DARE Mission and Spacecraft Overview

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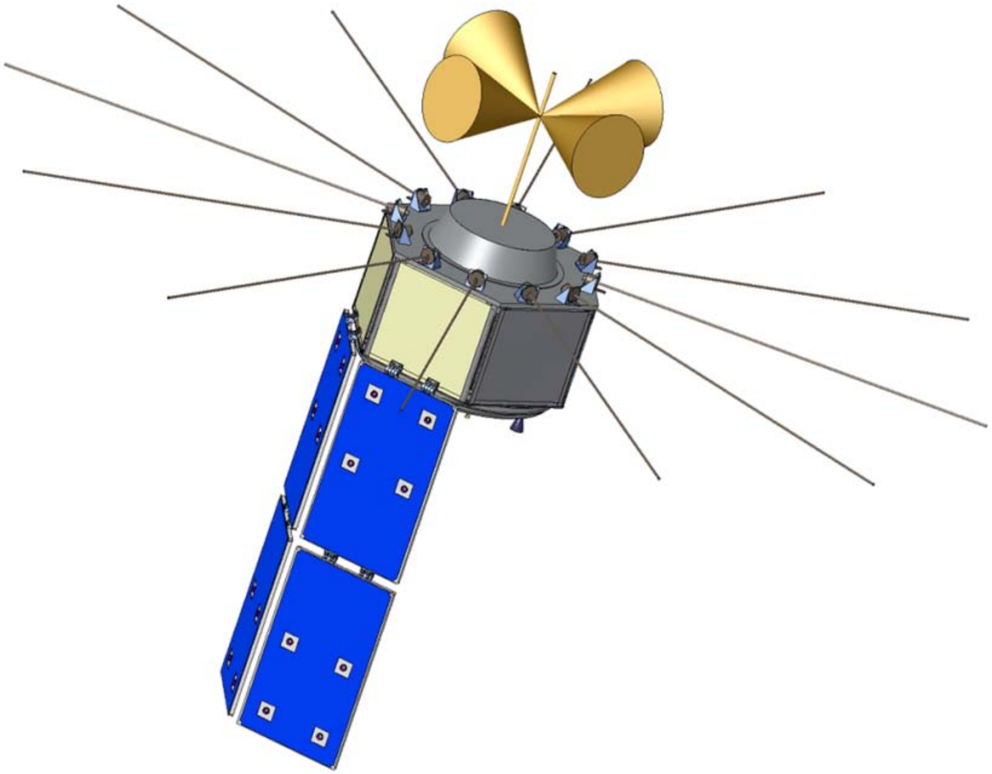
Agility to innovate, Strength to deliver

