Small Spacecraft Attitude Control & Propulsion Systems

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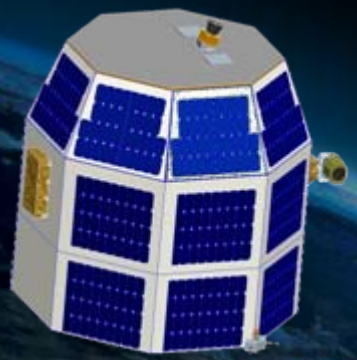
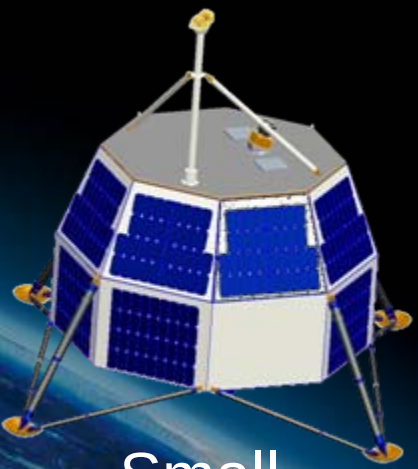
Common Spacecraft Bus – Modular Approach

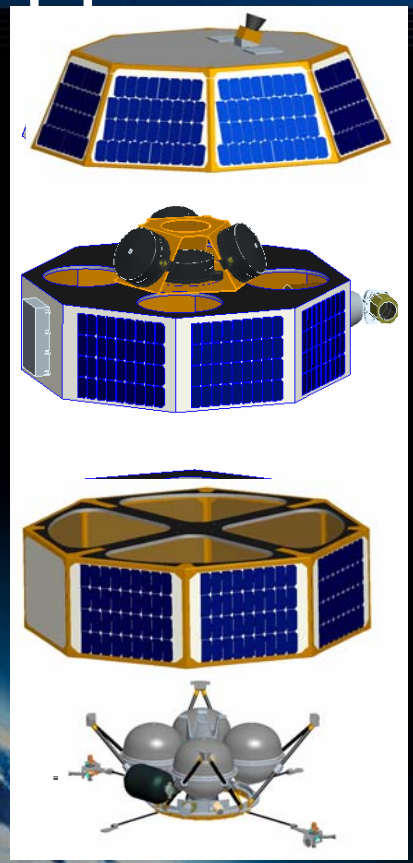
Orbiter





Small Lander

Featherweight Lander

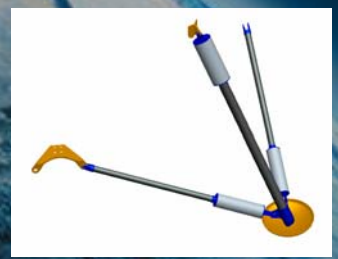


Bus Module

Payload Module

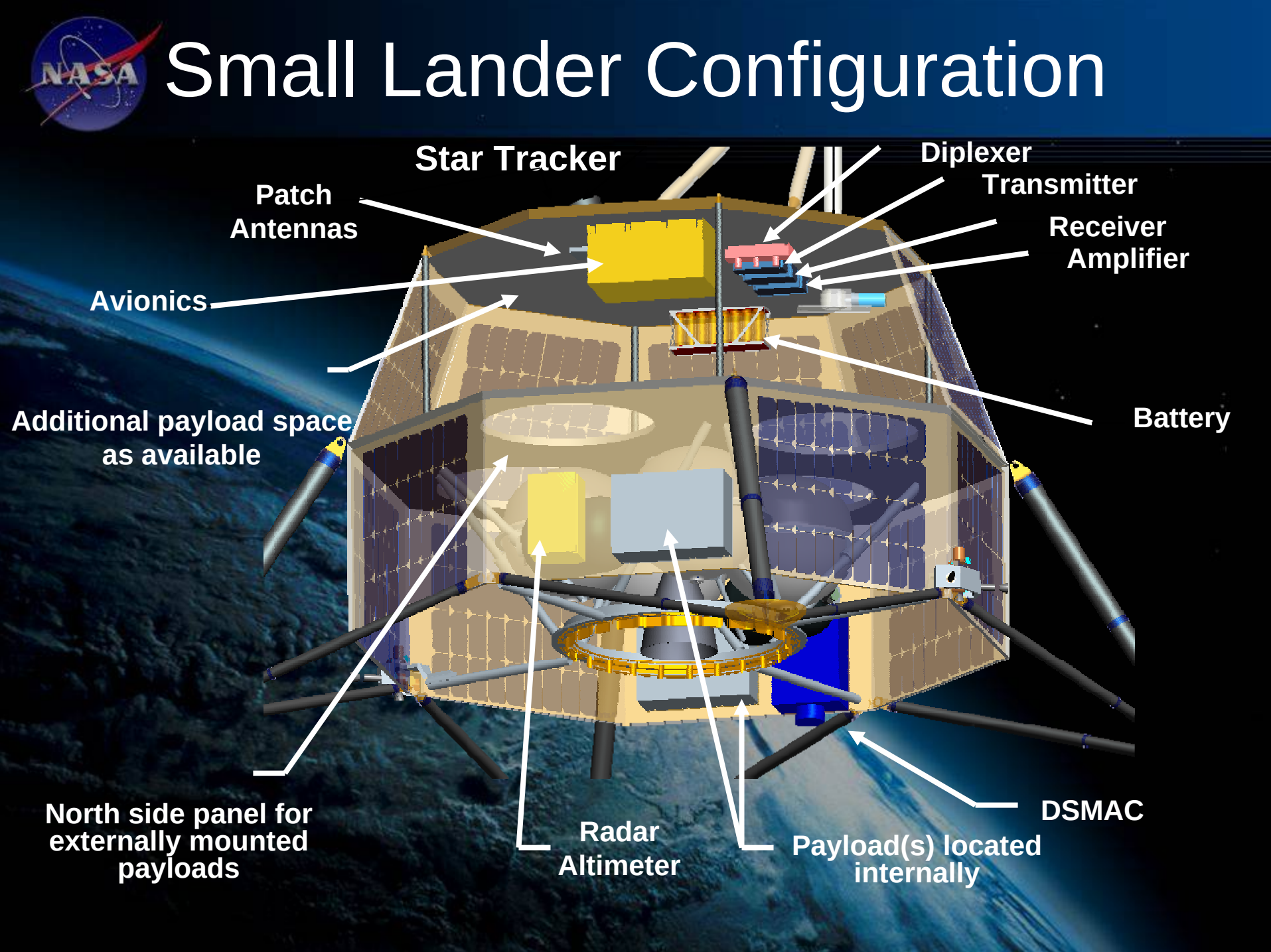
Extension Module

