**Pointing Budget**

The attitude control system for the Snapsat will consist of three air core magnetorquers operating on 3 separate planes capable of producing 0.05Am2 each. Only two of the magnetorquers can work at any one time, which will reduce total power usage for the system. The first component of the determination system is a 9DOF IMU which will primarily be used in the detumble phase due to accumulated error issues with this equipment which are expected to occur later in the mission. The second component is a solar tracker system consisting of six photodiode pins, one on each face, which will be used to accurately determine the attitude of the satellite based on the location of the Sun.

According to the specification data, the IMU will experience a 2% error based on the expected temperature range, although this will increase over the course of the mission due to the accumulated error. Although the exact error will need to be calculated during calibration and testing, based on current literature there are a number of similar solar tracking systems which are able to achieve an accuracy of 0.2% (Beaudette 2004). However given the lost cost budget a conservative estimate of 0.5% will be used for the solar tracker error. In regards to the magnetorquers expected error based on similar models 1%, although error will be finalised during the calibration and testing phase.

**Calculation of Error**

Due to the fact that the two attitude determination systems will almost always be used separately we have calculated three different total errors.

The total errors were calculated using the following formula:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | IMU Error (%) | Solar Tracker Error (%) | Magnetorquer Error (%) | Total Error (%) | Total Error (degrees) |
| Overall System | 2.0 | 0.5 | 1.0 | 2.3 | 8.3 |
| System 1 | 2.0 |  | 1.0 | 2.2 | 7.9 |
| System 2 |  | 1.0 | 1.0 | 1.1 | 4.0 |

The majority of the mission is expected to be spent using system 2, which produces an error of 4.0 degrees. Whilst this is within the range for the widest application of the three mapping scenarios (see Appendix A) it is slightly outside of the range of the second more focused scenario. However, it should be noted that these are conservative calculations and the finalised error may be lower than these figures.

Piontek, D., 2004, Satellite Mission Analysis, 2004 Final Design Report, *Carleton University,* <http://www.agi.com/downloads/corporate/partners/edu/Satellite\_Mission\_Analysis.pdf>

**Appendix A:**

**Mapping calculation considerations**

Calculations are based on an orbit of 300km altitude.

In general if we are targeting cities, metropolitan areas for a number of major cities are approximately 100 km2. Thus assume a target size of 10km by 10km. For an orbit path that goes directly over the city:

This is a very narrow window however if we instead photograph an area of 100km by 100km, or 10 000km2 roughly the area of Sydney, this equation changes to:

Thus if the satellite is misaligned by as much as 8 in any direction it will still capture the original 10km by 10km area that was intended. However this is a much larger area and as such there will be less focus on the intended target. Thus the third option is a 50km by 50km picture:

This image would provide greater focus but would require the attitude of the satellite to be within 3.8 accuracy of the measured attitude.

It must be noted that this calculation is for an orbit where the satellite will pass directly over the target area. If this does not occur it will require the satellite to be more accurately aligned due to the fact that it is aiming at a comparatively smaller target. However at small angles this effect is not that significant and since the idea of the mission is to capture cities only when the satellite passes over them it should not be a major issue or consideration.

**Appendix B:**

**Magnetorquer Calculations**

Although there is significant data to support the fact that a 0.05Am2 magnetorquer will be powerful enough to control a satellite in space I did some simplistic calculations to check it on an order of magnitude basis.

Calculation of the magnetic dipole of the magnetorquer:

Calculation of the minimum earth’s magnetic field at 300km:

Calculation of torque:

Torque = M1.34

Given the satellite will weigh 1kg and its centre of mass is at the structural centre of the satellite. Assume that the magnetorquers are located 1cm away from the edge of the satellite. Thus use the equation:

Design requirements for the system are that it can recover from a 10 deg/s spin within two days. Assuming average acceleration and that the correct axis is perpendicular to the earths magnetic field.

This is obviously an oversimplification and there are a number of other factors involved which will cause this number to increase. However it is clear from these calculations that the system will have the power to recover form a 10 deg/s spin within the two-day limit.