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## OVERVIEW OF THE TWARDOWSKY HYBRID SOUNDING ROCKET AVIONICS DESIGN

**Abstract**

For many years, Earth's atmosphere has been an object of interest for scientists and engineers alike. As of late, many student teams have also managed to develop their own solutions and projects, therefore expressing their aspirations to study and analyse low layers of the Earth's atmosphere. One of such projects is Twardowsky, the first hybrid propulsion rocket developed by the Students' Space Association at the Warsaw University of Technology.

The rocket has been constructed as a launcher for small payloads, capable of carrying up to 4 kg of scientific equipment to an altitude of 3000 m. Thus, an ejection system for deployable experiments was developed along with a dedicated electronics system. Furthermore, as opposed to solid rocket motors, hybrid propulsion operation requires information about several of its parameters to achieve the target performance due to its utilization of liquid oxidizer. Successful realization of all aforementioned goals demanded a sophisticated on-board electronics system.

For the purpose of this project, an advanced avionics system was developed, based on a single-board computer with expandable capabilities realised through attaching auxiliary modules. Those include a power management system with on-pad charging functionality, an ignition board with 6 independent pyrotechnic initiation channels and an external sensor board for measuring the parameters of the oxidizer during remote filling and flight. All wiring between these complementary systems is simplified by using a motherboard, which connects all of the modules together and provides an interface for the payload deployment actuator. A robust CAN bus is used for inter-module communication. Four Raspberry Pi single-board computers are used for video recording and storage. Additionally, as a means of providing redundancy, a commercial off-the-shelf telemetry computer is used as a back-up and data verification system. Communication with the ground station is realised through a radio transceiver operating in the ISM band.

The 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 plans for further development.