The First Kuwait National Satellite Project - KuwaitSat-1

Ali Meerza, Danah Alotaibi, Maha Alkharji, Sara Eskander, Albandary Alotaibi, Hanen Alotaibi
Physics Department, College of Science, Kuwait University
Kuwait City, Kuwait; 0096565892292
ameerza99@hotmail.com, danahotb@live.com, maha.n.alkharji@gmail.com,
sara.eskander7@gmail.com, albandryalotaibyi5@gmail.com, hanotybi@gmail.com

ABSTRACT

Nanosatellites present many opportunities and enable many nations and organizations to participate in the space field. The affordability of these satellites offers a short-term strategy for developing space systems capability. The first Kuwaiti satellite project known as "KuwaitSat-1" started back in 2019 and it was initiated by Kuwait University and funded by Kuwait Foundation for the advancement of Sciences (KFAS). Kuwaitsat-1 is a 2U nanosatellite with an imager payload in the visible light (RGB) and it was Launched on January 3rd, 2023, by Space-x, falcon 9, Transporter 6. The main objective of Kuwait Sat-1 project is to provide the students with the knowledge of the different pre-launch sessions of designing, assembling, integrating, and testing the nanosatellites. The post-launch training sessions include communicating with the satellite, data acquisition and processing the images for different applications. Since the start of the project, many educational seminars rooted in foundational space knowledge were given and then followed by more technical training in nanosatellite subsystems and deployment. Kuwait University has developed the supporting infrastructure to encourage and foster a new generation of students who have the understanding and vision to recognize the potential applications for small satellite systems. This paper describes the overall process, with the results achieved, and the current status of the KuwaitSat-1 project and possibilities for future space-related ventures.

INTRODUCTION

The KuwaitSat-1 project was a joint-venture funded by the Kuwait Foundation for the Advancement of Sciences (KFAS) and initiated by Kuwait University's Physics Department in 2019 in collaboration with other departments in the college of science and college of engineering. The project is considered to be a capacity building experience, with the underlying goal of establishing a space domain within Kuwait [1,2,3]. The actual KuwaitSat-1 nanosatellite is a 2U CubeSat, that holds a Gecko RGB imager payload with the scientific objective to capture aerial photographs of urban and rural Kuwait. These images will be received by the ground station located within Kuwait University and then used for scientific research and monitoring purposes. Over the past four years, the project accumulated two waves of students: Wave 1 started in November 2019, and Wave 2 in June 2021. Each wave underwent multiple educational sessions including on-campus lectures and workshops to online training and webinars. KuwaitSat-1 project is divided into three teams: technical team (engineers), control team (management and media) and application team (scientists). KuwaitSat-1 project consists of 30% males and 70% females from different majors like mechanical engineering, electrical engineering, computer engineering (college of engineering and petroleum), marine science, geology, and physics (college of science).

OBJECTIVES

The objectives of KuwaitSat-1 project are divided to primary and secondary [1]:

Primary

1. To build the capacity of the youth of Kuwait in the space domain.
2. To build the basic infrastructure to facilitate the design, assembling, testing and operational capabilities for future space missions in Kuwait.

Secondary

1. Capture the first image of Kuwait from the first Kuwaiti Satellite.
2. Analyze the imagery, with processing and analyses conducted by various disciplines such as marine science, architecture and geology.
3. Build an archive for the images.

MISSION CONCEPTS

KuwaitSat-1's main mission concept is to utilize national youth capabilities to design, construct and operate the first Kuwaiti Satellite. By establishing communication with KuwaitSat-1, the first major milestone will be achieved for Kuwait in the space domain, represented as KuwaitSat's first mission concept in Figure 1.

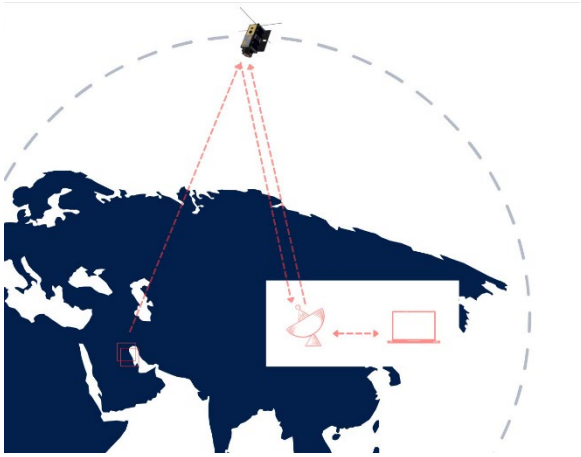

Figure 1: The KuwaitSat-1 Mission Concept 1.

