Satellites

by Dave Hylands
dhylands@gmail.com

Before Launch

After Launch

Sensors

IMU - Inertial Measurement Unit

has a 3 axis accelerometer (measures changes in velocity)

has a 3 axis gyroscope (measures changes in acceleration)

Magnetometers

has a 3 axis magnetometer (measures magnetic field around satellite)

GPS

special high-speed GPS (the satellite travels at 7.8 kms/second or 28,000 km/hr)

Satellite is in Low Earth Orbit (about 350 kms above earth) going

around the earth about once every 90 minutes.

Sensors

Temperature Sensors

- Lots of temperature sensors distributed throughout the satellite
- Temperatures can vary from -65C to +125C

Sun Sensors

- Detect angle to the sun.

Star Trackers

- Detect star field and can determine position and speed of satellite

Actuators

Magnetorquers

- basically 3-axis electromagnetic coils
- can interact with the Earth’s magnetic field to orient the satellite

Reaction Wheels

- Motorized Flywheel
- A torque in the wheel induces an opposite torque in the body of the satellite

Propulsion

- Used for orbit raising - very limited supply

Miscellaneous

Heaters

- Used to keep electronics etc at a suitable operating temperature

High Speed RF Antenna Pointing Mechanism

- Used to keep high speed antenna pointed at the ground station

Lots of computers

- 12 blades running linux using Raspberry Pi level computers

Solar Array and charging circuitry for batteries which power satellite

Communications

Optical - gigabits/sec

- Used for establishing optical communications with another satellite
- Satellites are typically 4-5000 kms apart

High Speed RF radio - megabits/sec

- Needs to be pointed at ground station

S-Band radio - kilobits/sec

- Omnidirectional - works even when satellite is tumbling

Detumble

After launching the very first thing that is done is that the solar panels are deployed. This provides power to the satellite and allows the onboard batteries to be charged.

When the launched, the satellite will have some rotation. Neutralizing this rotation is called a detumble. This is typically done using the IMU (Inertial Managment Unit) which has accelerometers and gyroscopes.

Coarse Pointing

Once most of the rotation is gone, the the sun-sensors and IMUs can be used to orient the satellite close to desired orientation.

This gets the satellite stable relative to the sun.

Fine Pointing

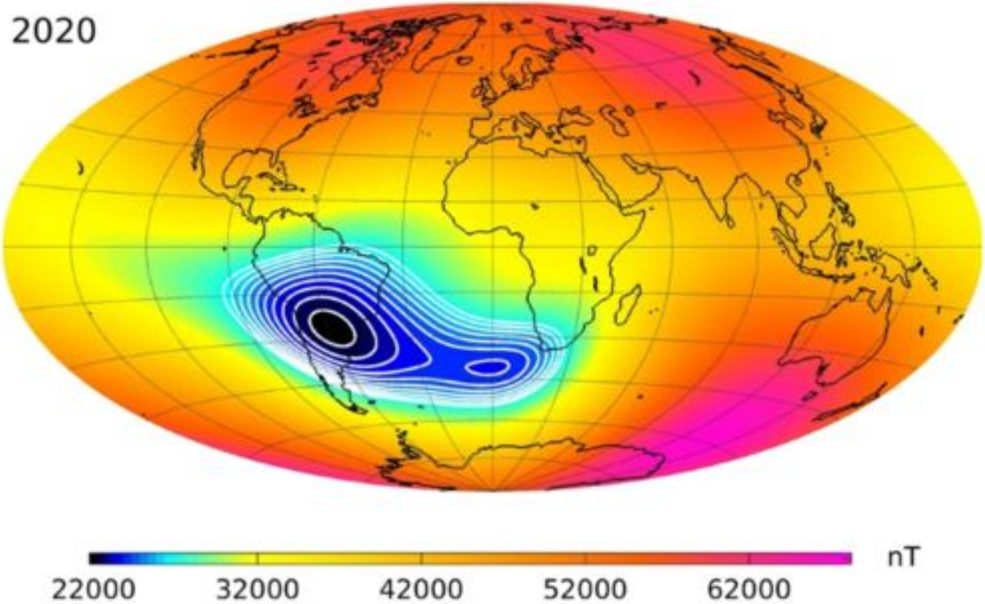
When the satellite is suitable oriented then the star trackers can be used to take pictures of the star field and determine absolute position and speed.

A GPS is also used to augment the speed and position.

Note that GPS signals can be be blocked and aren’t available in all positions around the earth because of this.

Southern Atlantic Anomaly (or SAA)

This is a place where the Earth's inner Van Allen radiation belt comes closest to the Earth's surface, dipping down to within 200 kms of the surface. Satellites passing through this region are subject to higher than usual levels of ionizing radiation.



Can control speed of satellite by orientation

Even though the satellites are at 350 kms, they still experience atmospheric drag. The speed of the satellite can be influenced by using a high drag or low drag orientation.

Space debris

More than 26,000 objects larger than 10 cm are known to exist, (about 1 object per 20,000 square kms).

There are about 500,000 objects between 1 cm and 10 cm (about 1 per 1,000 square kms).

The number of particles larger than 1 mm exceeds 100 million (about about 1 per 5 square kms).

About 35,000 objects are tracked.

There are currently about 12,000 active satellites in orbit.