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Title

Overview of the Twardowsky Hybrid Sounding Rocket Avionics Design

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Abstract

For the past 12 years, students from Students' Space Association at Warsaw University of Technology have been developing solid motor rockets to study lower levels of atmosphere and perform scientific experiments. As a next step in the evolution of student rocket design, a hybrid motor rocket was developed, so that the higher performance and reliability could be guaranteed in future rockets.

Twardowsky is the first rocket propelled by a hybrid rocket engine, developed by the Students' Space Association. The rocket has been constructed as a launcher for small scientific payloads, capable of carrying up to 4 kg of scientific equipment or prototype devices to an altitude of 3000 m. To allow for deployment of scientific experiments at such altitude, a dedicated ejection system has been proposed along with a custom-built electronics system. Furthermore, as opposed to solid rocket motors, hybrid propulsion operation requires live information about several of its parameters before launch to achieve the target performance. Moreover, to perform a safe retrieval of the rocket, a two-stage recovery system was designed, which created a demand for a robust, dedicated pyrotechnic ignition system. The system also had to be designed with ground crew safety in mind, both during pre-flight preparations and in flight. Successful realization of all aforementioned goals demanded a complex on-board electronics system.

A single-board computer with capability to be expanded by attaching auxiliary modules in the form of a stack has been developed for the purpose of this project. Among those modules are a power management system capable of charging onboard batteries while on the launch pad by drawing power from an umbilical, a pyrotechnic ignition system with 6 independent channels capable of remote arming and a payload board for control over non-pyrotechnic deployment of experiments carried on board. An external sensor board located in the engine compartment of the rocket is used to take measurements of the parameters of the oxidizer during remote tanking and in-flight operation.

In order to manage all control and data transfer between each module, a robust CAN bus is used for inter-module communication, including configuration, mission-critical data transfer and control signal transmission. Four independent Raspberry Pi Zero single-board computers are used for video recording and storage. This allows for validation of each experiment's deployment, as well as the opening of drogue and main parachutes. Communication with the ground station is realized through a radio transceiver operating in the ISM band.

As a means of providing on-board redundancy, a commercial off-the-shelf telemetry computer is used as a backup, allowing for parachute deployment independent of the main computer. Additionally, it allows the verification of data gathered during flight, aiding in post-flight analysis.

This paper covers technical design of the Twardowsky avionics and the philosophy behind its creation followed by a discussion and analysis of its performance during the rocket's test campaign. Conclusions and lessons learned are

presented, along with challenges that had to be overcome during the design process, as well as plans for further development.