KuwaitSat-1 contains a camera with a ground sample distance (GSD) of 39 meters, through which will take images of Kuwait, the images will be received by the ground station, and will be processed then analyzed to be used for research purposes.

The second mission concept is to monitor environmental changes in Kuwait to take further actions in accordance with these changes and government guidelines. Multiple images over a period of time for a fixed location are taken by the satellite camera. These images will be shared to local governmental and research entities.

Figure 2 shows the second KuwaitSat-1 mission concept.

Figure 2: The KuwaitSat-1 Mission Concept 2.

Part of the main mission is to build a space establishment that will target local youth capacities for future missions.

KNOWLEDGE ACQUISTION

During the early phases of the project, the group underwent weekly training programs conducted by field-experts, and at the same time were self-taught from relevant resources. A range of topics were covered through a series of training programs, are listed below:

- Preliminary Training Programs encompassed Mohammad Bin Rashed Space Center (MBRSC) and Khalifa University workshops in the UAE.
- In-house training included webinars from different international entities, and knowledge transfer between the two waves was the best tool to educate the new members. It begins with wave 1 by transferring their knowledge to wave 2 by conducting several lectures about many small satellite topics and the KuwaitSat-1 mission specifically.
- Participants went through multiple external trainings on the following topics: Theoretical -2U CubeSat Hardware, Practical -2U CubeSat Software, FlatSat Training, Design Reviews: PDR/CDR/FRR, Interactive Training in Europe SpaceLab, and Software Training on FreeFlyer.

PROJECT OUTCOMES

The KuwaitSat-1 project outcomes are capacity building, building the first ground station on Kuwait University's campus, and KuwaitSat-1 mission results.

Capacity Building

Kuwait University has created the infrastructure to encourage the development of a new generation of students who understand and see the potential uses for nano-satellite systems.

The journey began with bootcamps oriented on CubeSat satellites, using common subsystems and technologies, including widely available COTS parts and equipment. This was followed by analyzing PDR, CDR, FRR documentation to follow industry-standard procedures. After the objectives were set, and the CubeSat's specifications suitably chosen, various training programs were introduced regarding different aspects of satellite development.

Project-based learning was introduced first with orbital analysis including contact and lifetime analysis, data and power budget which was conducted using several software, with training provided by FreeFlyer, SaVoir and Gpredict. Mechanical engineers worked on COMSOL to simulate the vibrational and thermal analysis in the satellite. Part of mission operations involved utilizing visualization software such as Grafana, as well as PostgreSQL databases to analyze and maintain the large telemetry datasets produced by the satellite. Autodesk Fusion 360 was used to create a 3D model of the satellite and print it using a 3D printer to

help visualize the satellite parts and dimensions during analysis. Figures 3 and 4 show the 3D model of KuwaitSat-1 and the internal parts.

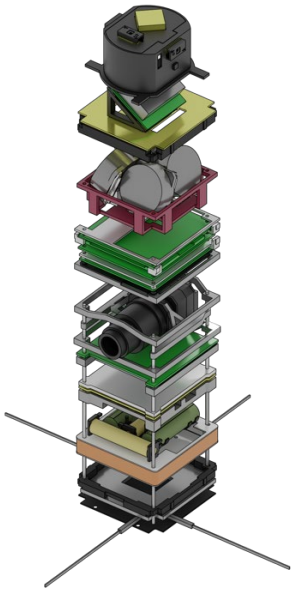

Figure 3: Internal Parts of KuwaitSat-1 [4]

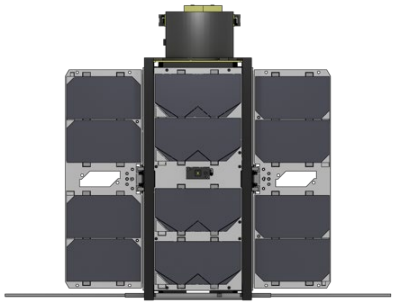

Figure 4: A 3D Model of KuwaitSat-1 [4]

Additionally, FlatSats were utilized for software-related training, being able to communicate directly with each subsystem, and sending commands via Mission Control Software (MCS). The aforementioned tasks were accomplished by the technical team.

Furthermore, image-processing was performed using common python packages as well as in MATLAB and QGIS by the applications team to identify and amplify points of interest and engage the local scientific community with the latest studies.

