Space Technology Capacity Building in Support of SDG 2030 through CubeSat SharjahSat-1

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***Abstract*— The SHARJAH-SAT-1 would be the first CubeSat mission to be developed by the Sharjah Academy for Astronomy, Space Sciences, and Technology (SAASST) students and researchers, with the aim of not only designing, fabricating, testing & launching the CubeSat itself, but also building the capacities and expertise for future SAASST CubeSat missions as well. For the project, SAASST is working in close collaboration with an experienced international partner, the Istanbul Technical University, Space Systems Design and Test Laboratory which has already developed and launched 5 CubeSats into low earth orbit. Overall, the project, puts the human capacity development in its center, in support of UN SDG 2030 for an equal world.**

Keywords— UN-SDG-2030, CubeSat, X-Ray detector, Imaging, Capacity Building

I. Introduction

The years 2017 and 2018 have been home to a record number of CubeSat launches into low earth orbit. This trend is growing further. As a low cost- fast delivery space assets, CubeSat's are creating novel opportunities for all the nations very poor or wealthy. Almost every year, several developing countries are having their first ever satellites placed into orbit as a result of international collaboration, including support from the United Nations [1]. On the other hand, NASA had the first couple of CubeSats (Marco A and B) launched to reach Mars to aid the InSight mission [2].

In addition to countries entering the space technology arena, the institutions within countries with already space assets are also benefiting from CubeSat technology towards having their own satellite in space. In that respect, the Sharjah Academy for Astronomy, Space Sciences, and Technology (SAASST) of the University of Sharjah (UAE) has started a CubeSat Project with international collaboration to develop its very first CubeSat to aid its educational and research goals through a scientific mission. For the project, SAASST is working in close collaboration with an experienced international partner, the Istanbul Technical University, Space Systems Design and Test Laboratory which has already developed and launched 5 CubeSats into low earth orbit [3].

The University of Sharjah is home to many students from different nations (over 15,500 students from more than 90 countries). About 100 of those students of various disciplines were exposed to space technology through a CanSat course in January 2018. The present mission will enhance the view and the knowledge of all of them towards a better future. On the practical side, the project involves developing a 3U CubeSat, called SharjahSat-1, for solar corona and star detection investigations. Moreover, the required infrastructure to develop the CubeSat, a clean room and development equipment and ground station for communicating with the CubeSat is also being established. The necessary environmental testing will be carried out at ITU-SSDTL to increase interaction among partners and to reduce cost. The launch of SharjahSat-1 is planned to take place before the end of 2020.

Overall the project, puts the human capacity development in its center, in support of UN SDG 2030 for an equal world [4].

The presented work is fully funded by the University of Sharjah, Sharjah, UAE.

II. SHARJAH SAT 1

The SHARJAH-SAT-1 would be the first CubeSat mission to be developed by SAASST students and researchers, with the aim of not only designing, fabricating, testing & launching the CubeSat itself, but also building the capacities and expertise for future SAASST CubeSat missions. The objectives and expected outcomes of the project were itemized, and the SharjahSat-1 is described in some detail, in the following sections.

A. Objectives of the Project

Human capacity development is the most critical aspect of UN SDG 2030. Educating students in cutting edge technologies such as space technology, will contribute to their wellbeing and leading them to a better life affecting their neighborhood, as well. The current project objectives are:

- Have the University of Sharjah (UoS) have its first space asset in orbit.
- Provide practical knowledge of space technologies to students.
- Extend knowledge on miniaturized X-Ray detectors and their capabilities to contribute to Space Weather research.
- Have a practical on orbit tool to support educational activities in UoS.
- Have a strong basis for international collaboration among MENA countries and beyond.
- Create infrastructure to develop and test CubeSats and satellite components.
- Provide a substantial playground for multidisciplinary and international teamwork.

A multidisciplinary project team at UoS is being trained by ITU-SSDTL through theoretical and practical space technology courses. The program covers space technology basics and spacecraft design with a unique methodology for CubeSat development. In addition to extensive design lectures and exercise problems, the project team has also been subject to hands-on training using representative electronics simulating basics CubeSat mission operations: CubeSat management for command and onboard data handling using a COTS microcontroller to manage to send commands, operating software and payload, read/write data operations and downlink to a representative ground station. Subsystem selection and pinout diagram forming, conflict analysis and prevention were also carried out. Communication over UHF bands using COTS transceiver, antenna binding and deployment (ITU-SSDTL system), payload operations with a VGA Camera, sensor readings and analysis from accelerometer, gyroscope, magnetometer, temperature and pressure sensors, sun sensing through photodiodes, beacon simulations through buzzer modules, power management using sets of Li-Ion batteries, solar panels and power distribution and regulation modules, subsystem interference and placement are all among the hands-on work.