Propulsion Module

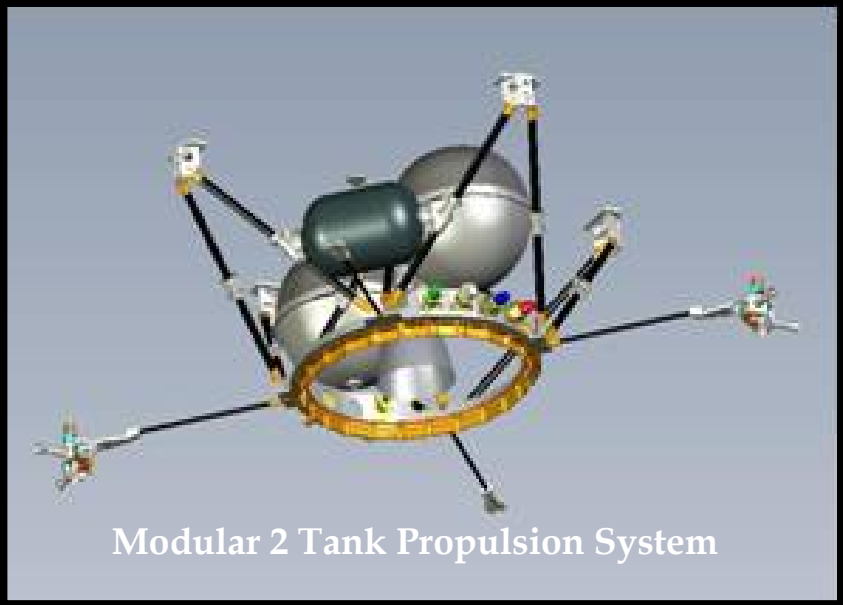


- Legs

Small Lander Configuration



Propulsion Systems



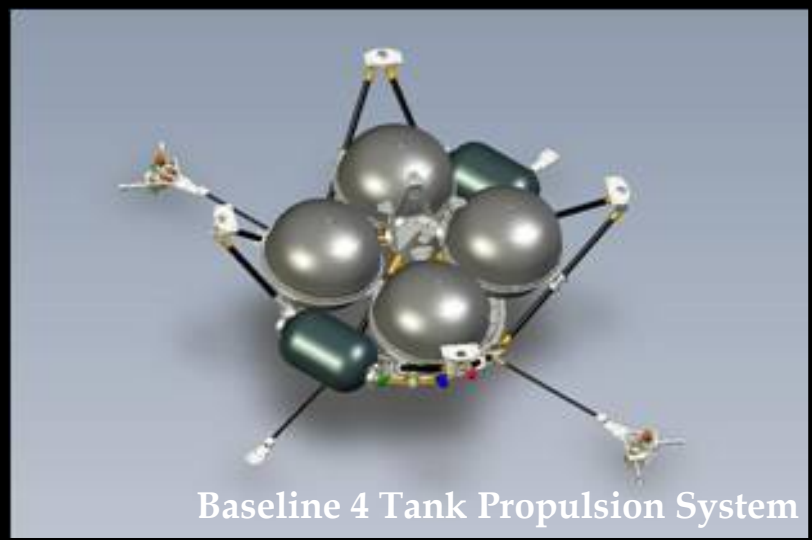
Modular 2 Tank Propulsion System

Descent Thruster

Maximum Thrust (T_{max}):	3200 ± 200 N
Specific Impulse (rof Epsilon=30):	292 ± 3 sec
Minimum engine-on time:	0.005 ± 0.002 sec
Minimum engine-off time:	0.005 ± 0.002 sec
Thrust ramp-up time constant (τ_{on}):	0.002 ± 0.0002 sec
Thrust decay time constant (τ_{on}):	0.002 ± 0.0002 sec
Maximum continuous firing time:	10.0 ± 1.0 sec
Epsilon:	30 ± 0

ACS Thrusters

Maximum Thrust (T_{max}):	30 ± 3 N
Specific Impulse:	266 ± 3 sec
Minimum engine-on time:	0.001 ± 0.0001 sec
Minimum engine-off time:	0.001 ± 0.0001 sec
Thrust ramp-up time constant (τ_{on}):	0.001 ± 0.0001 sec
Thrust decay time constant (τ_{on}):	0.001 ± 0.0001 sec
Maximum continuous firing time:	20.0 ± 1.0 sec
Epsilon:	20 ± 0

