National Aeronautics and Space Administration

On Board Autonomous Health Assessment

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Strategic Initiative

Project Objective:

Demonstrate state-of-the-art Diagnostic Reasoning technology MONSID (Model-based Off-Nominal State Identification and Diagnosis) on flight hardware:

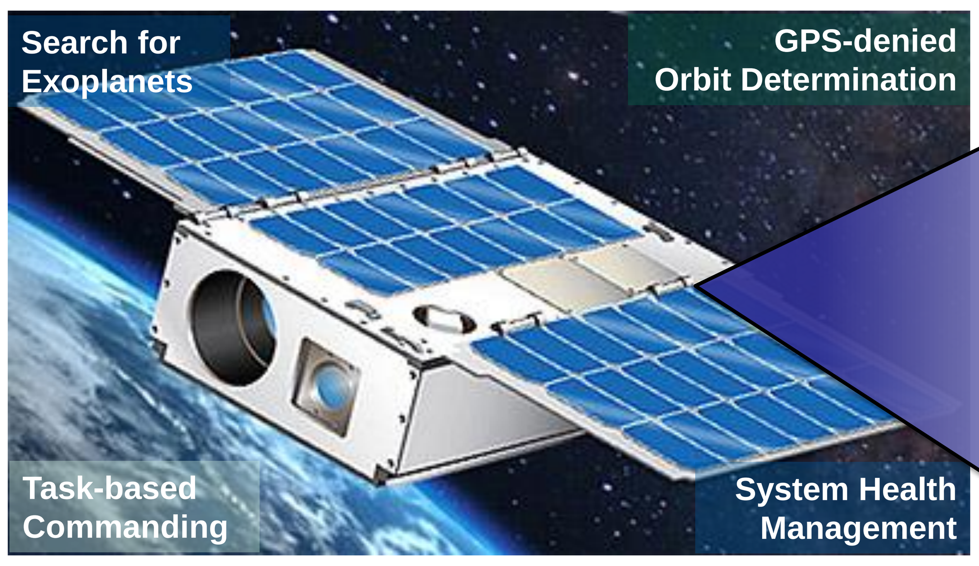
1. Advance the *state-of-the-art in diagnostic modeling* by showing new modeling techniques are sufficient and effective for modeling a realistic, complex flight subsystem
2. Enable *near-term flight demonstration* of on-board, real-time fault management by modeling key components of the Blue Canyon XACT Attitude Control subsystem
3. Enable *system-level autonomy* by providing a health reasoning capability within the autonomous control loop, capable of providing detailed status information in support of on-board recovery and activity replanning

FY19 Results:

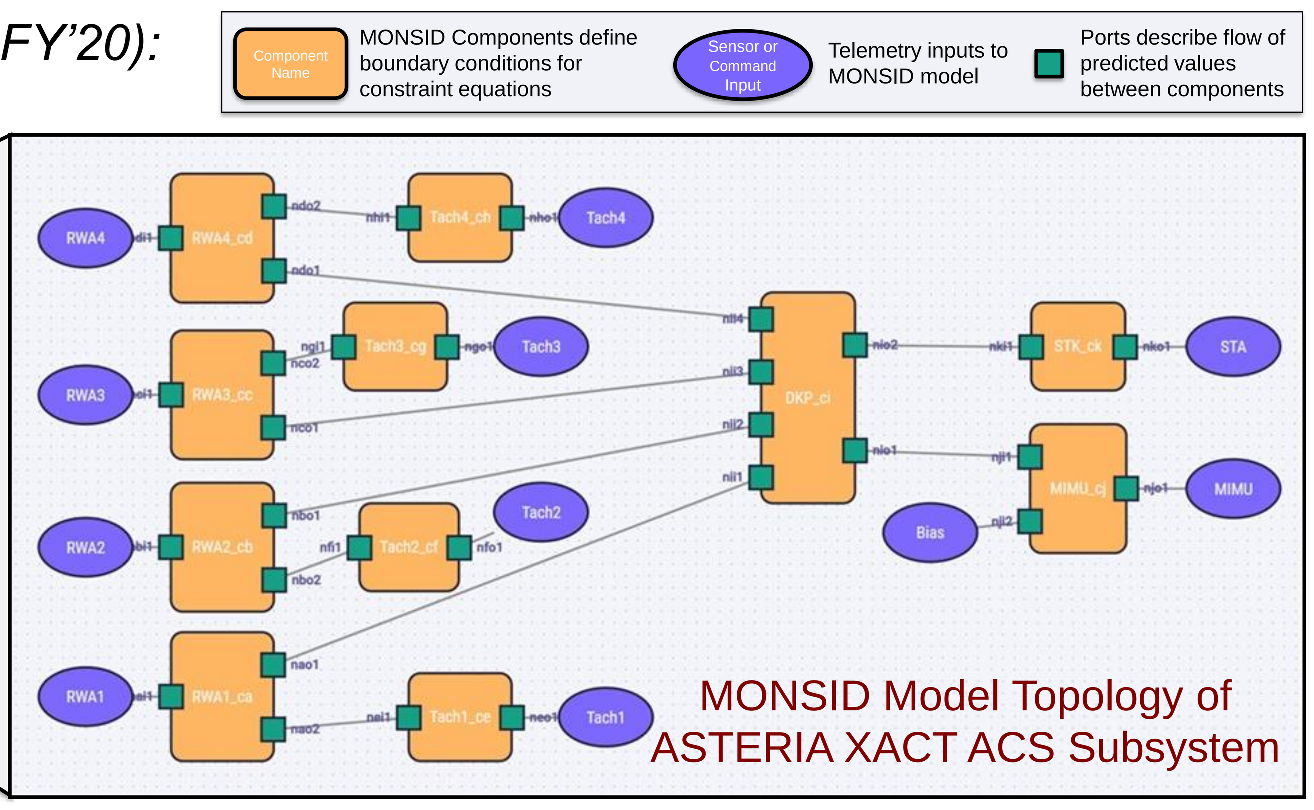
- Captured ASTERIA XACT telemetry at high rate (5 Hz) to provide accurate assessment of spacecraft dynamics as they would appear to an on-board reasoning system
- Developed MONSID models for full suite of ASTERIA ACS components:
  1. Inertial Reference Unit: Relates gyro readings to estimated spacecraft pointing and rates
  2. Reaction wheels: ASTERIA has three reaction wheels used for pointing and rate control
  3. Tachometers: Separated from the reaction wheel model components to allow disambiguation of wheel behavioral faults from wheel sensor faults
  4. Sun sensors: Relates diode readings and pointing estimates to other sources
  5. Magnetorquers: Simple models relating magnetorquer commands to spacecraft torques
  6. Magnetometer: A simple model component to treat magnetometer faults that lead to incorrect field readings, thus altering magnetorquer performance or skewing expected response
  7. Star tracker: Relates spacecraft motion to star tracker results, also accounts for star tracker availability (viz. star tracker faults, sun / moon / earth in view)
  8. Dynamics Pseudocomponent: Models spacecraft physical parameters and environmental contribution to spacecraft behavior (e.g., solar pressure, aerodynamic forces, external disturbances)
- Tested MONSID constraint models against captured flight data