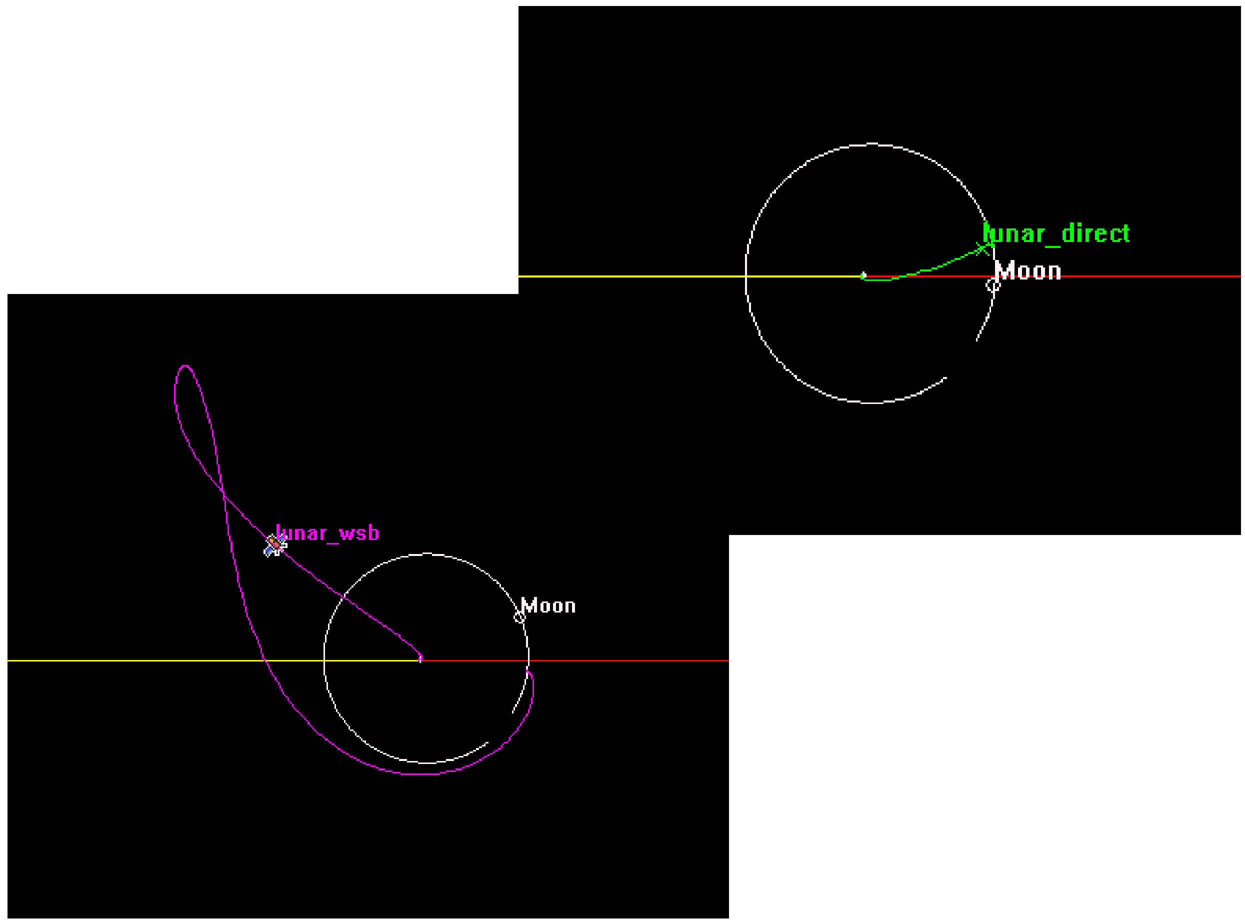
Agenda

- Mission Design Overview
  - Lunar trajectory
  - Insertion
  - Orbit
- Spacecraft Design Overview
- Mission operations Overview



Two Types of Trajectories to Get to the Moon

- Direct (conventional) Hohmann transfer, used by most lunar missions including Apollo
- Weak Stability Boundary trajectory
  - The WSB lunar trajectory offers savings in terms of orbit insertion delta-v, at the cost of restricted launch days per month and much longer transit duration.
- DARE has selected the WSB due to fuel savings
  - Smaller fuel tank enables use of smaller launch fairing
  - Gravitational attraction of Earth and moon approximately balanced
  - Used successfully by the Japanese Hiten mission in 1991.
  - Compatible with Taurus and Minotaur launch vehicles



