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THE DESIGN AND ORGANIZATIONAL APPROACH TO A STUDENT-BUILT PARAFFIN-NITROUS OXIDE HYBRID SOUNDING ROCKET

Abstract

This paper presents the final design, testing methods and results, and organizational approach of Helios I, the University of Toronto Aerospace Team (UTAT) Rocketry Division's third-generation sounding rocket. Helios I was developed over a period of 10 months with the objective of delivering a 4.5kg 1U CubeSat scientific payload to 3km above ground level, as part of the 2015 Intercollegiate Rocket Engineering Competition (IREC).

Helios I was powered by the 15 000-Ns 'Kratos I' hybrid rocket engine, which used a mixture of paraffin-carbon black as fuel and nitrous oxide as the oxidizer. Spincastable fuel cartridges and shoulder-bolted assemblies promoted ease of assembly and enabled multiple consecutive static test fires. Modular and robust avionics enabled independent system development, simplicity of design, reparability, and protection from launch vibrations. The external structure that housed the various systems was fabricated using an advanced spread tow-carbon fibre, fibreglass, and foam composite. The payload contained an inertial measurement unit, atmospheric sampling and weather-sensing units, and parachute recovery system, all arranged inside a standard 1U CubeSat. Many of the overall system components, including structural members, internal flows and aerodynamics, engine, and flight performance were simulated through both in-house and commercial software packages. Numerous ground tests were performed to verify these predictions.

The Rocketry Division was headed by two individuals and organized into five subdivisions. The Rocketry Lead was primarily responsible for overall project management, as well as external partnerships with other UTAT divisions, university departments, and corporate entities. The Chief Design Engineer worked in tandem with the Lead to provide administrative support and manage overall rocket design and integration. Five subdivisions comprising Propulsion, Fluids, Avionics, Payload, and Structures executed specific design projects in response to high-level system requirements, as managed by Subdivision Leads. A team of four local high school students was also selected to develop the scientific payload, under the mentorship of undergraduate and graduate students. Further collaboration with the UTAT Outreach Division ensured public engagement through demonstrations, talks, and workshops held at schools and community centres.

Ultimately, robust and innovative design, strategic resource allocation, efficient organizational structure, collaboration with high school students, and extensive public outreach led to a successful technology with high community impact. Helios I was a safe, reliable, low-cost solution for high-altitude payload delivery that further served to educate and mobilize the public.