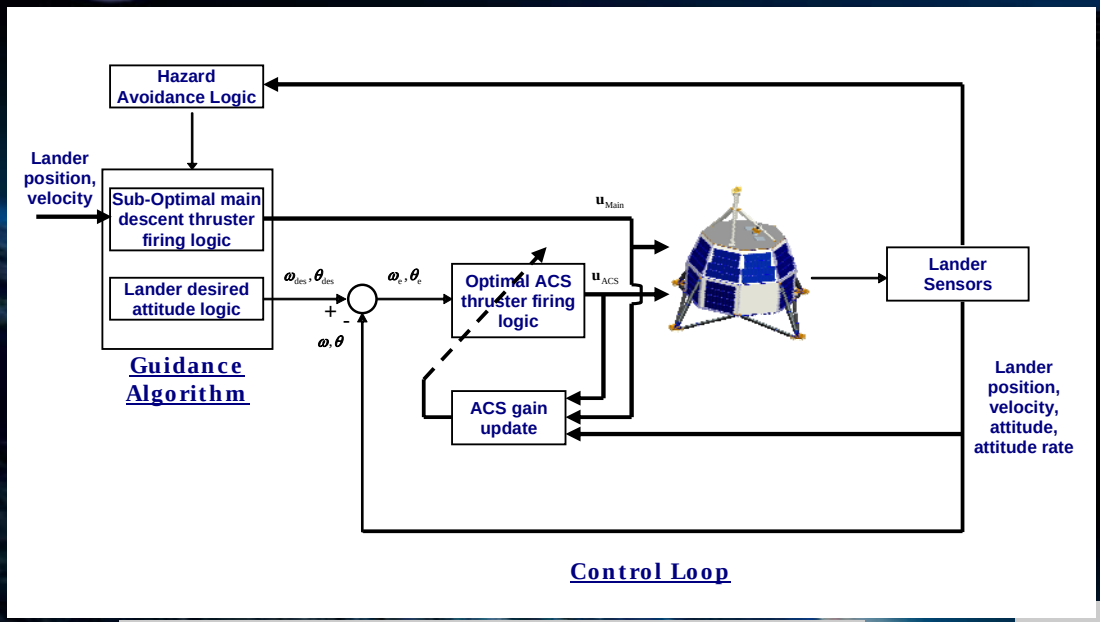


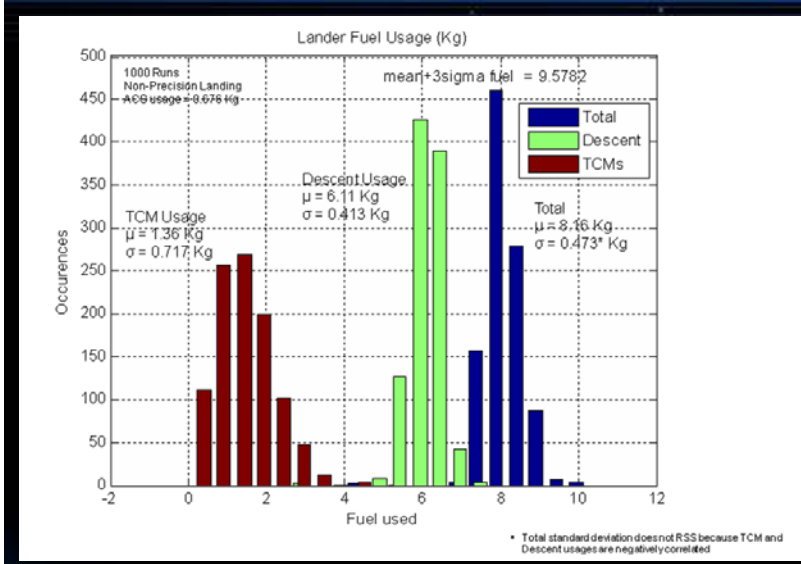
Baseline 4 Tank Propulsion System

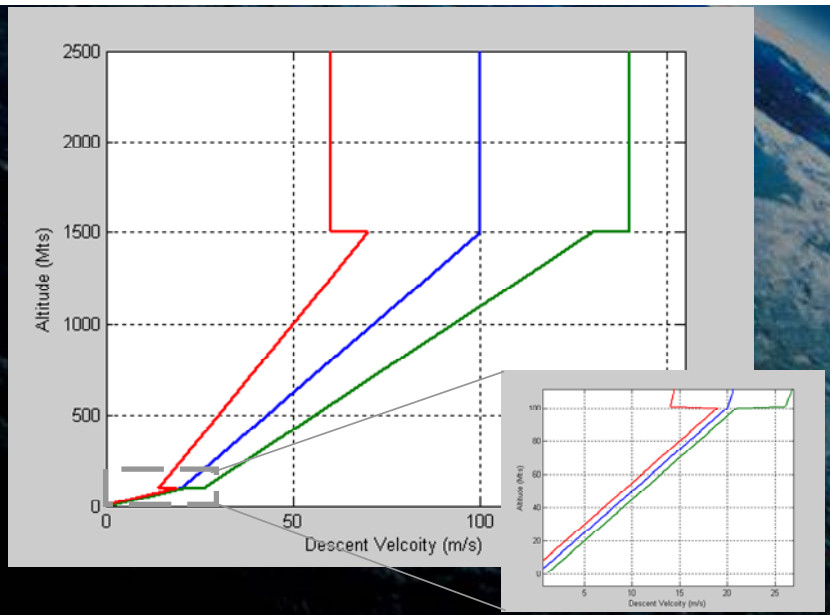
Mass Allocation

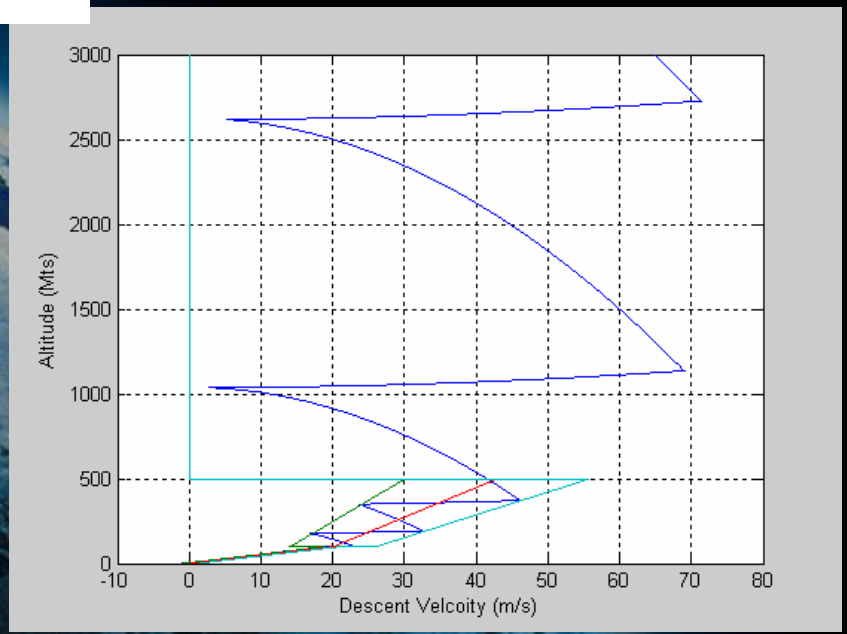
Spacecraft subsystem	103.7 kg Baseline	Feather Weight 55.7 Kg	130.9 Kg Maximized minotaur
Navigation and Attitude Determination	4.5	4.5	4.5
Command and Data Handling (C&DH)	5.0	5.0	5.0
Communications System	1.6	1.6	1.6
Harness	2.4	2.4	2.4
Power	6.0	3.1	6.0
Structure	14.9	10.2	14.9
Thermal Control	3.0	1.5	3.0
DACS Propulsion System	13.6	8.6	13.6
Trapped Propellant and Helium	1.8	0.9	1.8
Payload	15.0	2.6	41.6
System Reserve	9.8	2.3	10.4
Lander Dry Mass subtotal	77.4	42.5	104.6
Lander DACS Usable Propellants	26.3	13.2	26.3
Lander Wet Mass	103.7	55.7	130.9