Benefits to NASA and JPL (or significance of results):

Enables flight test of MONSID on board ASTERIA (Q2-3 FY'20):



3x/5x ASTERIA In-Flight Autonomy Technology Development

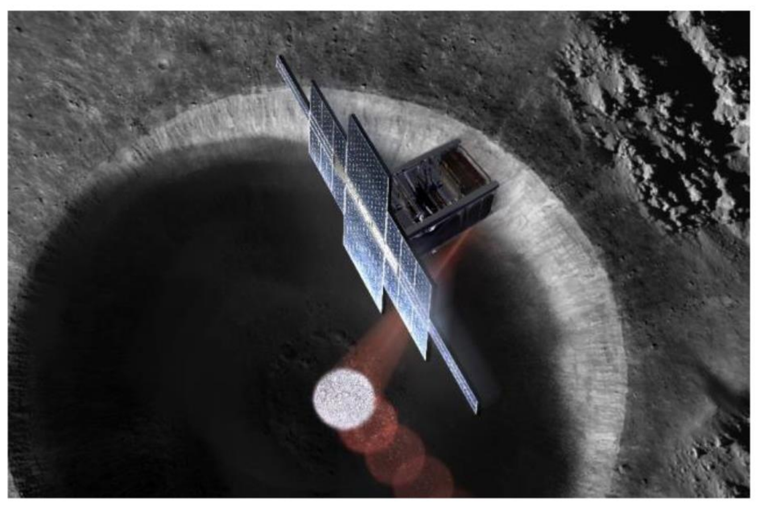


MONSID Model Topology of ASTERIA XACT ACS Subsystem

Flight Experiment Significance:

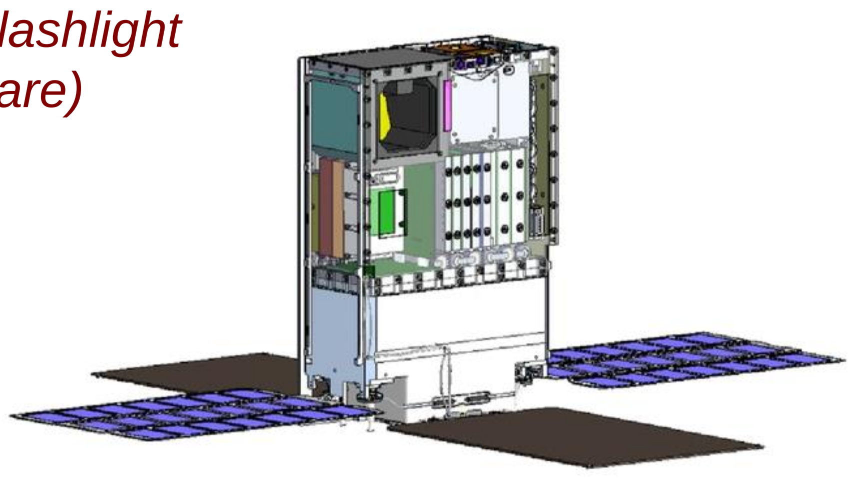
- Prove model-based diagnosis technology in flight operations
- Pioneer integration of fault management reasoning technology into modern F Prime flight software
- Demonstrate the potential of complete flight system autonomy through coordinated follow-on experiments with related on-board autonomy technologies (viz., planning and autonomous navigation)
- Develop reusable ACS models for future missions, especially Cubesats

Successful flight demonstration will ready on-board diagnostic reasoning for challenging missions:



Possible Infusion: Lunar Flashlight (Common ACS Hardware)

- Accelerate detection and diagnosis of faults to keep pace with ambitious ops schedules
- Provide an autonomous approach to avert mission-ending failures where full hardware redundancy is impractical / unaffordable
- Enable autonomous control to fully recover or maximize science collection through transient faults



Possible Infusion: MSL / Mars 2020 Extended Mission (Leveraging 2018 Athena testing)

- Enable scientist-led control of rovers by ensuring safe, goal-based autonomous operation in challenging environments
- Detect and characterize soft failures caused by wear, terrain, or behavioral uncertainty
- Extend the practical duration of unattended operations

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