Just as important, the media-management team handled administrative and managerial tasks, as well as public outreach. Relevant documentation regarding the progress and status of the project was also handled by the team.

First Ground Station on Kuwait University's Campus

Back in October 2022, the accommodating ground station was constructed and set-up on campus, within the KU's College of Science. The process took around four weeks, whereby two antennas were assembled. Both antennas, and their rotator controllers were appropriately calibrated and tested with superficial passes. The two antennas corresponded to the two frequency bands the satellite communicated through, which were the UHF and S-Band frequencies.

The UHF frequency would normally be utilized for TT&C purposes, whilst the S-Band for image downlinks, due to the nature of images having large file sizes. Figure 5 shows the communication towers utilized for these purposes.

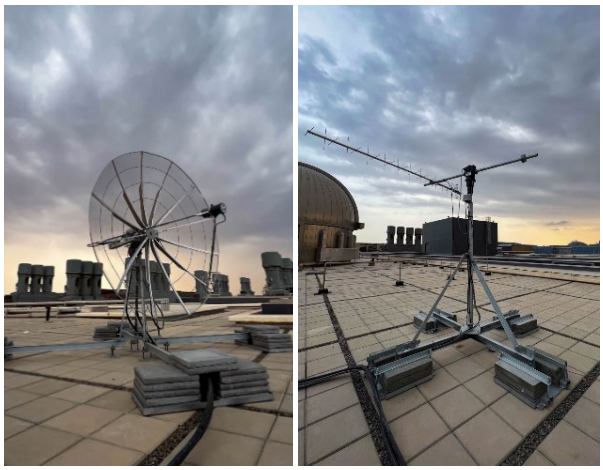

Figure 5: The S-band (left) and UHF (right) Towers.

The Ultra High Frequency Satellite (UHF) System offers communication links in the Ultra High Frequency band beyond the line of sight between specified mobile units and shore locations across the world via satellite. It is resistant to weather and can penetrate dense forest cover. Satellite communication and radar use the S-band frequency. It is employed in the space industry because of its efficiency as a conduit for delivering critical real-time data and its strong resistance to rain fade and other environmental interference. S-band radars are frequently employed for specific purposes such as seeing through bad weather or precipitation and detecting long-distance birds. S-band antennas are greater in size.

Figure 6 shows the team planning for S-band repairs and maintenance.

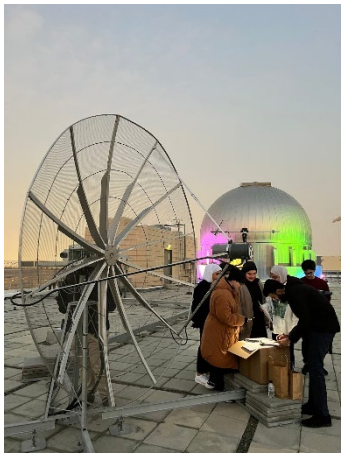

Figure 6: Maintenance Checkup on S-Band

Kuwait-Sat-1 Mission Results

On April 5th, 2023, the first series of images were captured by the satellite at approximately 9:36 AM. This includes a chain of five consecutive images (each with a swath width of 80 km) stitched together to give an enlarged aerial view of Kuwait, as seen on Figure 7.

Figure 7: The first image taken by KuwaitSat-1 on 5th of April 2023. The image shows Kuwait City and some Islands.

ACKNOWLEDGEMENT

We are thankful to Kuwait Foundation for the Advancement of Sciences (KFAS) for sponsoring this Project no. FP1814SP01. We are also grateful to Kuwait University (KU) for the administration support.

CONCLUSIONS

KuwaitSat-1 served its purpose of capacity building, training over 40 students of various backgrounds in the field of space science and technologies, with a focus on nanosatellites. At the same time, the satellite has successfully reached and maintained orbit at LEO. All systems are functioning nominally, as we have received the first batch of images from the satellite. The successful launch and execution of this satellite is a big step in establishing Kuwait's Space Centre, as a sustainable solution for space-related activities. This implies that all the objectives have been fulfilled, hence the team is looking forward to more opportunities for advanced space projects in future.

REFERENCES

1. AlJassar, Hala K., et al. (April 2021), Annual Report Kuwait University CubeSat 1.
2. AlJassar, Hala K., et al. (November 2021), Annual Report Kuwait University KuwaitSat-1.
3. AlJassar, Hala K., et al. (October 2022), Annual Report Kuwait University KuwaitSat-1.
4. KuwaitSat-1 [2U], Spacecraft Assembly Report, NA-025-SAR-002-R001, January 2022