Insertion into Orbit is Dependent on Launch

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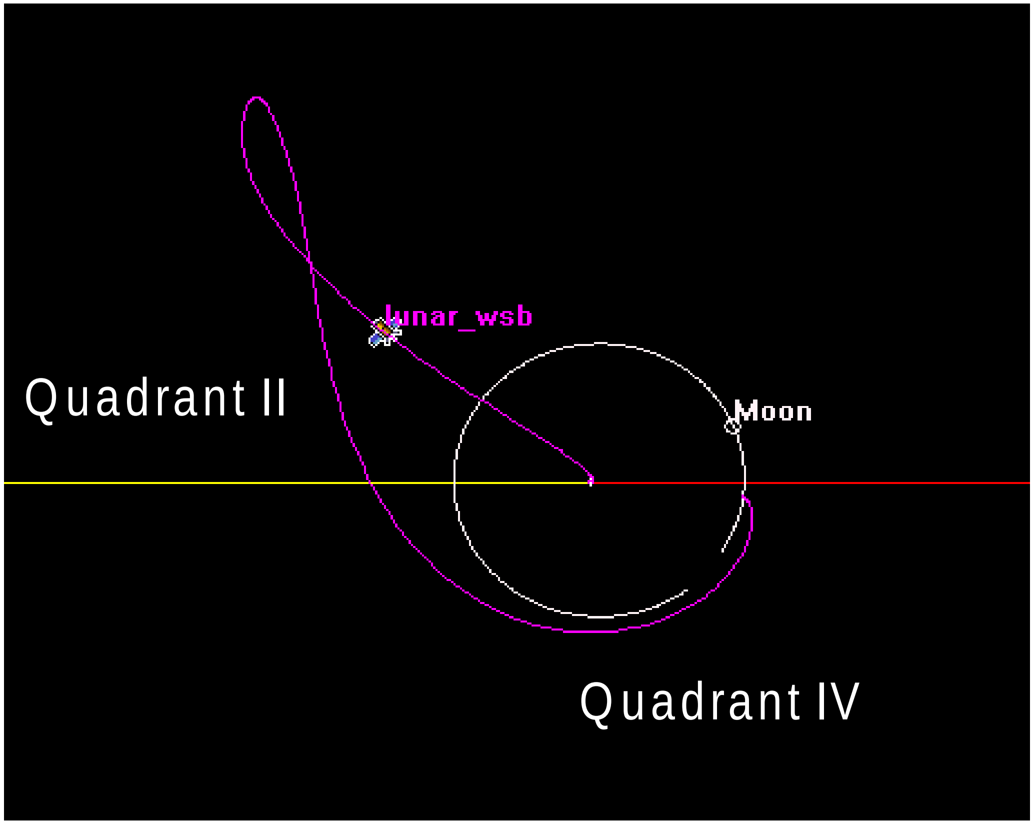
- Requires specific injection conditions (leaving Earth) and a few small, delicate trajectory correction maneuvers to produce the trajectory desired.
- Launch must occur when the moon is about 140 degrees counter-clockwise from the sun direction.
- The trajectory will then be as shown, in quadrant II.

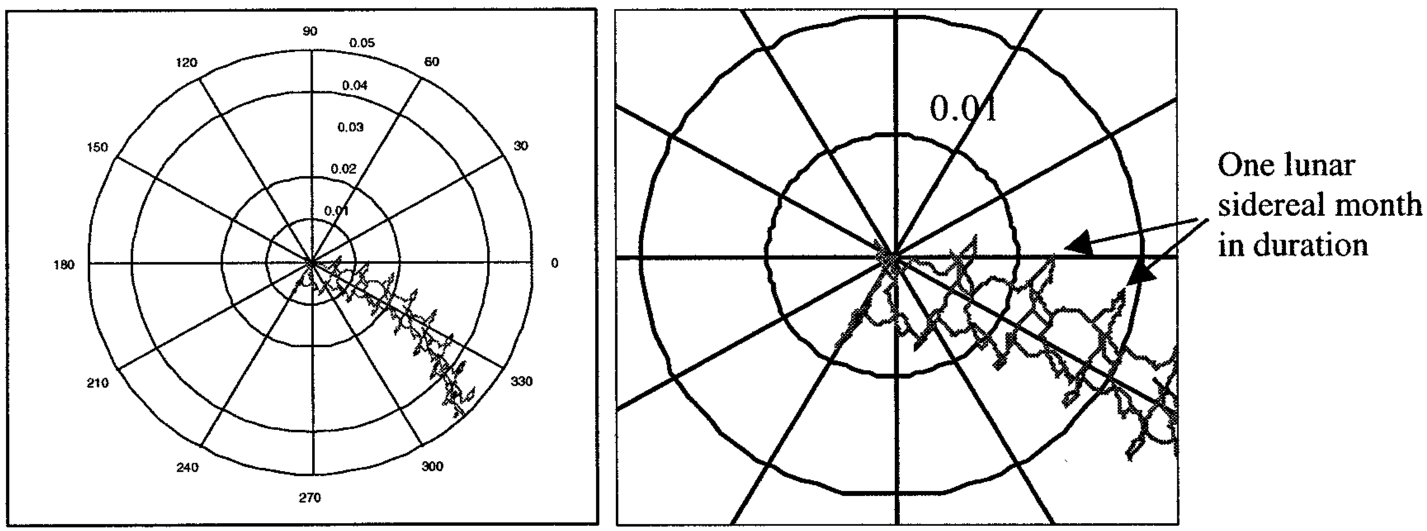


- There is a second launch opportunity each month in quadrant IV
- Launch a day or two earlier or later is possible,
  - At the cost of larger mid-course correction burns.
- Two sets of launch windows each month
  - Each is one launch opportunity per day for ~5 consecutive days.

