Solar Imaging Radio Array (SIRA)

Attitude Control System

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Competition Sensitive

SIRA Mission Summary

Integrated Mission Design Center

Mission Description	16 Microsat Constellation Image low frequency events on the Sun 2 Year Lifetime	
Drivers	Cost (~2M per spacecraft) Formation Flying	
ACS Requirements	Pointing Knowledge (3s): Pointing Control (3s):	1 deg 2 deg
ACS Type	Baseline: Earth Pointing Three-Axis Stabilized Option 1: Sun Pointing Three-Axis Stabilized Option 2: Earth Pointing Spinner (~1 RPM)	
Orbit	Distant Retrograde Orbit (DRO) at 60-150 RE	
Mass	12 kg	
Cross-Sectional Area	2.6 m^2	

Microsat Baseline ACS Design

- **Description**
  - Point spacecraft z-axis (yaw) at the Earth for communications.
  - Solar arrays are articulated to track the Sun.
- **ACS Architecture**
  - Three-axis stabilized with momentum bias.
  - Star tracker will provide three axes of attitude information.
  - Sun sensor will provide safehold capability if desired.
  - Y-axis (pitch) wheel will provide gyroscopic stiffness and Earth tracking.
  - Thrusters will control wheel momentum and X/Z-axes (roll/yaw) attitude control

	Specifications	TRL	Mass (kg)	Avg Power (Watts)	Peak Power (Watts)	Safehold Power (Watts)	Cost ($K)
ACS Sensors							
AeroAstro Miniaturized Star Tracker (1)	100 arcsec (3σ)	4	1.0	1.0	1.0	1.0	150
AeroAstro Medium Sun Sensor (1)*	< 1 degree (3σ)	9	1.0	0.5	0.5	0.5	15
ACS Actuators							
Dynacon MicroWheel 200 (1)	0.18 N-m-sec/30 mN-m	6	1.0	2.1	3.2	2.1	30
TOTAL			3.0	3.6	4.7	3.6	195

* Optional but recommended for power-positive Safehold capability.

Microsat Option 1 ACS Design

- **Description**
  - Point spacecraft z-axis (yaw) at the Sun for body mounted solar arrays.
  - Rotate the spacecraft once per day to Earth pointing for communications.
- **ACS Architecture**
  - Three-axis stabilized with zero momentum bias.
  - Star tracker will provide three axes of attitude information.
  - Sun sensor will provide safehold capability if desired.
  - X,Y and Z-axis wheels will attitude control for pointing and maneuvers.
  - Thrusters will unload reaction wheel momentum to avoid saturation.

	Specifications	TRL	Mass (kg)	Avg Power (Watts)	Peak Power (Watts)	Safehold Power (Watts)	Cost ($K)
ACS Sensors							
AeroAstro Miniaturized Star Tracker (1)	100 arcsec (3σ)	4	1.0	1.0	1.0	1.0	150
AeroAstro Medium Sun Sensor (1)*	< 1 degree (3σ)	9	1.0	0.5	0.5	0.5	15
ACS Actuators							
Dynacon MicroWheel 200 (3)	0.18 N-m-sec/30 mN-m	6	1.0 ea.	2.1 ea.	3.2 ea.	2.1 ea.	30 ea.
TOTAL			5.0	7.8	11.1	7.8	255

* Optional but recommended for power-positive Safehold capability.

Microsat Option 2 ACS Design

- **Description**
  - Point spacecraft z-axis (spin axis) at the Earth.
  - Body mounted arrays will provide power.
- **ACS Architecture**
  - Spin stabilized
  - Star tracker will provide three axes of attitude information.
  - Sun sensor will provide safehold capability if desired.
  - Thrusters will and provide spin axis pointing and active nutation damping.

	Specifications	TRL	Mass (kg)	Avg Power (Watts)	Peak Power (Watts)	Safehold Power (Watts)	Cost ($K)
ACS Sensors							
AeroAstro Miniaturized Star Tracker (1)	100 arcsec (3σ)	4	1.0	1.0	1.0	1.0	150
AeroAstro Medium Sun Sensor (1)*	< 1 degree (3σ)	9	1.0	0.5	0.5	0.5	15
TOTAL			2.0	1.5	1.5	1.5	165

* Optional but recommended for power-positive Safehold capability.

Microsat ACS Labor Cost

- ROM cost based on four year design, build, and test effort for 16 s/c

- A study is underway as part of the ST5 program to quantify recurring and non-recurring cost for building multi-spacecraft constellations.

GN&C Systems Engineering 1 Person @ 150K Full Time Equivalent	4 years x 150K = 600K
ACS/Propulsion Design and Analysis Labor 1 People @ 150K Full Time Equivalent	4 years x 150K = 600K
ACS Hardware Labor 2 People @ 150K Full Time Equivalent	4 years x 2 x 150K = 1200K
Hybrid Dynamic Simulator Labor 1 Person @ 150K Full Time Equivalent	4 years x 150K = 600K
Integration and Testing Labor 2 People @ 150K Full Time Equivalent	4 years x 2 x 150K = 1200K
TOTAL	4200K

Clustered Cruise Phase ACS

- **Description**
  - Control the propulsion module for the clustered configuration during delta v maneuvers.
  - Use separate thruster drive electronics mounted in propulsion module.
- **ACS Architecture**
  - Three-axis stabilized
  - Microsat mounted star tracker will provide three axes of attitude information.

	Specifications	TRL	Mass (kg)	Avg Power (Watts)	Peak Power (Watts)	Safehold Power (Watts)	Cost ($K)
ACS Sensors							
AeroAstro Miniaturized Star Tracker (1)	100 arcsec (3σ)	4	N/A*	1.0	1.0	1.0	N/A*
ACS Actuators							
100 lbs Thruster Valve Driver Card (1)		9	1	4.7	85.2	4.7	200
5 lbs Thruster Valve Driver Card (1)		9	1	4.7	85.2	4.7	200
TOTAL			2	10.4	171.4	21.0	400

*Mass and cost of the star tracker are accounted for in the microsat budget.

Issues and Concerns

- Currently there is an effort underway to produce low cost/power/mass star trackers for microsat and nanosat constellation mission. The AeroAstro tracker was shown here but the Active Pixel Sensor under development at NASA-GSFC could also be considered. Contact: Bob Spagnola (301) 286-3122.

- With four cold gas thrusters on each microsat a maneuver will have to be performed for each delta v during constellation maintenance. Twelve thrusters would be required to allow for complete 6 dof control.

- Interference of microsats in the field of view of the star trackers should be investigated.