Momentum Management Strategies for Solar Cruiser and Beyond

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NASA MSFC

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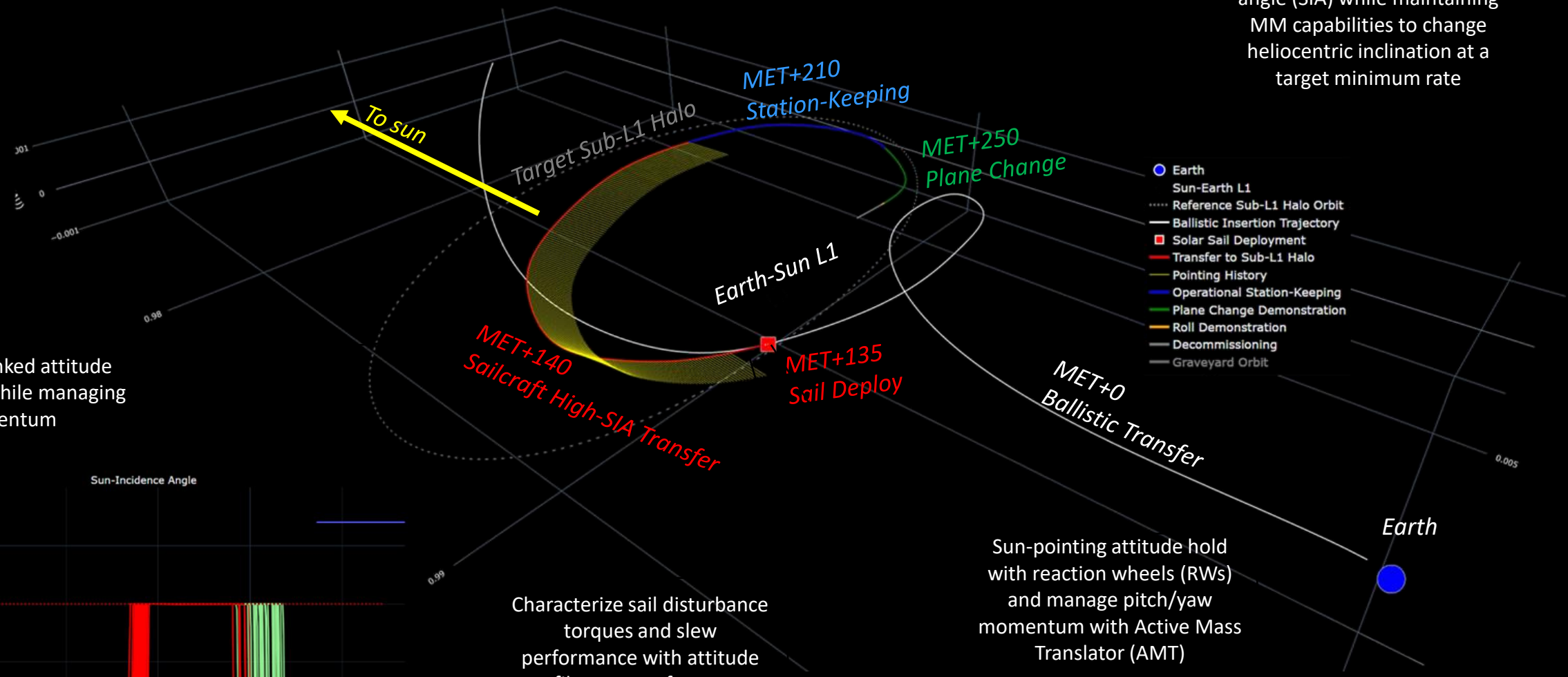
The Solar Cruiser Mission

Total Mission Elapsed Time: ~11 months

Follow uplinked attitude commands while managing momentum

Acquire and hold maximum achievable sun incidence angle (SIA) while maintaining MM capabilities to change heliocentric inclination at a target minimum rate

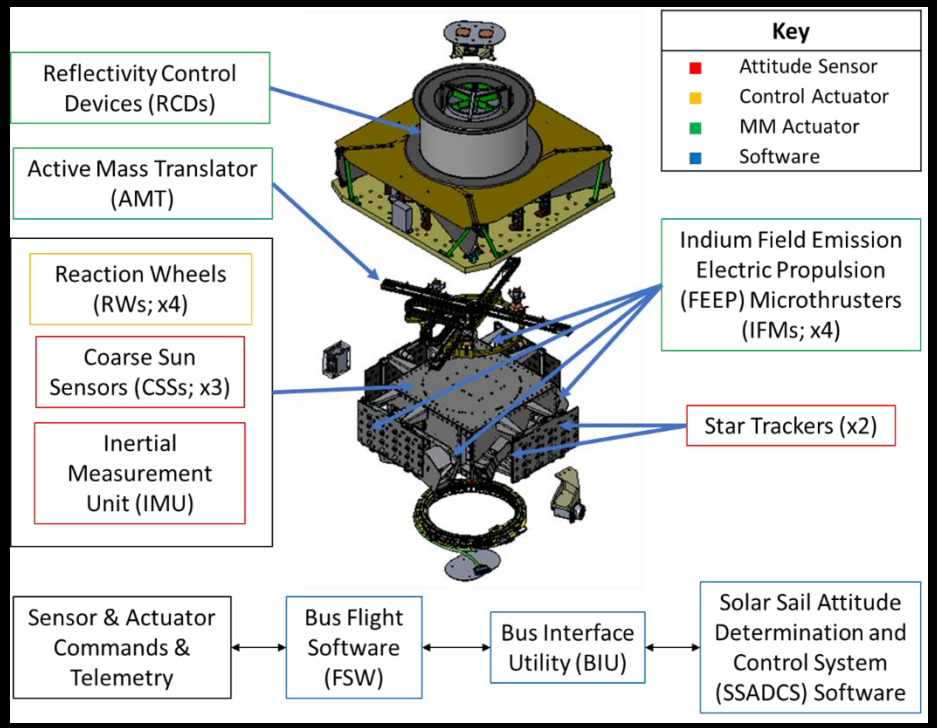


Follow uplinked attitude commands while managing momentum

Characterize sail disturbance torques and slew performance with attitude profile, MM performance, and pointing performance

Sun-pointing attitude hold with reaction wheels (RWs) and manage pitch/yaw momentum with Active Mass Translator (AMT)