The DARE Orbit has Heritage

DARE — DARK AGES RADIO EXPLORER

- 200 Km selected as best balance between maximum data acquisition and altitude variations
- Equatorial lunar orbits at an altitude of 100 to 200 km are stable
  - ~70-80 km periodic variations in apoapsis and periapsis altitudes
- DARE orbit stable without propulsive orbit maintenance for the mission



Actual Lunar Prospector eccentricity-argument of periapsis in 100 km orbit
(from Folta, et al., 1999, p. 3)

Spacecraft Maximizes Science Data Value by Optimizing Instrument Performance

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- The DARE spacecraft is specifically designed to support the DARE science investigations with these key features:
  - RF 'quiet' spacecraft implementation does not compromise data gathering
  - Spacecraft configuration that supports DARE antenna with a large, clear field of view
  - Maximization of the DARE antenna baseline within fairing constraints
  - Large data storage capacity, allowing for uninterrupted science even with missed ground contacts
  - System architecture with high heritage from Kepler, Deep Impact (DI), WISE, and STP-SIV
  - Propulsion tank sized to take advantage of a lighter spacecraft,
    - Additional fuel equates to a shorter burn time for orbit capture
  - Modular construction, allowing parallel integration and thereby reducing schedule risk
  - Compatibility with standard 63"-fairing LV