Guidance and Control







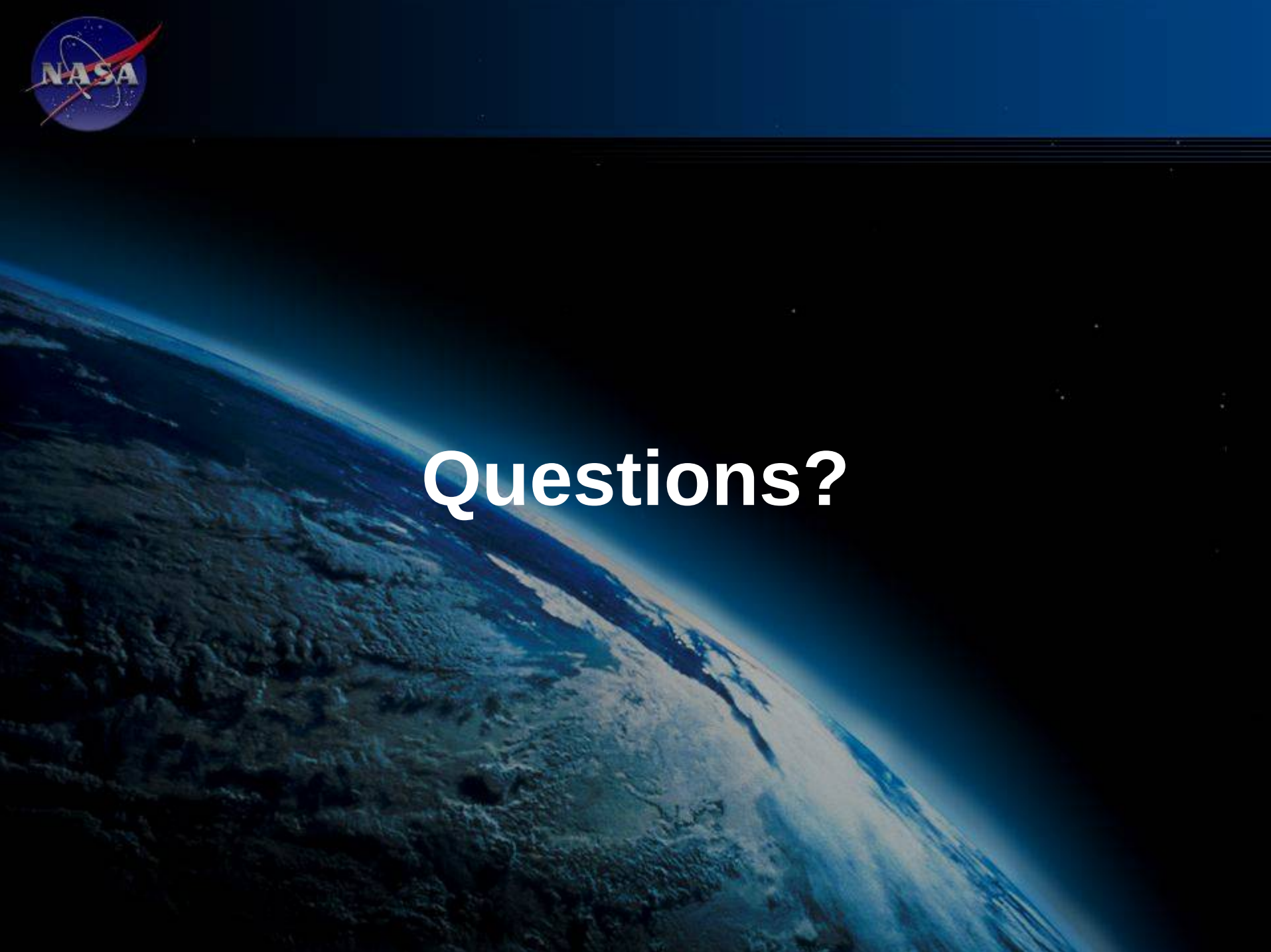


Early Hardware Integration Testing

- Early and frequent hardware integration testing is a key to rapid development schedules:
  - Software-in-the-loop testing
  - Hardware-in-the-loop testing
  - Propulsion system characterization
  - Sensor-actuator closed loop testing
    - Cold-gas floater testing – closing IMU and thrusters
    - String testing – closing star trackers and reaction wheels
    - Free-flight testing – full 3D attitude control testing
    - Drop testing – landing system control testing

Areas of Interest

- Technologies that provide superior performance in attitude control and overall orbit control.
- Propulsion systems and fuels that have superior performance for on-orbit applications including storage stability and propulsion.
- Sub-system components:
  - Low-cost high-performance attitude sensors
  - Low-cost reaction wheels
  - Low-mass propulsion systems
  - High-performance propulsion systems for LEO, GTO, Lunar Orbit or beyond
- Propellantless propulsion
- Flexible, modular and scalable propellant tank systems


Questions?