Ideas for a “Super-trackable” GEO Satellite

The following concepts are suggested as a starting point for a GEO mission that would be designed to better characterise the forces acting on high-altitude satellites; the aim being to better understand the behaviour of non-cooperative targets in GEO and graveyard orbits over time.

**CANDIDATE TECHNOLOGIES**

**Laser retroreflector array.** As per the IRNSS GEO satellites, and all MEO GNSS missions, this would enhance the ability to determine a reference value for the satellite’s position and velocity. Since the satellite is in GEO, simultaneous laser ranging by more than one laser facility could be feasible to further refine the measurements.

**GNSS receiver.** A GNSS receiver capable of receiving and decoding GPS, GLONASS, Galileo and Beidou transmissions on a continuous basis would allow high precision orbit determination, and could contribute to a range of other capabilities, including GNSS integrity monitoring.

**RF Beacon.** A beacon which could be operated for the whole, or a significant period of, each orbit, could potentially allow initial determinations of the satellite’s position, (derived from laser measurements), to be extrapolated more reliably.

**Optical beacon.** A light pulse that could be triggered either from the ground, or via timing information derived from the GNSS unit, could provide an alternative high-precision ranging capability if ground-based reflectometry is infeasible during daylight hours.

**Optical inter-satellite or space-to-ground links.** Laser inter-satellite links are highly directional, and have closed loop systems to maintain pointing. Data from such systems would provide an independent assessment of the vector on which the satellite is located.

**On-board star cameras.** To provide accurate attitude knowledge.

**Solar wind measurement.** An instrument designed to measure the physical effect of the solar wind particles, and their electrostatic effects on the satellite.

**Solar flux.** An instrument designed to accurately measure the incident electromagnetic solar flux on the satellite over time. Ideally the instrument would be sensitive over a range of wavelengths, as the solar spectrum is “harder” at the peak of the activity cycle.

 **On-board monitoring cameras.** Could be used to confirm deployments and physical configuration of the mission to create a baseline at the start of the mission. Later data-sets from such a satellite could provide data on “gerontology”, e.g. the spectral ageing of solar panels, which would affect the albedo; the long-term effects of material exposure to the space environment, which could, for example. Lead to gradual warping of the arrays.

**On board charge monitors.** An instrument designed to measure the accumulated charge on the satellite, and thereby assess the effects of Lorentz forces.

**Micrometeorite impact detectors.** To measure occasional transient impulses.

**CONCEPT OF OPERATIONS**

**Highly accurate propellant measurements**. To measure the change in the satellite’s ballistic coefficient over time as it performs station-keeping operations.

**Highly accurate solar array measurements.** To determine the precise angle of the arrays to the Sun.

**Detailed propulsion system telemetry.** To measure mass flow rates during station-keeping operations; propulsion system power consumption where relevant, (e.g. in the case of ion thrusters), since the Isp of a gridded thruster propulsion system can vary with time as the grid erodes.

**Detailed power system telemetry.** To allow potential characterisation of the amount of antenna thrust.

**Detailed thermal telemetry.** To better estimate the satellite’s thermal dissipation.

Prior to launch perform a detailed characterisation of the satellite’s albedo, spectral properties, centre of mass, moments of inertia, and effective ballistic coefficient from different directions.

Conduct experiments during the GEO eclipse season around the equinoxes, to assess the changes that occur to the perturbing forces when the satellite is no longer continuously in view of the Sun.

Having retired the satellite to a graveyard orbit, (where it would vary in longitude, and so cut magnetic field lines thereby experiencing Lorentz forces), continue to monitor telemetry and maintain attitude stability. Potentially allows comparison with non-stable satellites in graveyard orbits. Could require some variation in solar panel drive motor operation, as the rotation of the arrays would no longer be quite one sidereal day, and the array pointing errors would accumulate over time.