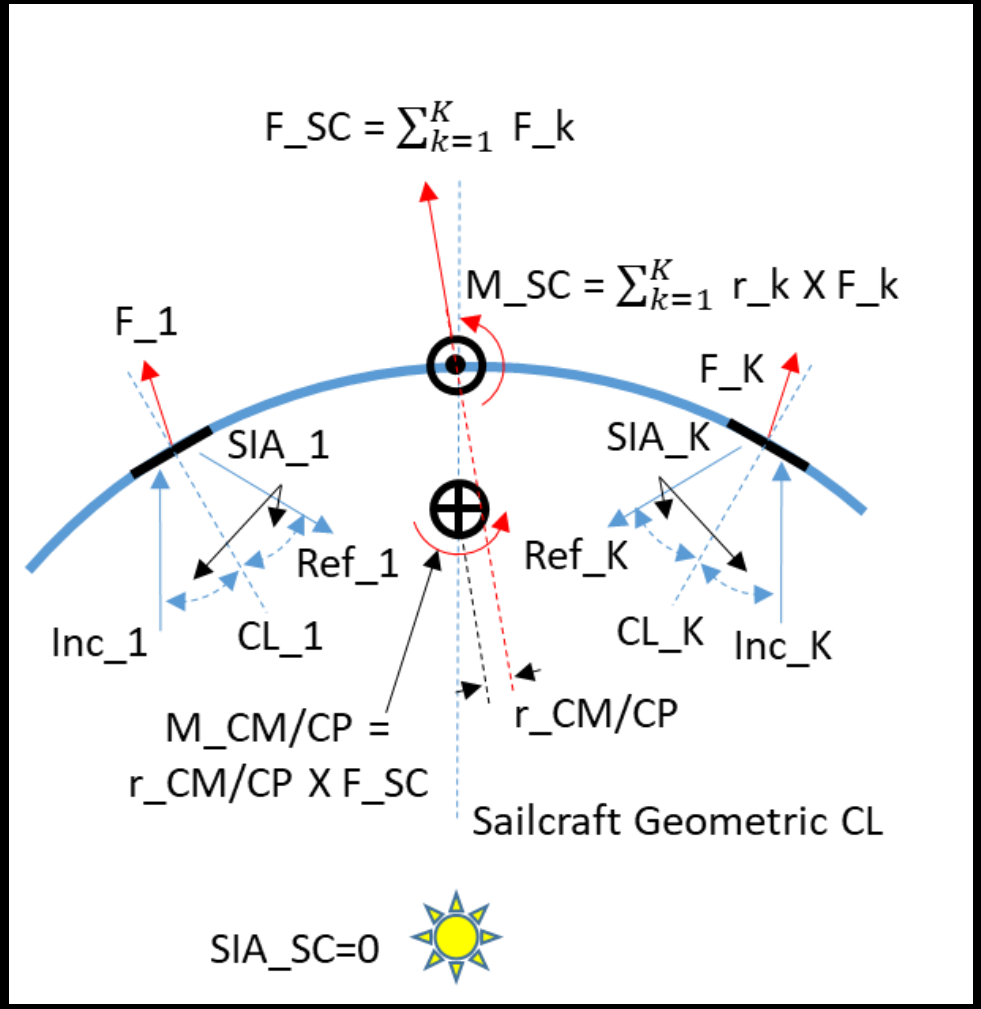
Solar Cruiser ADCS Design



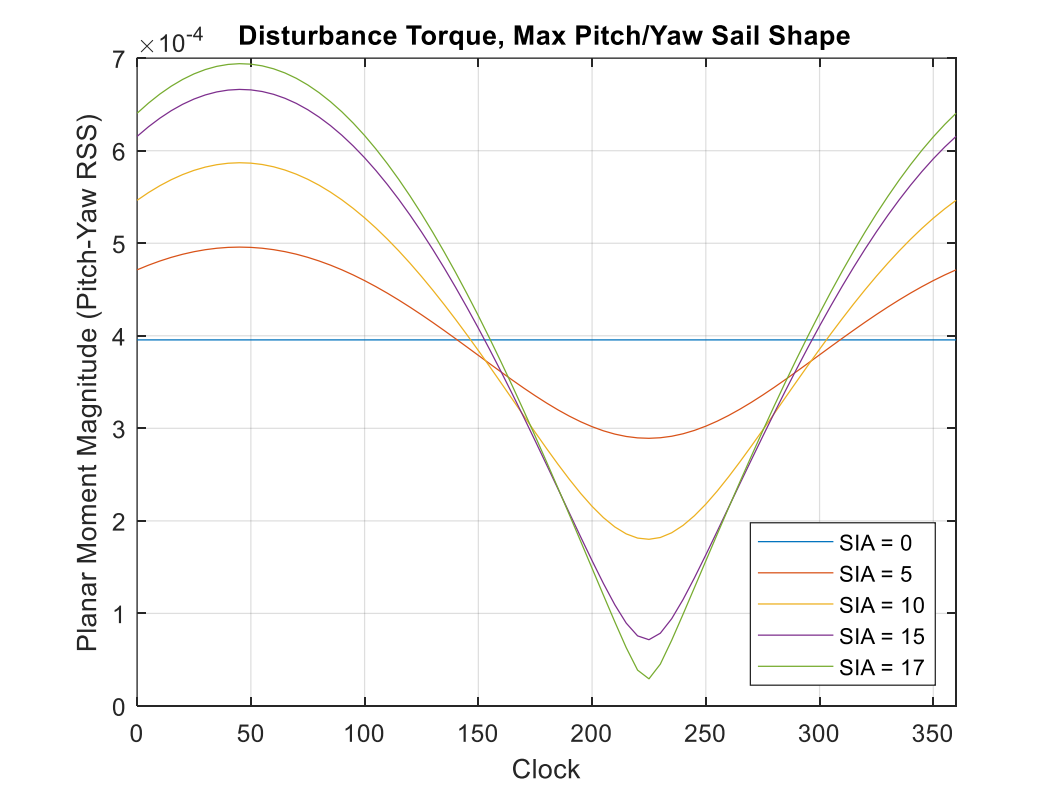
Solar Cruiser featured reaction wheels as the primary means of attitude control with RCDs, AMT, and IFMs for momentum management

