



Attitude Determination and Control System

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Period	Tasks and goals
Until next Mid of Semester	<ul style="list-style-type: none">● Verification of Matlab S-I-L● Gain Optimization for ADCS● Analyze Nanoprops operations and maneuver● Produce draft of ADCS operations plan(Integrated Satellite Magnetometer Calibration)● MIST Wiki● HIL Online Orbit Propagator● Familiarization of ADCS new recruits to SIL & HIL - Task Assignment



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Tasks	Status	Updates
Developing HPOP(High Precision Orbit Propagator)	Completed*	
HPOP Functionality for Orbit and Attitude Simulations	In Progress	<ul style="list-style-type: none">1- Documentation in Progress2- NanoProp Attitude Inputs in Body frame**3- Input for ADCS Code**4- Converting Outputs back to TLE(Prediction Tool)**5- Input for Power Budget Code to be added(Julia's Code)6- Temperature Analysis to be integrated(Maria's Code)
Active ADCS HIL Testbeds	Completed*	Documentation in Progress
NanoProp Orbital Simulations	To do	<ul style="list-style-type: none">1-Eccentricity Change Maneuver(Performed & Verified)**2-Altitude Change & e.t.c
Improving SIL Results	In Progress	<ul style="list-style-type: none">1- ADCS Library Import In Matlab(Failed!)*2- Analyzing Error Sources**3- Filter Behavior and Implementation in Matlab**4- Full SIL in Matlab**5- Heavy Documentation in Progress6- Optimization for Tuning



NanoProp & SIL(MSM 2023)



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Active ADCS HIL Testbeds	Completed	Documentation in Progress
NanoProp Orbital Simulations	To do(Not Priority)	1-Eccentricity Change Maneuver(Performed & Verified) 2-Altitude Change & e.t.c
Improving SIL Results	In Progress (~Mid April)	1- ADCS Library Import In Matlab(Failed!) 2- Analyzing Error Sources* 3- Filter Behavior and Implementation in Matlab 4- Full SIL in Matlab* 5- Heavy Documentation in Progress**(Still On-going) 6- Optimization for Tuning



Tasks	Status	Updates
Yaw Motion Analysis	In Progress	1-Recent Bug in EoS Found 2- Code Correction 3- Documentation of Modeling
NanoProp Attitude Simulations	In Progress	1- Disturbance Function ready in C&Matlab 2- Immediately after Full SIL Implementation in Matlab 3-PWPF Modulator in case current ADCS not good enough
Full NanoProp Simulations	To do	
FDIR of NanoProp Helper Board	To do	
ADCS Final ConOps	To do	



Tasks	Status	Updates
SIL & HIL Code Updates Plan	Completed	<ul style="list-style-type: none"> 1- Bug in EoM Found 2- Found the corresponding C headers and Functions 3- Documentation of Modeling(Based on ISIS Library)
NanoProp Attitude Simulations	In Progress (Early May)	<ul style="list-style-type: none"> 1- Disturbance Function ready in C&Matlab 2- Immediately after Full SIL Implementation in Matlab 3-PWPF Modulator in case current ADCS not good enough
Full NanoProp Simulations	To do(Not Priority)	A Combination of Previous Step and Orbital Simulations
FDIR of NanoProp Helper Board & Firing Sequence Testing	To do(Start in May)	Future Test Plans are required if Modulator is required.
ADCS Final ConOps	To do	

Errors Faced:

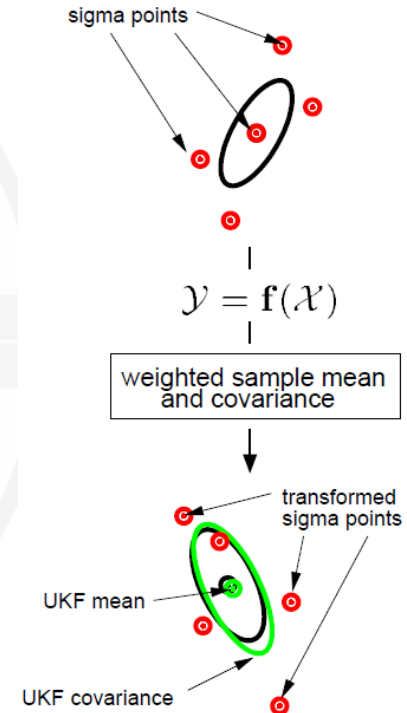
- Unit Vector for Quaternions in Mid-Steps of RK4-Integrator
- Normalization of Sensor Predictions (Sun Vector) Generated While Averaging

$$\mathbf{x}_{k|k-1} = \sum_{i=0}^{2L} W_i^{(m)} (\mathcal{X}_{k|k-1})_i$$

$$\mathbf{x}_{k|k-1} = \left[\left(\frac{\sum_{i=0}^{2L} W_i^{(m)} (\mathcal{X}_{k|k-1})_{1-4,i+1}}{\left\| \sum_{i=0}^{2L} W_i^{(m)} (\mathcal{X}_{k|k-1})_{1-4,i+1} \right\|} \right)^T \left(\sum_{i=0}^{2L} W_i^{(m)} (\mathcal{X}_{k|k-1})_{5-7,i+1} \right)^T \right]^T$$

- Quaternion Multiplication while computing adaptive Q
- Full Updated Quaternion based on Quaternion Multiplication after Kalman Gain
- Normalization of Sensor Predictions (Sun Vector) While Averaging

UKF



Errors Faced:

- Disturbance and Command Vector additional rotation vector from OCF to ECI
- **Off Duty Cycle Control Torque Implementation for Sigma Points**

$$\left(\chi_{k|k-1}\right)_i = \text{RK4}\left(\left(\chi_{k-1|k-1}\right)_i, {}^c\mathbf{N}_{ctrl,k-1}, Ts, steps\right), i = 1, \dots, 2L + 1$$

Debug Plan:

- A test sequence of pairings and matchings of code parts(Control & Estimation Decoupling)
- Switch to simpler Filter(Original Kalman Filter) for local variable check



Remaining Question in terms of Verification(for ISIS):

- IGRF or Dipole in Sensor Model
- Quaternion Estimation w.r.t to ECI or OCF
- Multiple Model for Eclipse and Sunlight or One(Implemented version has 1)
- Additional Propagation Model Terms(GG, Albedo, ...)
- PhdtoSS Function Methodology





Division of work

- **Maheen: adding features in the AOCS using functionalities of ISIS library**

Aniruddh: writing a test plan for proper calibration of integrated Magnetometer

- Methodology for running SIL and HIL on (meetings were arranged with previous ADCS-subteam in the integration lab)
- Familiarising with the C code of AOCS that previous MIST teams have developed

Goals before end of semester:

- A comprehensive understanding of general ADCS setup
- Adding the feature of Online Orbit propagation and TLE update (must be approved)