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LIFE AFTER BEXUS: STRATOSPHERIC BALLOON ACTIVITIES AT GDAŃSK UNIVERSITY OF TECHNOLOGY

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ABSTRACT

How do you restart an academic stratospheric balloon programme after taking part in the REXUS/BEXUS programme? How to assemble a new team and share the passion for stratosphere with a new generation of students? In this paper we want to summarise the stratospheric balloon activities at Gdańsk University of Technology held by SimLE Science Club since 2022. We'll outline the challenges of creating a new team as well as the technical details of the devised stratospheric balloon platform which allowed us to send two stratospheric balloon missions with new scientific experiments. Ultimately our efforts lead us to get selected for Cycle 15 of the BEXUS programme with a new payload called STORMDUST.

1. BEXUS 30 - Stardust Project

The Stardust project, led by the SimLE Science Club at Gdańsk University of Technology, used stratospheric balloons to explore the presence and diversity of microorganisms in the stratosphere, a challenging environment characterised by low temperatures, low pressure, and high solar radiation. Since 2016, the team has refined methods used across five missions, culminating in a successful 2021 launch from the Esrange Space Center as part of the REXUS/BEXUS program. The scientific approach combined classical microbiology with modern biotechnology, including MALDI-TOF mass spectrometry and Sanger sequencing, to capture, cultivate, and analyse microorganisms. This methodology proved effective in isolating and identifying various microorganisms, revealing potential new bacterial strains. The findings underscore the complexity and resilience of microbial life in extreme conditions and highlight the need for further research to understand microbial diversity, distribution, and survival in the stratosphere [1].

2. KEEPING SKILLS SHARP

After the completion of the Stardust BEXUS Project, many senior team members graduated and moved on, prompting us to recruit new members to continue our work. Fortunately, our project gained recognition and attracted many first-year university students. We decided to divide our efforts into two specialised teams: SimLE Science, focusing on scientific experiments like STORM and AMBER [2], and SimLE Stardust NEXT, dedicated to the technical development of the stratospheric balloon platform.

Fig. 1: Mission path of the SimLE Stardust NEXT Project.

2.1. Stardust NEXT - February 27th, 2022

The first mission after the BEXUS program aimed to introduce new team members of "Stardust NEXT" to the process of conducting a balloon mission. Focus was on preparation and the ground segment, teaching students to organise equipment (Fig. 2 & 3) and follow procedures. This mission was divided into three phases: launchsite preparation, tanking & launch procedures, and tracking, chase & landing. The payload was a simple radiosonde with a camera attached. Students learned key skills, such as the tanking procedure, using balloon tracking software, and managing the unique challenges of a car balloon chase.

Fig. 2: Prepared equipment before launch.

Fig. 3: Launchpad setup.

Fig. 4: Gondola made out of Eurobox-style Styrofoam boxes; rigging and launchpad visible in the background.

2.2. Stardust NEXT - May 26th, 2023

In May 2023, after a year of preparation, the Stardust NEXT team successfully completed their first mission, testing a range of systems and components they had designed and built. This mission focused on evaluating a newly designed Onboard Computer (OBC), communication systems and new rigging concept which implemented an idea of mechanical cutter system, shown on Fig. 5.

The mechanical cutter system was designed to move the cutter from the top of the parachute down to the gondola, due to a lack of technical skills within the team to develop a remotely actuated cutter system. While the rigging system itself functioned well, the servo-based cutter system failed to actuate properly. The system was susceptible to rope tangling due to gondola rotation, despite a swivel added at the top of the rig, between the balloon and the lines. The bottom of the rig could not have a swivel, creating a weak point where the lines become tangled, preventing the cutter line from releasing properly. However this condition was anticipated, and an additional length of the rope (about 10-15m, highlighted in red) was used to give the parachute space to unfold despite any twists in the lines. Despite the challenges the flight train landed safely.

The platform featured standardised styrofoam boxes (Fig. 4) which served as the mechanical interface with the payload and kept the team's electronics separate from external payloads. The payload consisted of an analog camera (Fig. 8), a quantum random number generator, and Paulownia tree seeds, which were later auctioned off for charity.

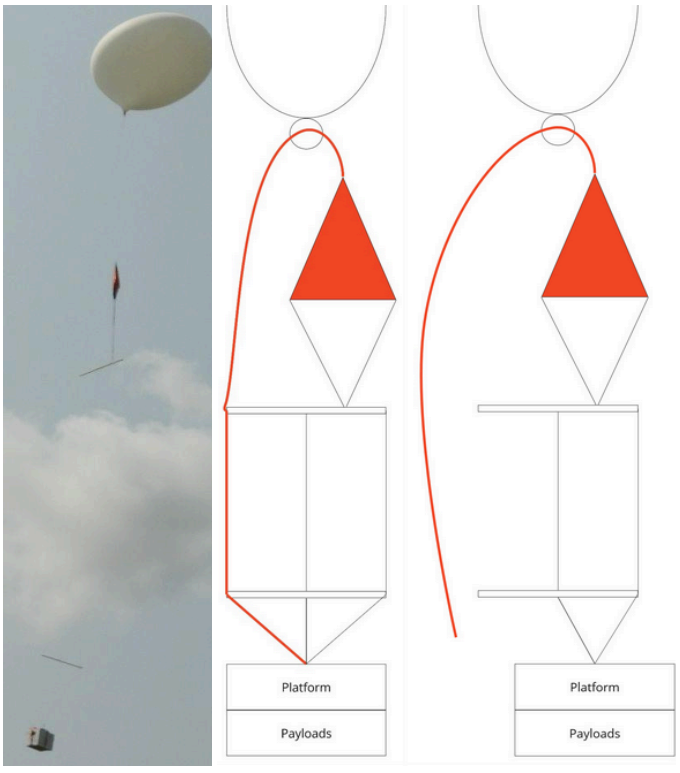

Fig. 5: Rigging and cutter system used in the May 2023 mission.