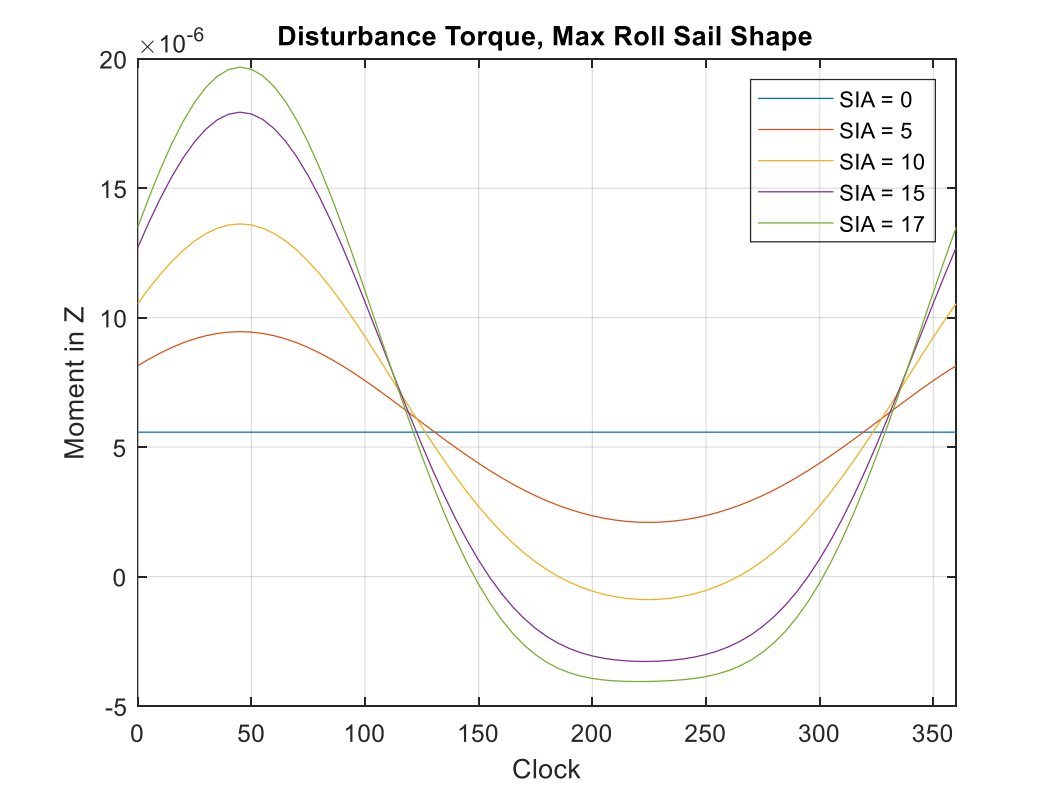
Disturbance Torques Overview

- During the sailcraft's flight, solar radiation pressure builds up momentum from imparting an unequal force on the sail



