Cold Gas Jet Roll Control System Project Proposal

Gabe Paris: RCS Team Lead, Portland State SEDS
Jessica Vinh: Airframe Team Lead, Portland State SEDS
Emilio Gizzi: SEDS Chapter President
February 28th 2021

The Portland State Aerospace Society (PSAS) is the Portland State University chapter of the Students for Exploration and Development of Space (SEDS). We are an open source, interdisciplinary student-led amateur rocketry and satellite project. We plan to launch our latest generation amateur rocket, Launch Vehicle 3.1 (LV3.1), in July of 2021. We would like to fly the vehicle with an active onboard cold gas jet roll control system (RCS). A prototype, non-flyable RCS system was previously designed and tested by a mechanical engineering senior capstone project (Figure 1). We propose to redesign this prototype into a robust, light-weight, flyable system that can be flown on LV3.1 by the July launch deadline. To the best of our knowledge this will be the first cold gas roll control system built by undergraduate students to fly on an amateur rocket.


Figure 1: Capstone's RCS assembly in its testing module.

Project Description and Timeline

We've divided this project into four major phases. Since our last update, we've been focusing on refining our CAD, conducting risk analysis, writing safety documentation and standard operating procedures, and assembling a bill of materials. This places us right at the end of Phase 2 and just starting Phase 3. Phases 1 and 2, already completed, involved researching the previous demonstration system and redesigning the prototype into a flight-ready system.

Phase 3 is to order, fabricate, document, and test components. The new components we receive, such as the regulator and the

solenoid valve, will be individually tested. Initial control system code will be written in this phase, and tested with hardware. Phase 3 is expected to be completed by the end of April 2021.

Phase 4 is integration and system testing of the RCS. Through system testing, we can confirm the system meets our performance requirements. The assembly process will confirm that we meet the space constraints within the module. After the RCS is tested and fits into its flight module, it will be assembled with the full LV3.1 airframe to confirm that the components fit with the rest of the rocket systems. Phase 4 should be complete by the end of June 2021, which will give us enough time to fly the system in the July 2021 launch of LV3.1.

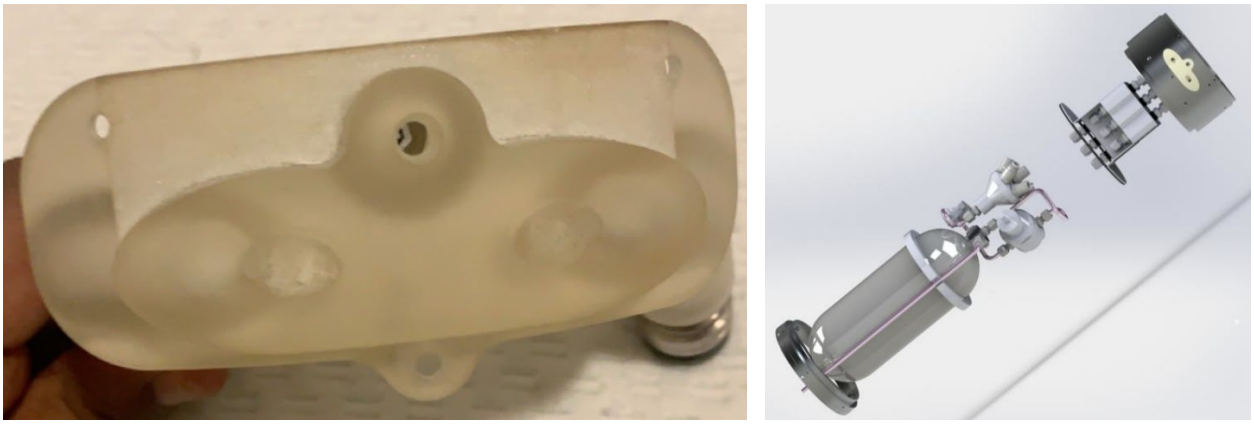

Figure 2: A 3D-printed deLeval nozzle cluster (left) and the full RCS components assembly (right), both designed in CAD.

Benefits of the RCS Project

One of the outcomes of working on this project is that members will have a team-based, interdisciplinary, hands-on engineering project, giving them a well-rounded engineering experience. The RCS will give students hands-on experience with control theory, finite element analysis (FEA), testing and lab procedures, and digital design such as CAD and plumbing & instrumentation diagrams (P&ID). These are all valuable skills, especially for those going into aerospace and other STEM fields. This is one of many projects within PSAS that challenges students to think outside the box, collaborate with students, and network with industry leaders. We are a smaller university and do not receive as much funding as larger schools which pushes students to come up with creative and innovative ideas.

It is uncommon to see a compressed-gas attitude control system on a university-built amateur rocket, which is partly why we want to build one. PSAS has a history of flying things

previously unheard of on amateur rockets in order to test our own capabilities, such as flying Linux on an amateur rocket and flying wi-fi past Mach 1. We want to do so again with the RCS and be the first university in Oregon, and possibly the nation, to fly a cold gas roll control system.

The end goal for the RCS project is to expand it into a full 3 degree of freedom reaction control system for Launch Vehicle 4 (LV4), our entry into the Base11 Space Challenge. The Base11 Space Challenge is a competition between universities to reach the von Kármán line with a single-stage liquid fuel amateur rocket. LV3.1 will be our technology demonstrator, where roll control will be demonstrated first before we demonstrate a system with 3 degrees of freedom (pitch, roll, and yaw).

Requested Budget

We are asking SEDS USA for a $2,100 grant to help cover the costs of purchasing off-the-shelf components, having Aluminum parts fabricated, and doing specialized 3D printing (SLA for deLeval nozzles and SLS for structural components). The budget list (Table 1) provides an estimated cost for each item.

Table 1: Budget list for the Roll Control System, with approximate cost values.

Component	Qty	Approx. Cost	Ext. Cost
Flight weight Pressure Regulator (3500 to 100 psi)	1	$300.00	$300.00
N2 Supply Regulator (8750 to 3500 psi)	1	$300.00	$300.00
High Pressure Relief Valve	2	$60.00	$120.00
Flight tank hydro pressure testing	1	$50.00	$50.00
Test Stand Structure PVC Pipe	5	$8.20	$41.00
Test Stand Structure PVC fittings	10	$2.00	$20.00
12V Solenoid Valve	1	$42.00	$42.00
Nitrogen Gas Supply	1	$140.00	$140.00
DeLeval Nozzle 3D print (3 design spins)	6	$150.00	$900.00
Structural 3D prints from SLS nylon	1	$150.00	$150.00
High Pressure hoses	5	$27.50	$137.50
Total			**$2,100.50**