2.3. Stardust NEXT - August 9th, 2023

The second Stardust NEXT mission took place in August 2023 (Fig. 6), just a few months after the initial mission. It was entirely managed by the new team members without any assistance from senior members. This mission introduced a new payload, named STORM, which was designed to sample air from the stratosphere, similar to the earlier Stardust BEXUS project. The objective of the experiment was to study the migration of toxins at various stratospheric altitudes, continuing prior research in this area [3].

The August 2023 mission had three main goals:

1. **Team Building**: Integrate the technical team from SimLE Stardust NEXT, who were experienced with stratospheric balloon missions, with the scientific team from SimLE Science, who developed the new research concept.
2. **Technical**: Reduce the weight of each component and test new design concepts. The platform design was similar to the May mission, with modifications such as replacing the mechanical, servo-actuated cutoff mechanism with an electrical cutter system while keeping the rigging unchanged.
3. **Scientific**: Achieve the first identification of toxins in the stratosphere using Solid Phase Extraction (SPE) columns, marking a significant step in understanding stratospheric chemistry and microbiology.

The new hot-wire cutter system failed to activate correctly because the electrical wire, intended to release the rig from under the balloon, did not burn long enough. The hope for the new mechanism was that it would release the wire despite the ropes tangling up, but the test was not successful.

The August mission successfully tested the research concept collecting scientific data and demonstrating the team's growing capabilities in scientific exploration. The results will be discussed in future publications by the team.

Fig. 6: August 2023 mission during tanking procedure.

3. STORMDUST

From Team Building perspective the previous mission was a success and the teams officially joined on August 9th, 2023 establishing the SimLE STORMDUST project. The new team submitted their concept to the next cycle of the REXUS/BEXUS programme, and in November 2023 they were invited to the Selection Workshop. On December 13th, 2023 it was officially accepted to participate in the 15th cycle of the programme.

The project builds upon the legacy of previous missions conducted by the Stardust team, including the Stardust BEXUS Project and Stardust NEXT missions. The earlier missions laid the groundwork by developing essential technical capabilities and gathering initial scientific data from the stratosphere.

STORMDUST represents the next evolution of this research, integrating the lessons learned from previous missions to pursue more ambitious scientific goals. With the experience gained, the team developed their own version of the payload designed to sample and analyse the stratospheric air for volatile chemical compounds and microorganisms. Unlike earlier missions that were primarily focused on establishing technical feasibility and collecting initial data, the project now aims to create a comprehensive chemical map of the stratosphere, exploring the presence of toxins and the survival of microorganisms in an extreme environment.

4. FUTURE OUTLOOK

The STORMDUST team plans to expand their stratospheric exploration to various global locations, enhancing the diversity and scope of their atmospheric research. They are also developing an auxiliary drone for rapid, low-altitude testing of electronics and payloads, which will improve the efficiency and readiness of their stratospheric missions.

Additionally, the team is working towards commercialising the launch of stratospheric payloads using their platform, opening new opportunities for external researchers and commercial applications. Most importantly, the team is dedicated to passing on their expertise to future generations, ensuring the continuity and advancement of their scientific efforts in atmospheric research.

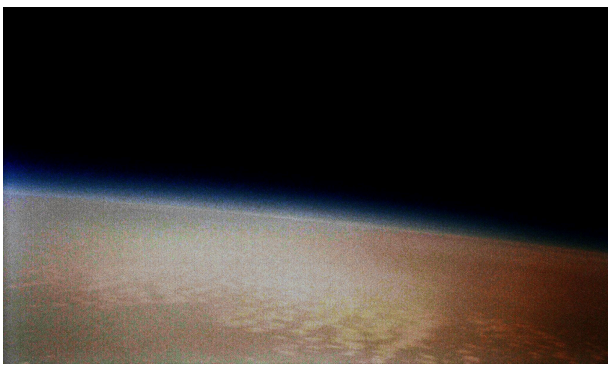

Fig. 8: Analog camera photo of Earth's curvature from the May 2023 mission.

5. CONCLUSIONS

The progression of the team's efforts demonstrates that scientific progress is deeply rooted in collaboration, systematic work, and the continuous sharing of knowledge. Through a series of carefully planned and executed missions, the team has not only acquired the technical skills necessary for high-altitude research but has also defined their own scientific goals. This approach highlights the importance of teamwork and sustained effort in achieving meaningful scientific advancements. Moving forward, the STORMDUST team is well-positioned to continue contributing to our understanding of the stratosphere and to inspire future generations of researchers.

6. ABBREVIATIONS AND ACRONYMS

REXUS/BEXUS - Rocket/Balloon EXperiments for University Students.
AMBER - Autonomous MicroBiological Experiment on a Rocket.
STORMDUST - Science of TOxin migRation and Microbiology in DifficUlt STratospheric conditions.
OBC - On Board Computer
SPE - Solid Phase Extraction

7. REFERENCES

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