Disturbance Torques Overview



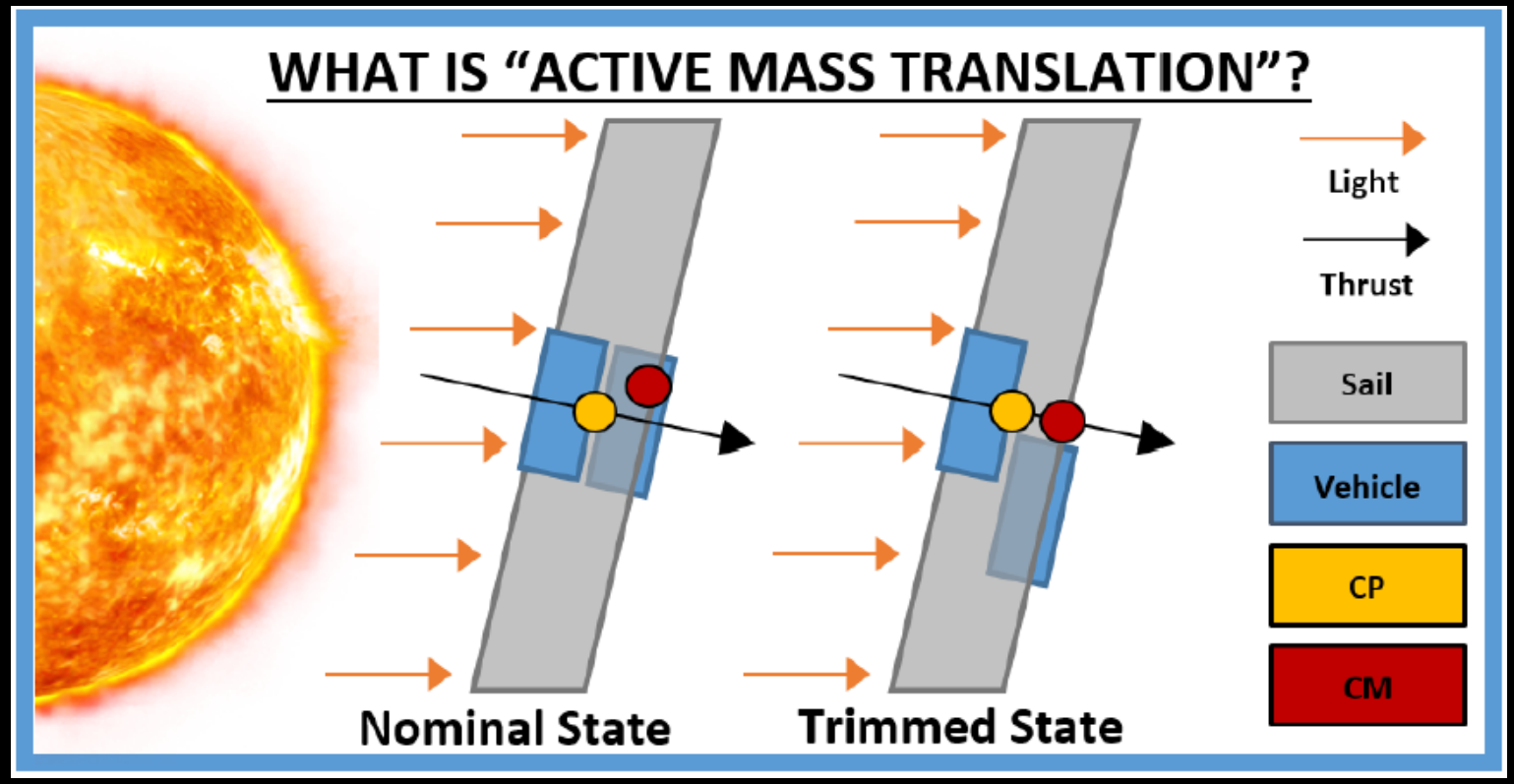


Momentum Management

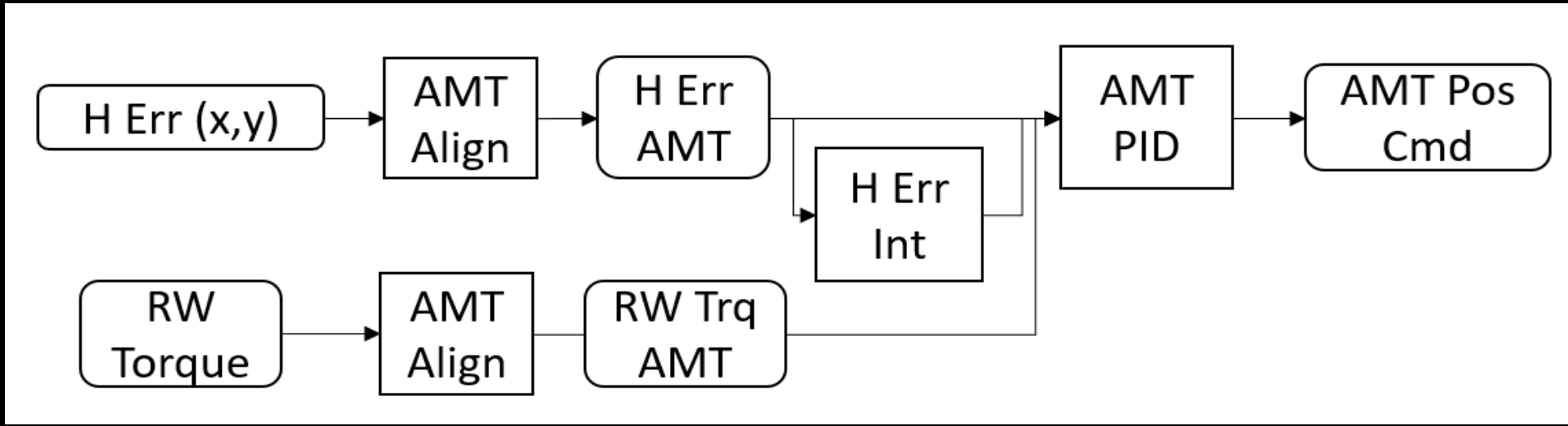
- To control the attitude of the sailcraft, reaction wheels are used which have a finite momentum capability

Active Mass Translator (Pitch/Yaw)

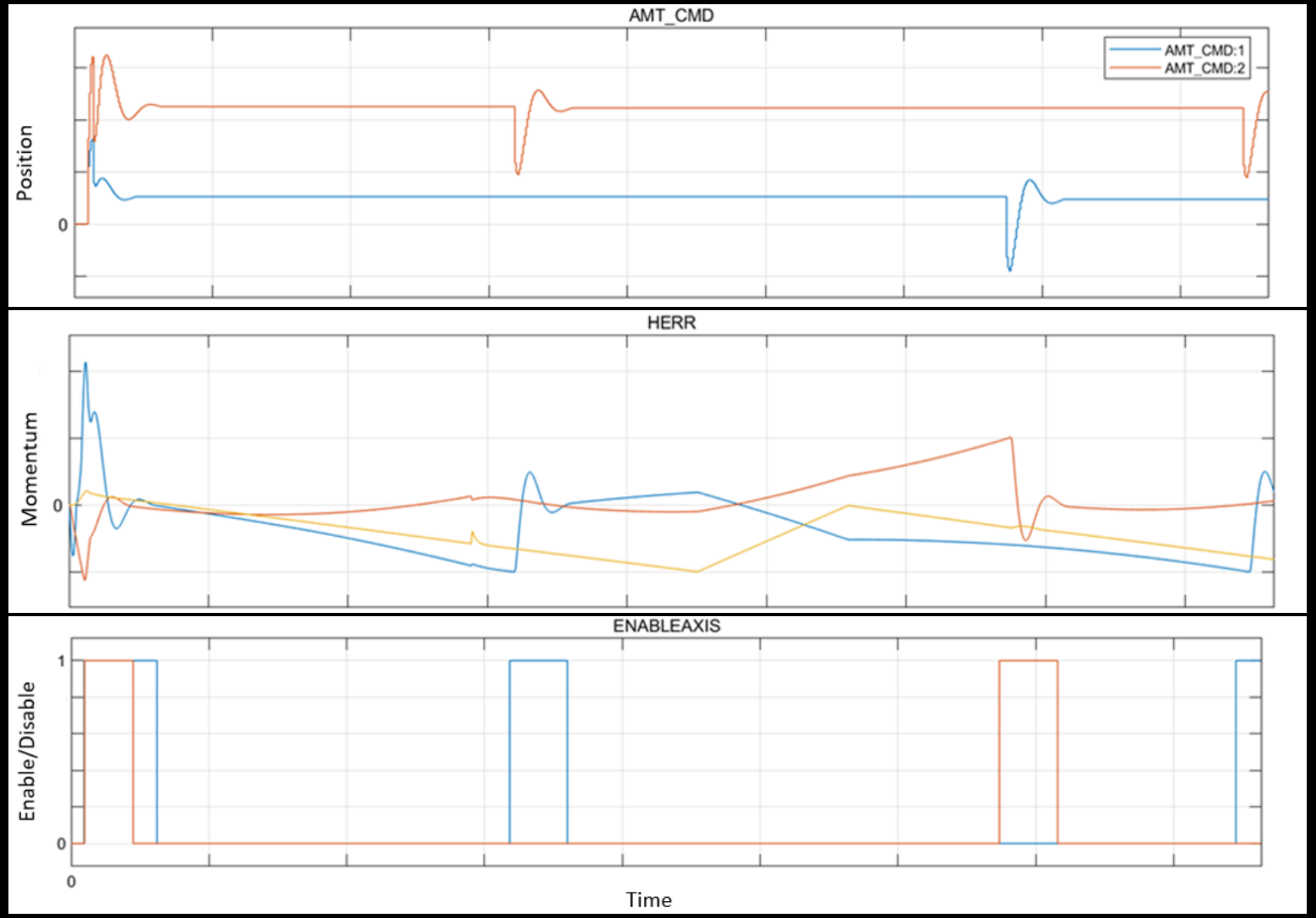
- The AMT moves the center of mass of the spacecraft to “trim” the spacecraft



Active Mass Translator (Pitch/Yaw)