B. Mission and CubeSat Development

The mission, depicted in Figure 1, is selected to comply with the educational objectives of SAASST, namely the space science and technologies. The primary science goal of the mission is to observe and study the development of solar coronal holes, responsible for driving the stellar wind at an early phase. Moreover, hard X-rays from very bright galactic X-ray sources will be complementary targets. Black hole candidates and pulsars can emit radiation up to a few 100 keVs making them potential targets. Another aim of opportunity is the transient bright events, like gamma-ray burst, magnetar bursts, and nearby tidal disruption events.

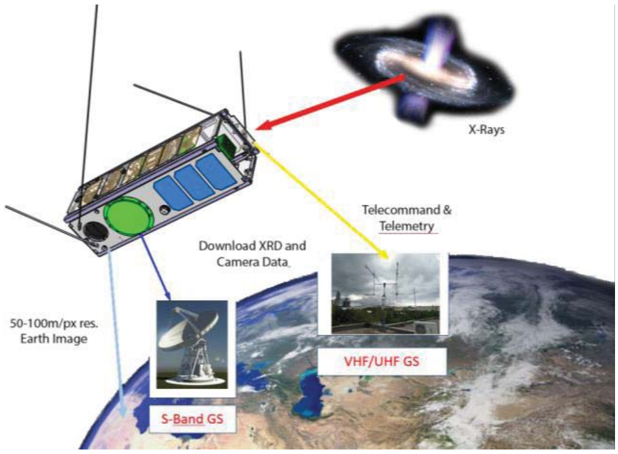

Fig. 1. Sharjah Sat 1 Mission

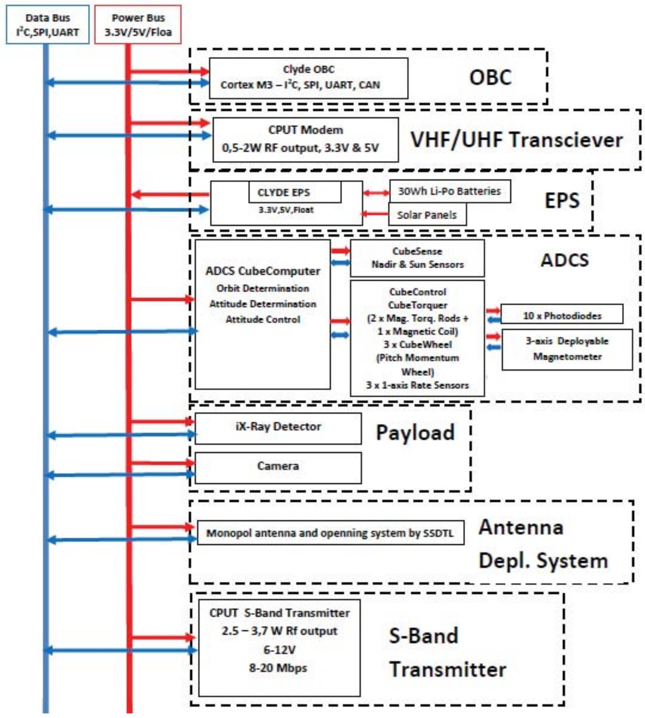

Fig. 2. Sharjah Sat 1 Block Diagram: data and power flow.

The primary science instrument on board is the iXRD (developed by the Sabancı University in collaboration with ITU-SSDTL) which will provide an improved version of XRD on board BeEagleSat [5], one of the QB50 project CubeSats. The leading technology behind iXRD will be a CdZnTe-based crystal, operational in the hard X-rays regime, between 20 and 200 keV energy range. The target spectral resolution of the detector is 6 keV at 60 keV. Figure 2, shows the block diagram of the subsystems supporting the iXRD and the secondary payload which is a camera working in visual bands. The high-level product break down structure (PBS) is presented in Figure 3, while further details are shown in Figure 4.

