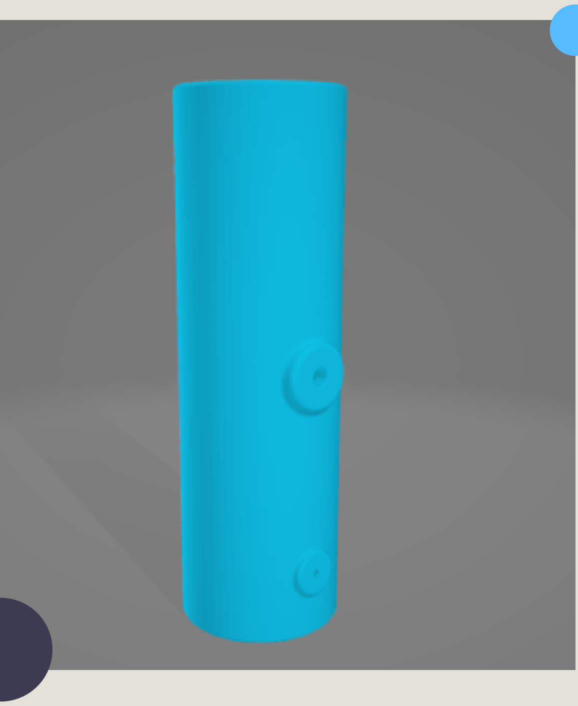
THRUST VECTOR CONTROL

Thrust Vector Control (TVC) is a cutting-edge technology used to manipulate the direction of an engine's thrust, enabling precise control of a vehicle's orientation and trajectory. Commonly utilized in aerospace applications
like rockets, missiles, and advanced aircraft. TVC enables precise control by redirecting the thrust vector, which can be accomplished through mechanical means like gimbaling the engine or fluidic methods that manipulate the jet stream. This capability enhances maneuverability, stability, and responsiveness, especially in dynamic environments where traditional control surfaces may be ineffective.



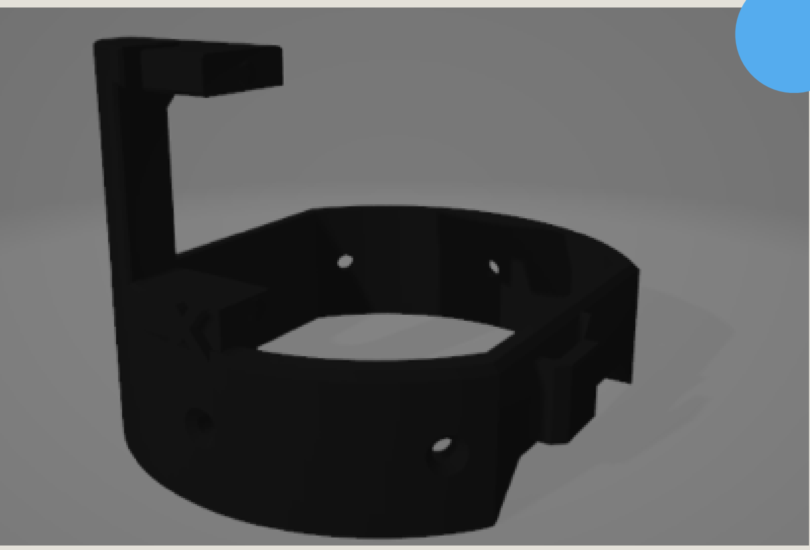
Control is an essential part of aerospace engineering. Without effective control systems, it would be impossible to achieve the fast and safe travel we experience today. This project focused on controlling model rockets using a simple PID controller implemented on a microcontroller. A PID controller is a simple yet powerful tool to manage and adjust a system’s behavior to match a target. It works by continuously comparing the rocket’s current position to where it should be, calculating any "error" and adjusting accordingly.

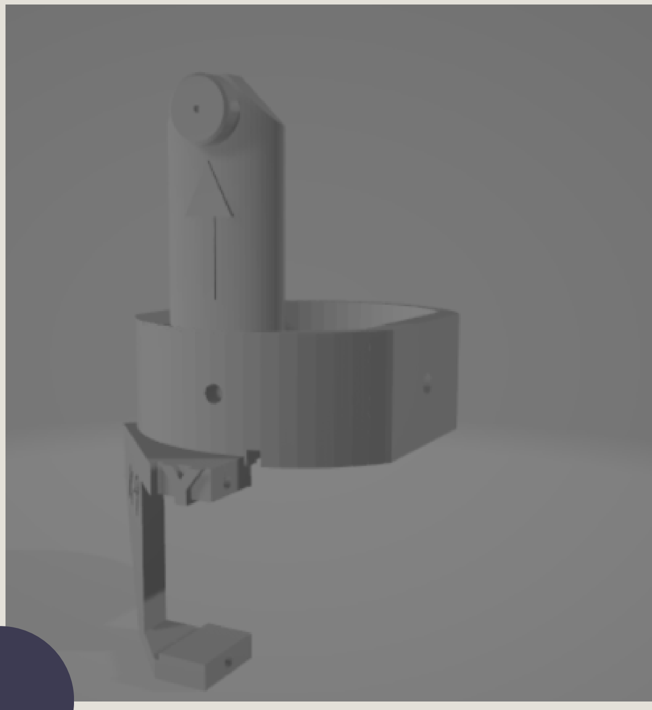
The controller works in three ways: proportional correction for quick adjustments, integral correction to fix past errors, and derivative correction to predict future errors. By balancing these three actions, the rocket can fly smoothly and stay on course. After thoroughly studying the system's dynamics, a mathematical model of the rocket was developed using Simulink, a simulation software. The model incorporated a PID controller to keep the rocket stable and ensure it flew straight vertically. The Simulink model was divided into three main components:

· the thrust block which simulated the rocket's thrust and calculated its distribution;

· the 3DOF block which handled motion parameters

· PID control which maintained the rocket's orientation. Servo delays and response times were added to simulate real-world conditions.





To test the system in the real world, a TVC mount for a model rocket was designed and built. This involved sketching the design, researching rocket motors, and creating a functional mount using CAD software, with reliable components to withstand flight conditions.

Despite achieving a stable model, there was room for improvement. The PID controller could be made adaptive to handle changing conditions like speed and wind, and different settings could optimize performance during various flight stages. Advanced techniques could also address unpredictable behavior, improving reliability. Using a real-time operating system (RTOS) could enhance precision and reduce delays, while fault detection systems and advanced control methods like Model Predictive Control (MPC) or fuzzy logic could make the system more robust and efficient. This project highlighted the critical role of control systems in aerospace engineering and how small adjustments can significantly improve performance and reliability