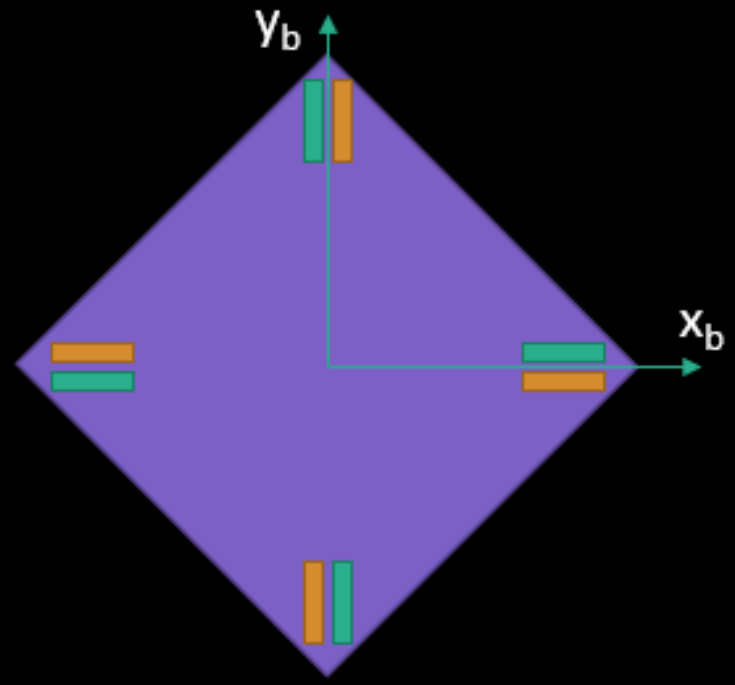


AMT Sim Example

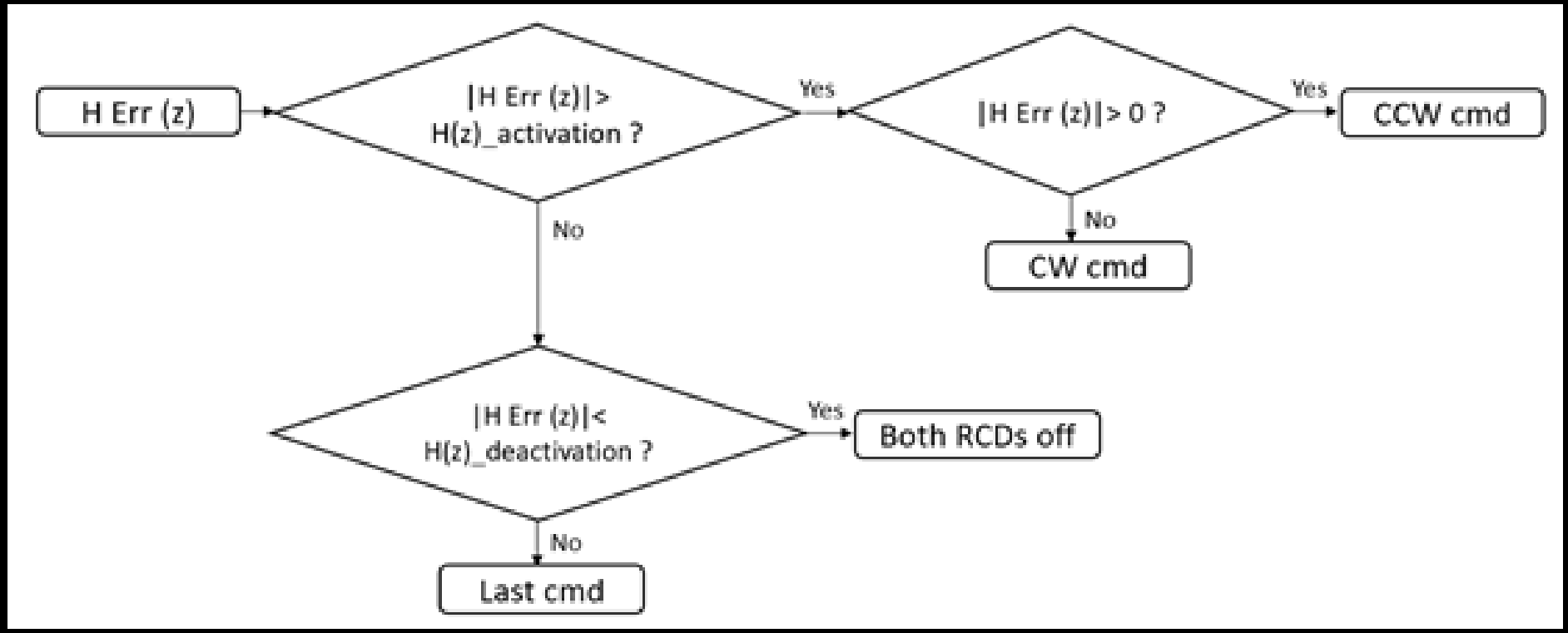


Reflectivity Control Devices (Roll)