Spacecraft and Payload Minimize Deployment

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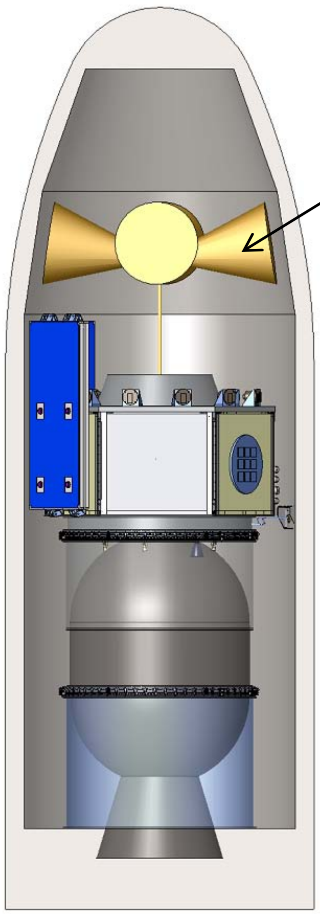
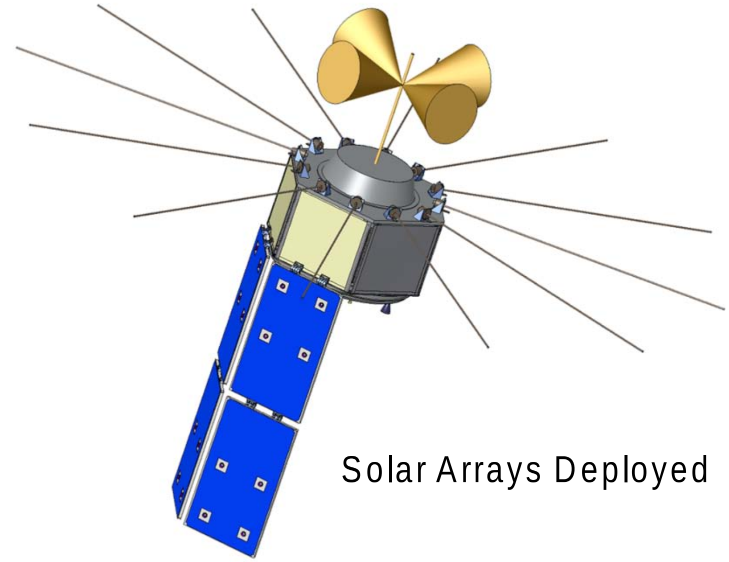
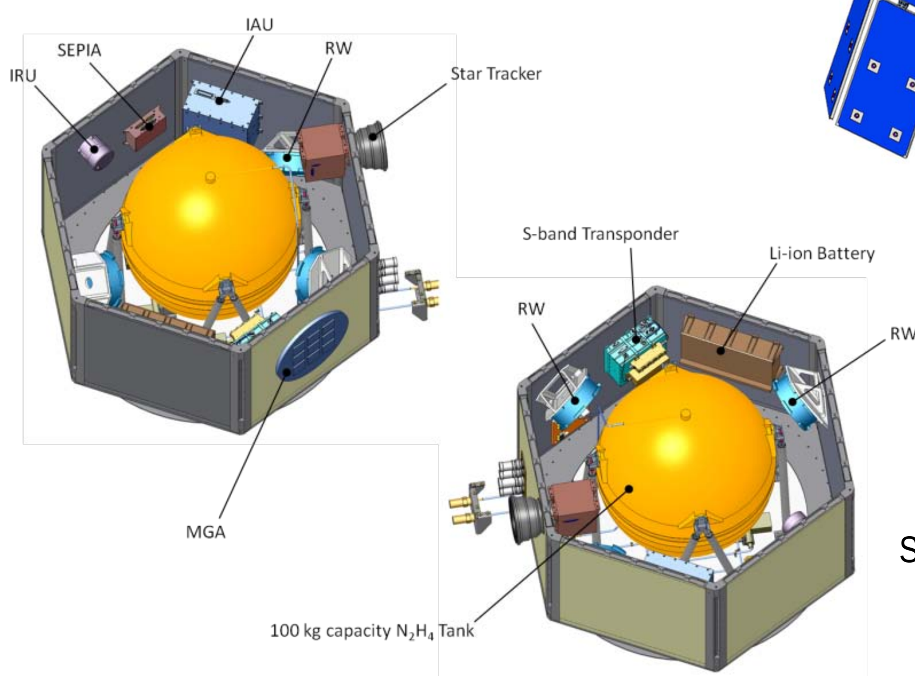
- Instrument radials deploy
- Solar arrays deploy downward away from the RF sensitive payload



Shown in Taurus 3113
(XL, 63" fairing, Star37 5th stage)



Solar Arrays Deployed



Spacecraft Interior

Ball Aerospace & Technologies Corp. Proprietary Information

Spacecraft Systems Simple and Proven

- ADCS design provides medium-accuracy pointing and navigation using flight-proven hardware and control algorithms
  - Single String
  - Star Tracker, IMU, Coarse Sun Sensor
  - 3-axis Stabilized
  - Reaction Wheels and Thrusters
- Monopropellant systems ensures a robust propulsion design.
  - Low-cost system that meets DARE requirements using high-heritage components
  - Lunar insertion with hydrazine thrusters
  - Thrusters provide (minimal) orbit maintenance and de-saturate the reaction wheels
- The electrical power subsystem (EPS) uses a direct energy-transfer architecture that is reliable and efficient
  - Battery dominated with fixed solar arrays
- The Thermal controls system will be mostly passive using Multi-Layer Insulation with a solar reflective outer layer
  - Radiators will be oriented to avoid the Moon's IR load.
  - 14 heater circuits controlled by redundant mechanical thermostats.

