natural metabolism to the receptor. The donated electron comes from hydrogen that is present in complex organic matter. This evolved hydrogen can be used in a microbial fuel cell to generate electricity. This may be of benefit on a long-duration spaceflight where MR-1 could digest waste material generated by human astronauts and generate electricity available for use.

The viability of the Shewanella MR-1 bacteria will primarily be determined by directly measuring their growth rate in space. This will be important to determine how different their life cycle is when compared to the life cycle on earth.

The bacteria will be launched in a stasis condition and then a water-based nutrient solution will be pumped into the bacteria chamber upon command from Earth. A light source will shine through the transparent growth chamber and light intensity measured on the other side. This can be correlated with growth rates for the bacteria in the space environment.

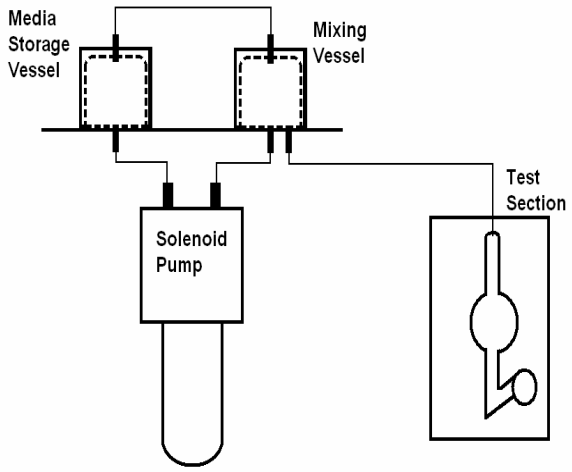

Figure 2 Shawenella MR-1 Experimental Setup

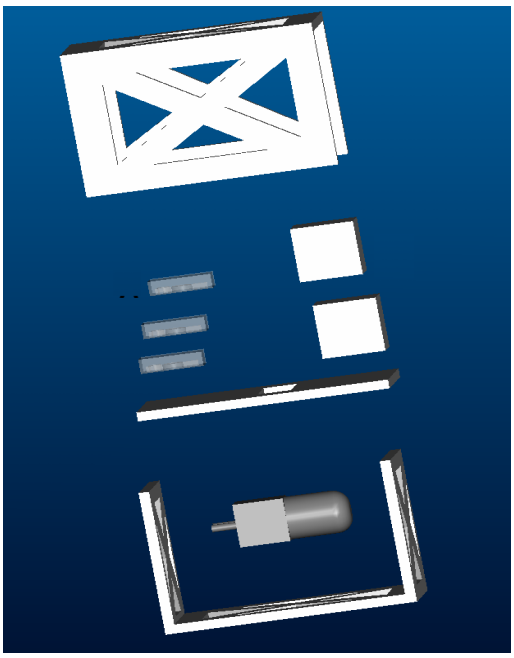

Figure 3 Exploded view of Shawenella experiment showing outer structure, growth chambers, vessels, electronics support plate, pump and bottom structure.

The second experiment will test technology developed using Live/Dead Molecular probes and microfluidics capillary technology to permit in-situ bioanalytical assessment of the viability of selected anaerobic bacteria for future astrobiology instruments that may operate on other planetary surfaces. The apparatus and payload development has been described previously.[2]

In the experiment, a micron-scale channel allows cells to pass by a blue diode which causes emission of fluorescent dyed cells which are detected by a filtered photodetector. A small microcontroller then operates high speed valves to select which chamber the cell is collected in (a collection chamber or a waste chamber). Cells with the expressed characteristic will be collected and counted in the collection chamber. The payload is under development with Richard Hoover of the NASA/NSSTC Astrobiology Laboratory in Huntsville, Alabama. Bacteria to be studied include Spirochaeta americana, Desulfonatronum thiodismutans, and Tindallia californiensis.

Research conducted by the NASA astrobiology group led by Hoover suggest the possibility of microbial extremophiles being capable of surviving on the Polar Ice Caps of Mars, and the crusts of other frozen bodies of our Solar System. This experiment should provide meaningful and valuable data required to develop and evaluate instruments and mission operational techniques to search for and recognize evidence of extant or extinct life during future Mars Missions or during explorations of other Solar System bodies.

The microbes will be treeated with a live-dead stain which causes the bacteria to fluoresce in green wavelengths if living and red wavelengths if dead. They will then injected into a microfluidics channel which will flow them in front of a blue excitation diode causing the cells to emit. Two photo sensors, one sensitive to green and one to red will measure relative intensites. Three separate injections will occur during a 3 month period to determine microbe viability during the first 3 months on orbit. Cells can then be collected demonstrating capabilities to identify, analyze and sort cells for future astrobiology instrument applications.