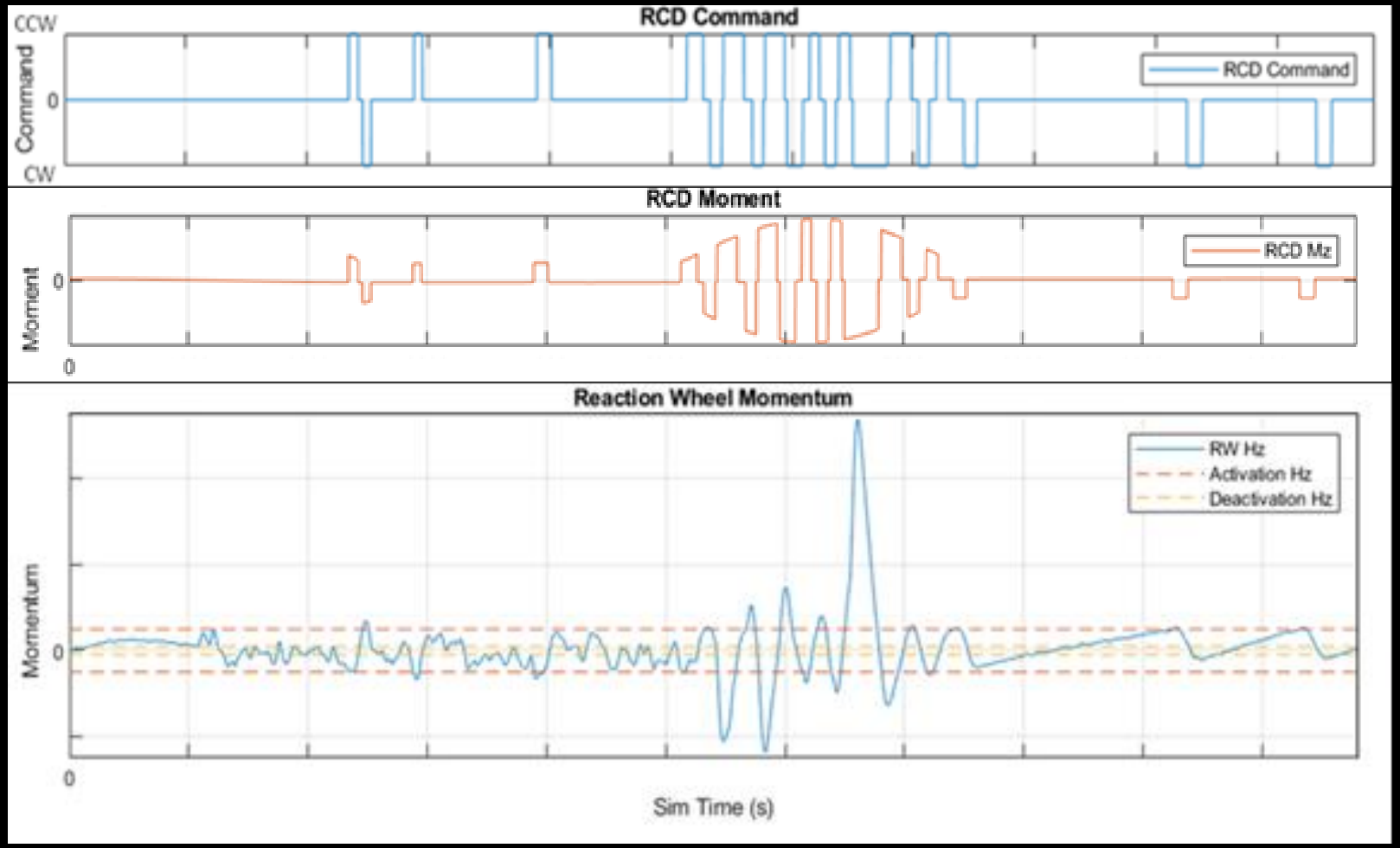
- RCD's work with a section of the sail that the opacity can be controlled. This change in opacity changes the reflectivity of the sail and induces an opposite moment to the saturation



Reflectivity Control Devices (Roll)



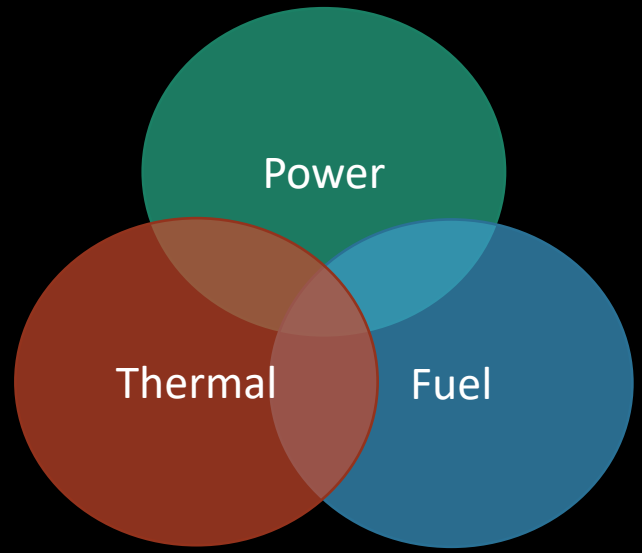
RCD Sim Example



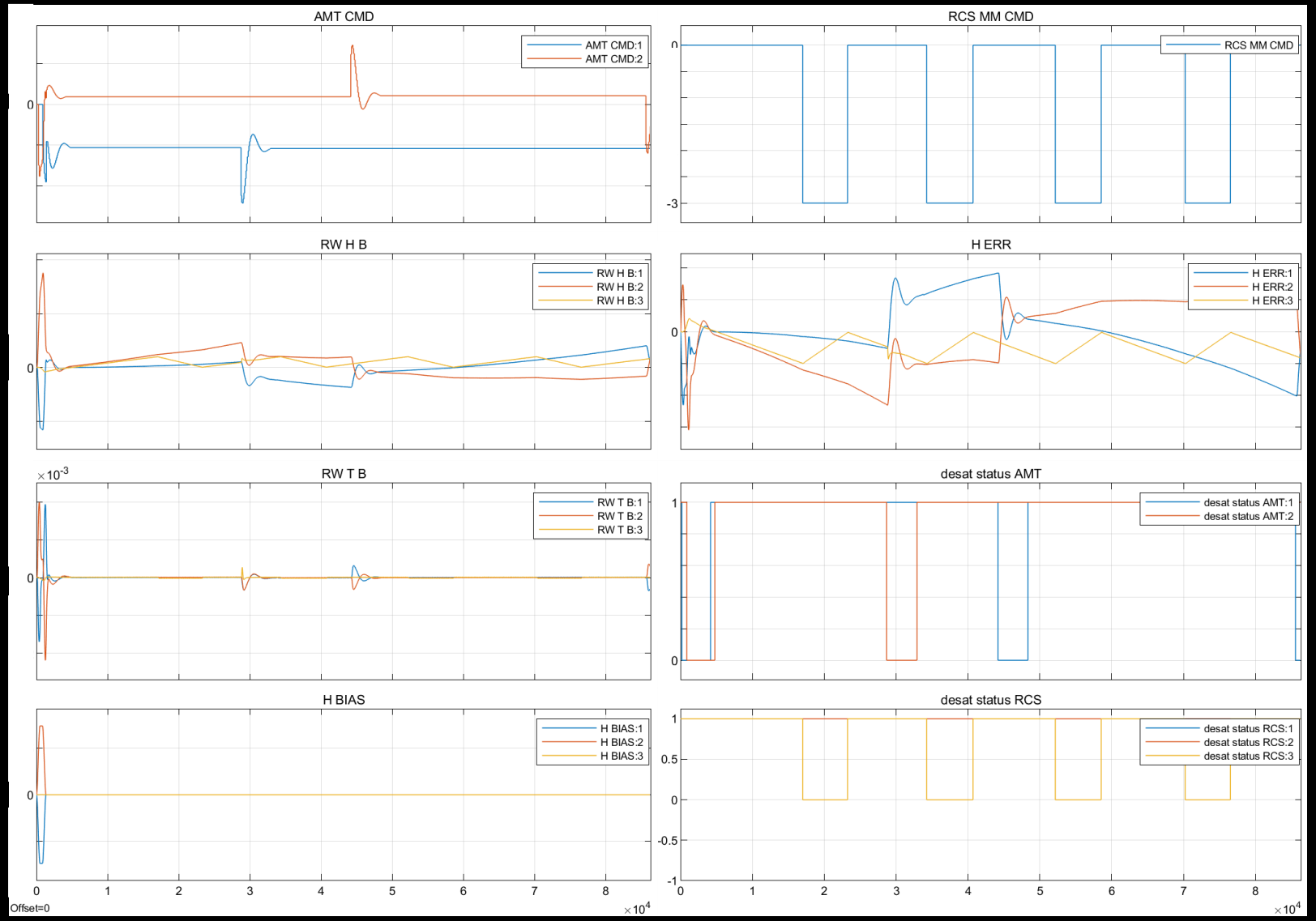
Reaction Control System Thrusters

- Same design principle as RCD's but using thrusters to create the opposite moment

