Overview
This research presents a modeling tool for the rapid-design of CubeSat rendezvous and proximity operation missions. The model is applied to a concept for a low Earth orbit CubeSat constellation designed to demonstrate the technological capability of docking with liquid apogee engines. The model analysis includes:

- An open-loop, fuel-optimal maneuver planner capable of generating controls over a complete orbital period
- A closed-loop, model predictive control (MPC) algorithm capable of locally-fuel optimal trajectories with collision-avoidance measures.
- Computer vision algorithms for relative range finding and translational positioning.

Attitude and Sensor Models
The model includes an attitude controller that reacts to automated trajectory design.
- Model-based attitude actuator sizing for pointing requirements

![Attitude controller diagram](image)

Model predictive control is used for closed-loop control during close-proximity operations and docking with the apogee engine.
- Multi-objective cost function to allow for greater control over the behavior of the deputy spacecraft in proximity operations.

![Model predictive control](image)

• Mixed-integer linear programming for binary constraints allows for binary-thrust control and collision avoidance

Constellation Design Concept
- 3U “target” CubeSat with onboard liquid apogee engine representation
- 6U “active” satellite which acts as the chaser with RPO capability and demonstration technologies.
- Using a cold-gas propellant tank and the presented guidance methods, the 6U is capable of a large rendezvous and several docking attempts.

Summary and Future Work
This work provides the user with the ability to:

- Rapidly design microsatellite RPO concept of operations.
- Evaluate different thruster performance on mission ability.
- Calculate Δv and fuel usage for constrained station keeping. Future improvements and additions to this work include:
- Migration of the work to a system programming language is necessary to benchmark the performance.
- Implementation of a method to convert discrete-time outputs in continuous-time control signals.
- High-precision propagation with corrective measures using similar techniques.