Construction and Integration of Balloon-Borne Telescopes

Sky Bjel, Supervised by Prof. Barth Netterfield

Through SURP 2021, I have received the opportunity to engineer critical submodules for the construction and integration of the Super-Pressure Balloon-Borne Imaging Telescope (SuperBIT), under the supervision of Prof. Barth Netterfield of the Dunlap Institute for Astronomy and Astrophysics. SuperBIT is a high-resolution telescope with sensitivity to ultraviolet, optical, and infrared light, launched to the edge of outer space via a pressurized balloon the size of a football field. This unique instrument conducts groundbreaking research, including mapping the distribution of dark matter around galaxy clusters to further analyze its fundamental behaviour. The advantages of balloon launch, as opposed to traditional rocket launch, include lower development and mission costs, as well as smaller-time scale projects aboard the spacecraft. The submodules that I have designed over the course of my fellowship include a spacecraft Data Retrieval System (DRS) power circuit board, a GoPro-Raspberry Pi (GoPi) mission documentation interface, as well as the onboard solar array and its corresponding software application.

My DRS power circuit board design, now integrated within the telescope flight computer, is employed to regulate power to the 4TB hard drives containing SuperBIT science data. Composed of 10 separate circuits powering one hard drive each, the board will be responsible for managing data collection to the drives, and controlling their eventual release by parachute to an area where they can be safely recovered. The latter function of the board is especially important, as the massive amount of data aboard the telescope results in limited ability to transfer data remotely to our computers on Earth, leading to our need for a specialized system to safely enable their drop. The GoPi interface submodule, also housed within the flight computer, holds the purpose of keeping record of the mission in flight as an outreach initiative, through collecting and downlinking high-quality 6K resolution images of the telescope in space. It consists of a GoPro MAX 360 degree action camera, controlled via HTTP commands over Wi-Fi using a Raspberry Pi 4. The GoPro images, then stored on the Pi, can be accessed remotely and transferred to the ground computers. The solar array aboard SuperBIT consists of a 3x3 panel array on either side, providing the power to carry out all functions aboard the craft. Through a highly modularized approach, my design will solve the two pressing design challenges faced by our group in past years: portability and assembly time. Each panel frame in the array will become a standalone system, and in groups can be rapidly assembled and disassembled in any configuration desired for the mission due to small design features incorporated within the frame structure. As a result, assembly time will be cut from a matter of months to a matter of days, and portability will be optimized due to significantly more efficient storage and transportation via frame stacking. I have created a corresponding program using Python that will take into account the trajectory of the sun at different latitudes and times alongside other astronomical parameters, to calculate the optimal angle at which to position the array to generate maximum power. This highly adaptable program can then be used to determine optimal solar array positioning for future telescope flights, and perhaps external aerospace projects, if made open-source.

All three subsystems will be fully integrated in November 2021 at the NASA Columbia Scientific Ballooning Facility in Palestine, Texas, in preparation for our 2022 launch in Wanaka,

New Zealand. Here, SuperBIT will launch for a 100-night flight, conducting deep observations of galaxy clusters and the dark matter surrounding them in the near-infrared to near-ultraviolet wavelength spectrum.

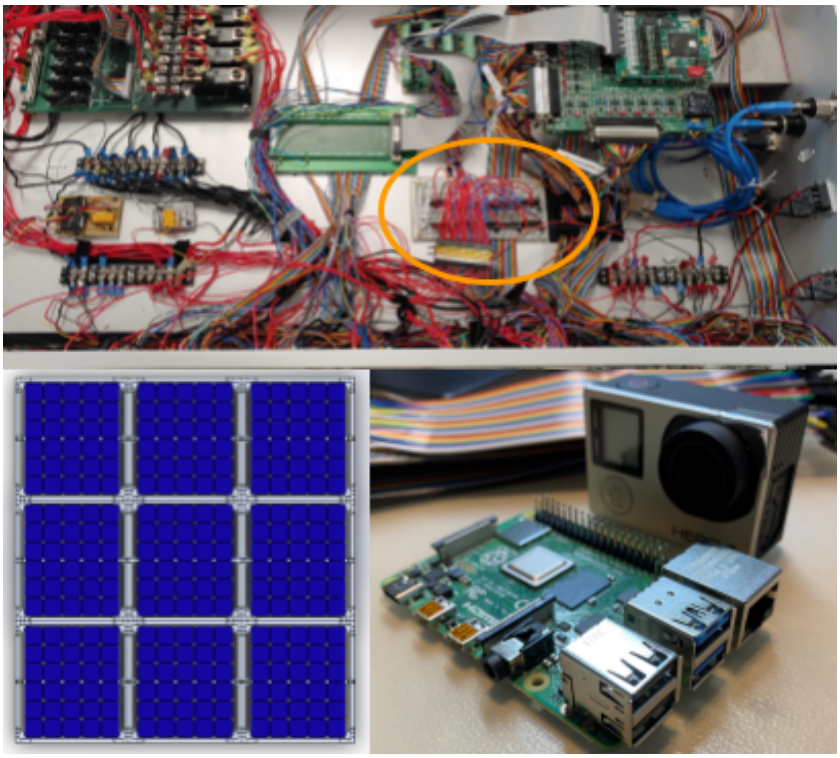

Fig. 1: The DRS power circuit board integrated within the flight computer (top, circled), a single solar array configuration (bottom left), and the GoPi submodule using an older GoPro during the testing phase (bottom right).