RCS Balance Challenge

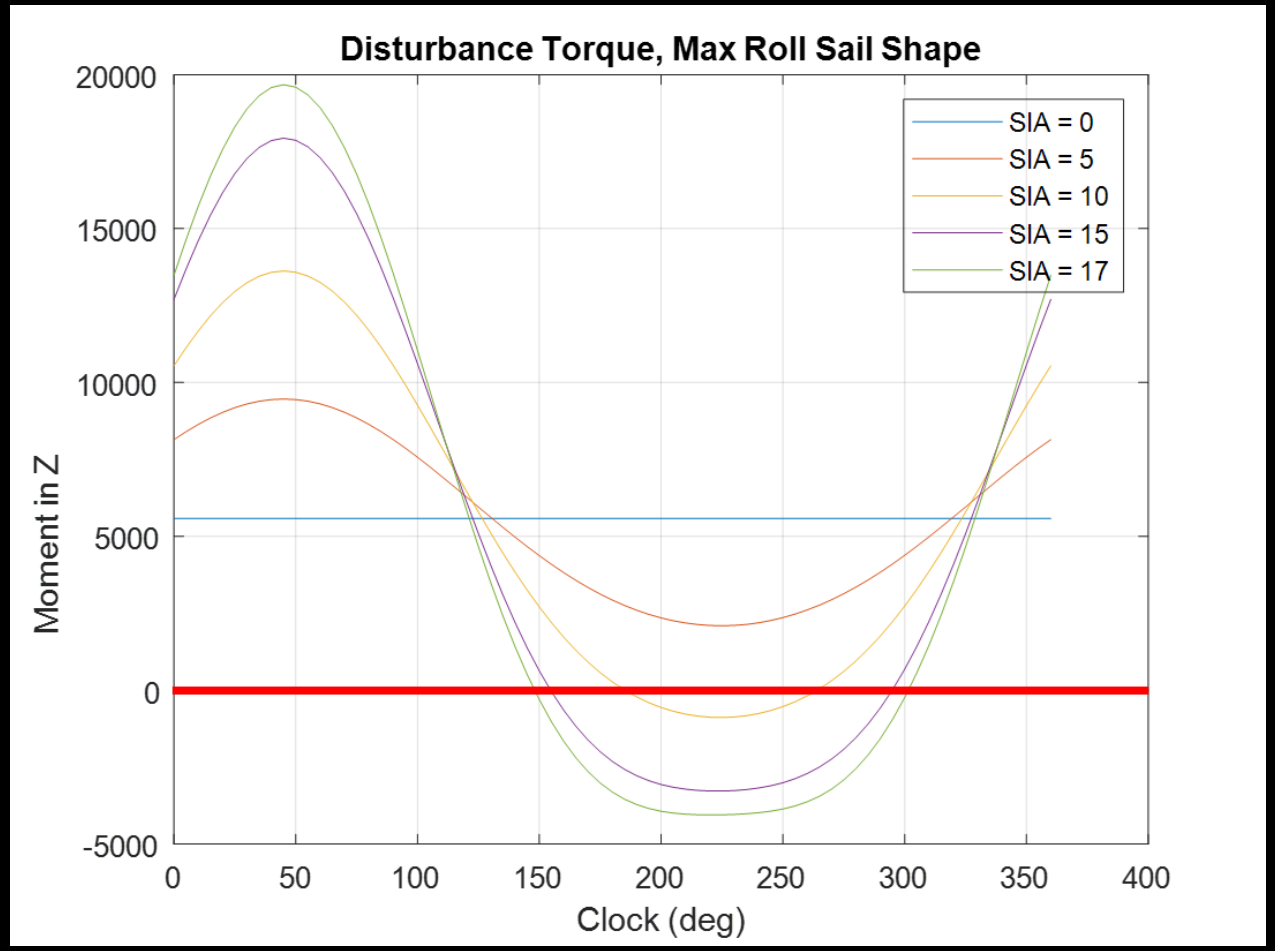


RCS Sim Example



Active Clock (Roll) Control

- Active clock control steps through different clock angles in order to minimize or zero the momentum build up in the roll axis