Modifications to Some Sub-systems Optimize Mission Performance

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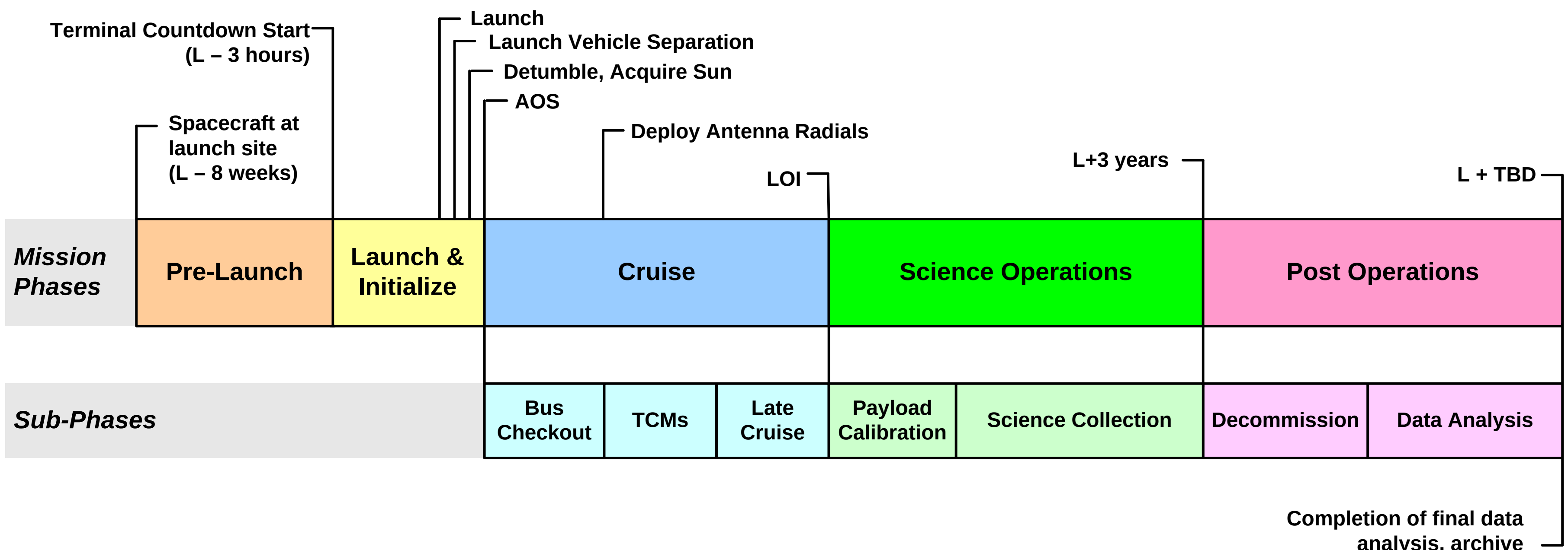
- The structure provides a Faraday cage to reduce RF noise emissions from the spacecraft components
- S-band telecom subsystem is based on the flight-proven architecture.
  - Standard S-Band multi-mode transceiver provides S-band uplink and downlink functions.
  - The S-band system provides both
    - (1) high-data rate, high-data-volume capability for the mission science using a medium gain antenna
    - (2) standard command/housekeeping functions via the hemispherical coverage low-gain antennas
- The data handling (C&DH) architecture is based on a light-weight high-performance single-string Integrated Avionics Unit (IAU)
  - Low volume and mass supports the 'RF quiet' bus
  - 32+ Gbyte mass memory board for science data storage
  - Incorporation of unique payload interfaces
- DARE FSW has the ability to easily adapt to changing mission demands.
  - Includes modules for real-time (CCSDS) command and telemetry management, stored command processing, fault protection, attitude determination and control, battery charge management and instrument control

Mission Operations Utilize the Near Earth Network

DARE
DARK AGES RADIO EXPLORER

- For command uplink, data downlink, and tracking data (Doppler, Ranging, Angle).
- The spacecraft uses medium gain antenna for science and stored engineering data downlinks, and a low gain antenna for uplink and real-time downlink via S-band.
- Data downlink is automated
- Commanding occurs once/week
- Data analysis will begin 6 months after first data received

DARE Mission Timeline



DARE Spacecraft Uniquely Suited to Science Objectives

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- Spacecraft does not interfere with data gathering
  - RF 'quiet'
  - Large data storage capacity
  - Deployables located below instrument ground plane
- Design simplicity and heritage optimize data quality and cost
  - Minor modifications where needed for instrument unique interfaces
- Trajectory and station keeping optimized to reduce fuel need
  - Reduces size of propulsion tank
  - Able to fit into standard size launch fairing
- Mission operations specific to DARE