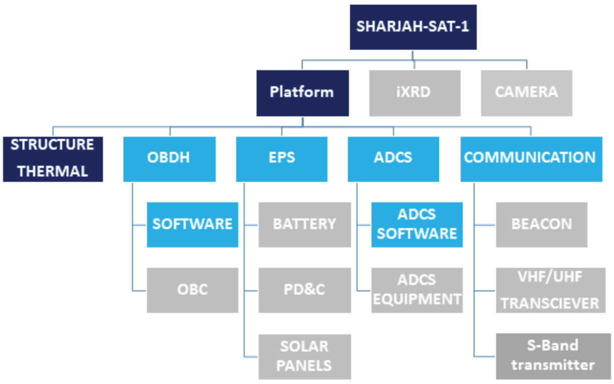

Fig. 3. SharjahSat-1 PBS

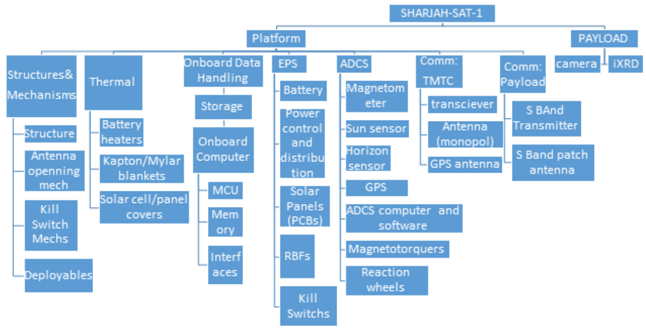

Fig. 4. SharjahSat-1 detailed PBS

The SharjahSat-1 together with human capital and infrastructure development will be completed in less than two years. The details are shown in Figure 5.

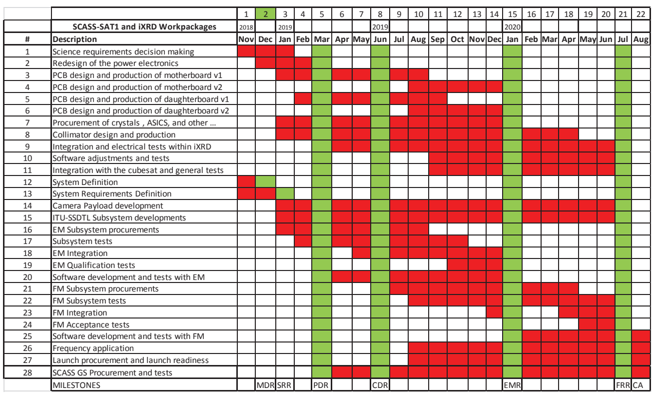

Fig. 5. SharjahSat-1 project calendar

III. IMAGER DEVELOPMENT

SharjahSat-1 has a secondary mission to provide project team a payload development exercise. Most CubeSat missions are employing a VGA camera as a low-cost, simple payload with continental resolution (see Figure 6 for the image from XI-IV- Sai Four, developed by Intelligent Space Systems Laboratory (ISSL)-Nakasuka Laboratory at University of Tokyo, Japan [6]). A similar payload was also used on board ITUpSAT1 [7] and TURKSAT-3U [8]. For the SharjahSat-1 the aim is to be able to take a photograph of SAASST which is located within a 500 m diameter field (Figure 6). The SAASST primary building diameter is about 90 m. Typically 1/3 of the length will be needed to have an image with SAASST visible. However, considering the cost involved in camera development, a GSD of better than 90 m is targeted.

The project team will develop an imager based on a COTS camera lens system and a suitable camera sensor board. Both parts will be integrated considering the camera system assembly to the CubeSat structure. The suitability to the space environment will be tested through extensive thermal vacuum testing to be held at ITU-SSDTL.

Commercial hard environment lenses with matching sensor boards will be used to form the camera payload. The TVAC tests will reveal the temperature and vacuum performance of the combined system. Based on the test results improvement and modifications on the system will be carried out to obtain an acceptable image quality.

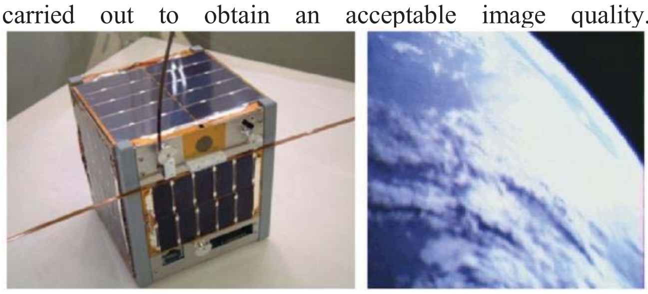

Fig. 6. Image of the wold (right) from XI-IV (Sai Four, right) developed by Intelligent Space Systems Laboratory, University of Tokyo, Japan.

