# Design Log

## Requirements

### Orbiter

Pointing direction:

* For communications the orbiter must be nadir pointing, except during probe deployment. **Driving requirement**
* Earth-pointing comms will have own gimbal mechanism for increased accuracy and to allow independent pointing direction
* The EPS must therefore be equipped with a gimbal mechanism to allow pointing towards the earth throughout the orbit.

Pointing Accuracy:

* EPS: max 23 degree incidence angle. Will be outfitted with gimbal mechanism, so not a driving req for AOCS
* Telecomms: For high-gain antenna 0.1-0.5 degree accuracy minimum. HGA will utilize separate gimbal for higher accuracy. **Driving requirement**

Maneuver Requirements:

* No need for high-rate maneuvers. Nominal rates will suffice (0.05 deg/s – 0.5 deg/s)
* Range – all angles must be accessible, as the probes must be deployed from various attachment points
* Jitter – unknown at this stage from other sub-systems
* Settling Time – unknown at this stage from other sub-systems

### Probe

Pointing direction:

* Comms will utilize and omni-directional antenna. No ACS requirements
* EPS will rely on internal batteries
* Propulsion – retrograde during de-orbit burn
* Thermal – prograde during atmospheric entry
* EDL – trajectory guidance if using a lifting trajectory
* De-tumble after deployment

Pointing accuracy:

* Exact pointing accuracies unknown at this design stage
* Dependent
* Large deadbands to save fuel [MSL entry]

Maneuver requirements:

* 180 degree flip maneuver during after de-orbit burn, prior to atmospheric re-entry
* Maneuver rate TBD
* Lift/bank control (likely if lifting trajectory is chosen)

## ACS Type

### Orbiter

* Primarily dependent on TT&C pointing requirements and accuracy

Orbit control type will be (SMAD Table 11-4):

* Three-axis, zero-momentum (3 wheels + thrusters)
* High pointing accuracy
* Combination of thrusters and reaction wheels
* Thrusters used for slewing and momentum dumping
* RW for high accuracy pointing
* Control Moment Gyros (CMG) likely not needed, TBD in hardware selection phase

### Probe

* If lifting trajectory is used, spin-stabilized will not be applicable.
* Spin stabilization also unlikely due to the need to execute a 180deg flip maneuver between de-orbit burn and atmospheric re-entry

Control type will be (referring to SMAD table 11-4):

* Three-axis, zero momentum (thruster only)
* Pointing accuracy 0.1 – 5 deg
* High rates possible

## Hardware Selection

### Orbiter

* Three-axis control:
  + Thrusters
  + Reaction wheels
  + Control Moment Gyros
  + Combination…

### Probe

* Likely thruster only (see 2007\_Brugarolas on MSL attitude control) wrt high attitude deadband vs low rate deadbands

## Disturbance Torques

### Orbiter

### Probe

## Control Law

### Orbiter

### Probe

* See 2013\_SanMartin\_Dev-of-MSL

## Budgets (Basic sizing based on MRO and MSL, **NO CALCULATIONS**)

### Orbiter (selection based on MRO)

* RCS (not MRO) mass TBD
* RWA 2 – 20kg; 10 – 110W (per wheel) [SMAD]
  + MRO 10kg per RW x 4 wheels
  + MRO mass = 1000kg, our orbiter = 1990kg
  + Estimate 20kg per RW 🡪 **80kg** total
* Sensors:
  + Star trackers 2 – 5kg; 5 – 20 W
  + Sun sensors 0.1 – 2kg; 0 – 3 W
  + IMU 1 – 15kg 10 – 200; W
* TOTAL MASS:

### Probe (based on MSL)

* RCS propellant for MSL:
  + Max 15kg for lander of 900kg (so 1.666%)
  + Assuming our probes of 100kg 🡪 2kg propellant to be safe
* Sensors:
  + IMU 1 – 15kg 10 – 200 W

### Other Sub-systems

#### EPS:

Orbiter power range: 25 – 333 W

Probe power range: 10 – 200 W (IMU)

#### Thermal:

Orbiter thermal range:

Probe thermal range:

#### CDH:

Commands from earth:

* s/c attitude model [2007\_You]

Commands from orbiter:

* attitude estimation [2007\_You]

Housekeeping telemetry:

* TBD