Development of a Nanosatellite Electrospray Propulsion System Towards Protoflight

Nanosatellites have become a critical asset for the space industry, enabling accelerated technological development at reduced costs and providing resource-limited organizations the opportunity to design, build, launch, and operate satellites. However, the recent trend of nanosatellite proliferation has not been complemented by an abundance of robust and economical propulsion systems due to the challenges of scaling propulsion systems down to meet nanosatellite size, weight, and power constraints. To this extent, electrospray propulsion (ESP) devices are increasingly being used onboard advanced nanosatellites missions. ESP systems are a subclass of electric propulsion systems that use a strong electric field to extract and accelerate charged particles from a liquid propellant to produce thrust. They have the unique advantage of operating on ionic liquids, which are non-offgassing molten salts that retain their liquid form under high-vacuum. This enables ESP devices to bypass the voluminous pressurized propellant management system found in conventional propulsion systems, providing thrust capabilities in a highly-miniaturized form factor — the decrease in system footprint in turn enables either a greater percentage of the nanosatellite to be dedicated to the payload(s) or a smaller overall satellite size.

The preliminary development and testing of a nanosatellite ESP Engineering Model (EM) was recently performed at the Royal Military College of Canada (RMC) Advanced Propulsion and Plasma Exploration Laboratory (RAPPEL) in preparation for protoflight onboard the RMC Audimus CubeSat. The Audmis CubeSat will monitor ice dynamics in the Canadian Arctic Archipelago and is built in collaboration with the Canadian Space Agency through the CUBICS programme. The ESP system was designed to provide trajectory control capabilities and end-of-life deorbiting to the CubeSat. The system employs a novel microfluidic emitter geometry, a custom high-voltage power processing unit, along with bespoke thermal control, telecommand interfacing, and performance diagnostics. Preliminary high-vacuum testing of the system was successfully performed in the RAPPEL high-vacuum chamber, demonstrating system feasibility to meet the mission propulsion requirements. The EM can easily be advanced into a qualification model to complete lifetime, vibration, and thermal vacuum testing in preparation for protoflight, and ultimately provides a foundation for future ESP research initiatives both in Canada and internationally.

Biography: Ivan Savytskyy received his BSc in Astrophysics from the University of Calgary, where he developed ion thruster simulations, built firmware for and tested ionospheric plasma instruments, and participated in student rocketry and nanosatellite teams. He completed his MASc in Aeronautical Engineering and two years of his PhD in Mechanical Engineering at the Royal Military College of Canada, specializing in spacecraft electric propulsion systems. He is currently a space systems engineer with the Canadian Department of National Defence.