Both experiments are providing students with hands-on experiment design, development, and testing experience with space research systems. It will also provide students with operational experience once on orbit. Students will be given an opportunity to use these projects to conduct research that can be presented at undergraduate and graduate research symposiums.

These payloads had a basis in cubesat payloads that have been modified a new flight opportunity. This demonstrates the utility of designing modular small satellite payloads capable of being launched on a variety of platforms.

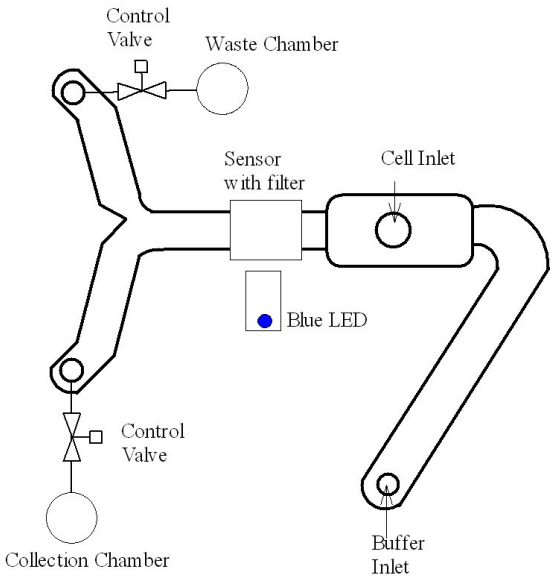

Figure 4 Extremophile microfluidics analysis instrument diagram.

Other Payloads

The payloads described above have a total mass of 10 kilograms and take up about one-half the available payload volume. Other groups around the world are being asked to submit proposals for payloads. It is anticipated that at least part of the available space will be used by Russian student payloads but other payloads are welcome to inquire about available space as well. Since launch will occur in 2011 proposed payloads should be well along in the development process.

TIMELINE

At this time the goal is to launch the satellite in 2011 and have an operational lifetime of five years. The experimental payloads described in this paper are expected to be completed and ready for launch by the end of 2010.

There is still plenty of time for other interested student groups to become involved with the project, building and testing ground stations, determining research projects and educational programs that can use the science data generated by the satellite. Also the satellite's ground track, orbit and other parameters could be used to teach high school and undergraduate students about physics, space science, celestial mechanics and other scientific or engineering disciplines.

After launch projects will continue to evolve and it is anticipated that conference and scholarships will be set up to offer students a chance to submit papers about research and activities conducted in conjunction with UNESCOsat.

FOLLOW-ONS

It is hoped that the satellite will be the first in a series of satellites and other educational collaboration efforts between many groups around the world, many of whom have not previously had the opportunity to be involved in space science-related endeavors.

CONCLUSION

The United Nations will soon have its first sponsored satellite in orbit. It is an excellent opportunity to involve students in an international collaboration space research project. The future of space exploration will require further cooperation from multinational partners.

This provides a chance for the space leaders of tomorrow to work together today developing partnerships that may lead to bigger successes in the future. Basic science will also be conducted on this project which will aid developing regions of the world.

The imaging payload will provide images for use in land-use and agriculture studies. It will provide imaging of areas of the Earth of interest to students and give them a chance to be a part in the entire process from identifying a region of interest, formulating the research proposal, determining data required, collecting the data and analyzing it.

Acknowledgments

There are many people around the world working on UNESCOsat in order to make the first United Nations Satellite a reality. I would like to thank UNESCO personnel including Maciej Nalecz, Clarissa Formosa-Gauci, Professor Herwig Schopper, Dr. Marva Ribeiro, Mr Alexandr Lazutkin, Professor Adnan D. Khamzaev, and Academician Vladimir E. Fortov. Also I would like to thank Russian Federal Space Agency Deputy Director, Sergei Saveliev. Florida Institute of Technology faculty making a large contribution to the project are Drs Lazlo Baksay and Hakeem Oluseyi. Florida Space Institute members working tirelessly on this project include Robert Crabbs, Randal Allen, and Jaydeep Mukherjee as well as UCF professor Ross Hinkle.

Lastly there are many students working on this project at various institutions. I would like to recognize my students: Ryan Bingham, Dave Borzillo, Christian Funk, Austin Perdue, and Jennifer Villalva.

References

1. ISS-Reshetnev Space Company web page, http://www.iss-reshetnev.com, accessed June 7, 2010.
2. Platt, D.W. and R.B. Hoover, "A Micro Fluorescent Activated Cell Sorter for Astrobiology Applications," Proc. SPIE, Vol. 7441, 74410B, 2009, doi:10.1117/12.831336.