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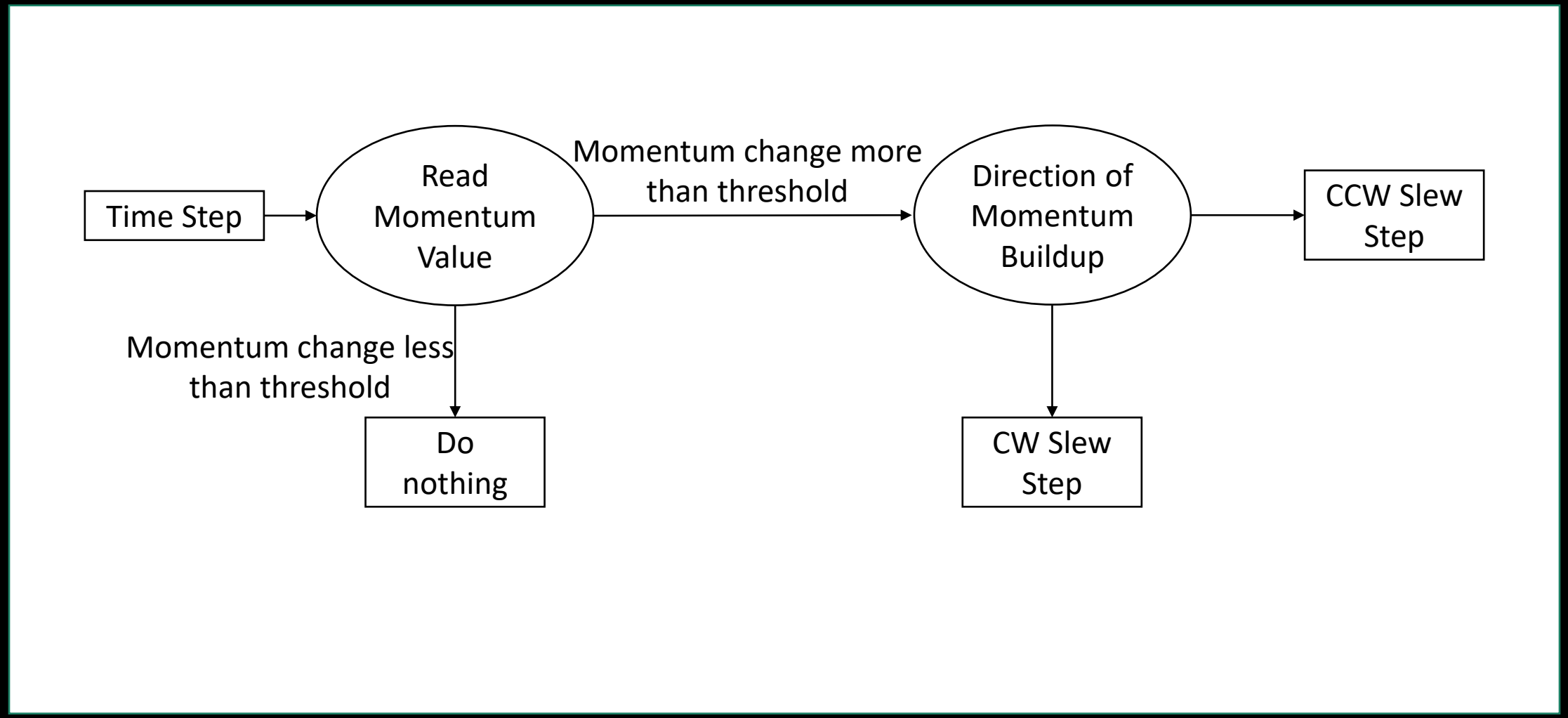
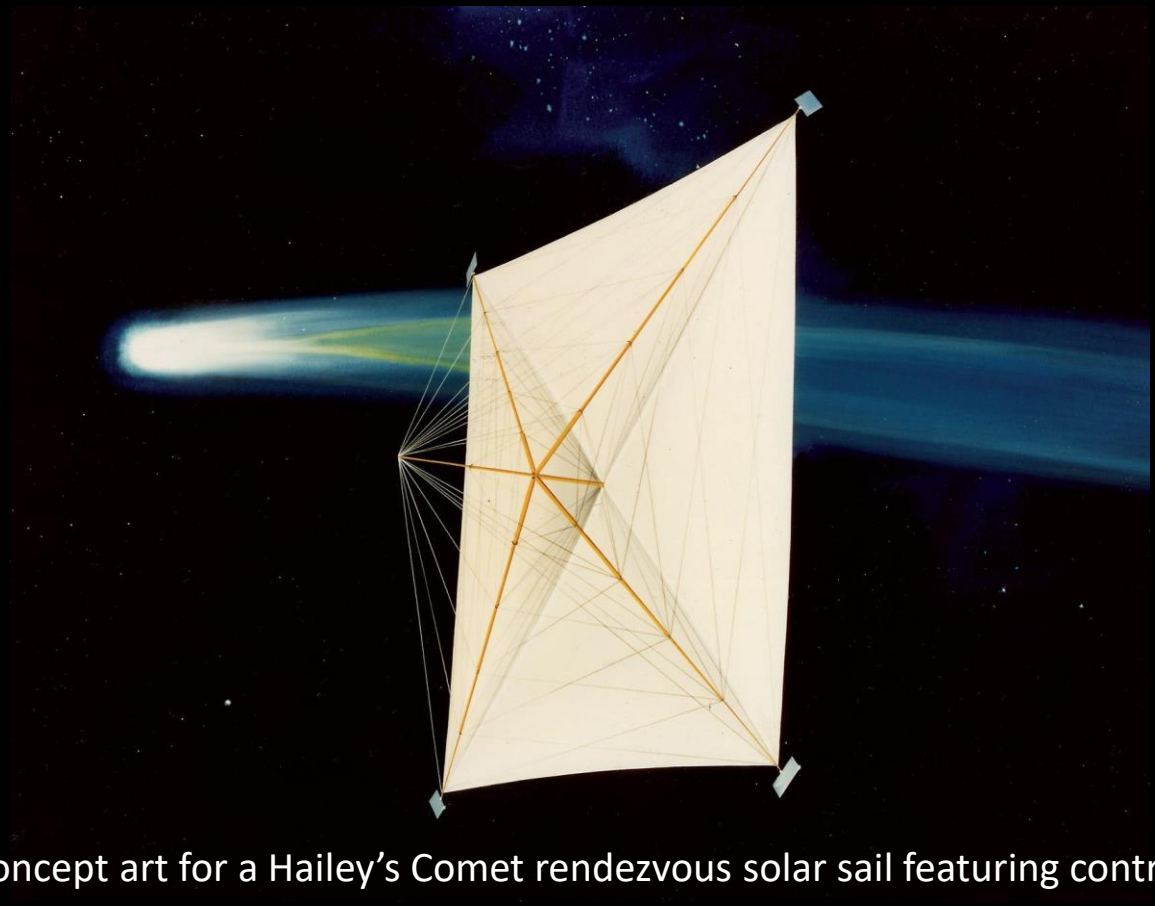


Sailcraft Control Vanes

- Control vanes mounted at the tips of the sailcraft can actuate and create an opposing moment to desaturate the reaction wheels



Concept art for a Hailey's Comet rendezvous solar sail featuring control vanes

Roll Momentum Management Summery

Roll Momentum Management Actuator	Pros	Cons
Reflectivity Control Devices	Low mass, volume, and power requirements	Not flight proven and still under active development
Reaction Control System Thrusters	Commercial offerings readily available	Systems level challenges such as thermal constraints
Active Clock Control	Easily implemented as part of the ADCS design	Potential for no zero-crossing of disturbance torques
Control Vanes	Proven principle, has been flight-proven	Challenges with implementing into a sailcraft

Conclusions and Forward Thoughts

- Momentum management is a crucial part of a sailcraft's ADCS design which ensures controllability throughout a mission
- One solution does not fit all momentum management needs, Solar Cruiser utilizes three different roll momentum management actuators to manage roll momentum and the AMT to manage pitch/yaw momentum

Questions?