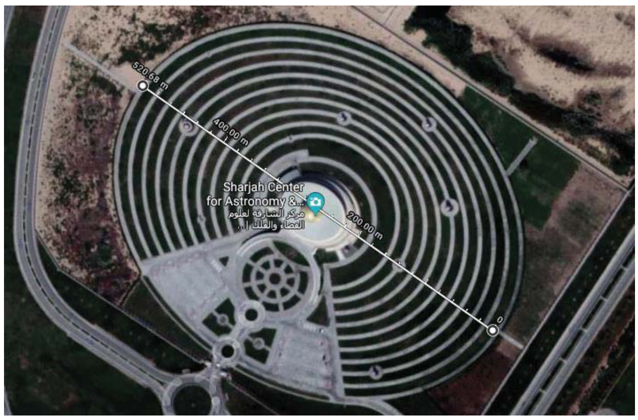

Fig. 7. Size of SAASST and its main building, Sharjah, UAE.

IV. CONTROL OF SHARJAHSAT-1

The SharjahSat-1 CAD with the subsystem locations is shown in Figure 8. Attitude determination and control system (ADCS) considered is the three-axis Cube ADCS from CubeSpace [9]. It has 1 or 3 reaction wheels and 3 magnetotorquers as actuators in addition to various sensors. For this specific mission required attitude and attitude rate accuracy could be acquired by a set of sensors which are, Sun and Horizon sensors, a deployable magnetometer, a rate gyro and a set of coarse sun sensors.

On the other hand, the actuator part of this mission requires further investigation. Since this mission requires high accuracy, using only the magnetic control alone is not an option yet, although it is an essential part of the control system for the detumbling phase and unloading process of reaction wheels. It may be possible to stabilize the system with only one wheel and to point an antenna and/or camera to nadir while pointing the X-Ray detector to the flight direction with 1-degree accuracy [10]. Although this more cost-effective option has only one wheel in the direction of the y-axis, it does not provide any maneuvering capability except the pitch direction. In consideration of the mission objectives to achieve the maximum data from celestial objects like Crab, Sco X1, Cyg X-1, GRS 1915, Velax1 and Sun, etc., maneuver capability in all 3-directions may serve better than one reaction wheel system. Analysis to be carried out will show which system will have a higher duration of high-quality celestial observation. Moreover, in orbit operation of a 3-axis ADCS will be quite an experience for the project team, in itself.

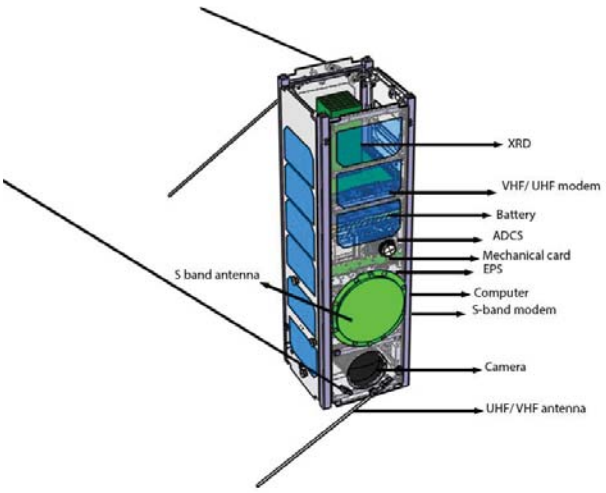

Fig. 8. Subsystems of SharjahSat-1

V. CONCLUSION AND FUTURE WORK

Space projects are inherently multidisciplinary and multinational. The project needs to consider the total space system consisting of not only the space segment but the ground and the launch segments, as well. Moreover, in parallel to the development of the hardware, the software related studies should also start as early as possible. An algorithm of the concept of operations should be prepared then to be coded for the CubeSat system. When constructing the CubeSat the Technology readiness levels (TRL) of subsystems needs to be considered together with the TRL of the project team and the partners. In this first project, giving the weight to gain experience in the individual testing/operation of procured subsystems, assembly and testing of the whole CubeSat will lead to a successful mission.

ACKNOWLEDGMENT

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