Chapter 5

Concluding Comments

The platform based tethered satellite model, although relatively simple, is useful in understanding complex interactions between the librational dynamics, tether flexibility, offset of the attachment point and initial disturbance. The parametric analysis of the system dynamics should prove useful at least in the preliminary design phase. The model is also helpful in assessing merits and limitations of the offset control in the presence of tether flexibility. It should be noted that because of the inclusion of the longitudinal tether oscillations, the equations of motion derived here demand considerable time and effort to solve numerically. This is especially true during retrieval since the frequency of the tether oscillations increases at shorter lengths.

The equations of motion and the parametric analysis reveal that platform and tether dynamics are coupled through the offset of the attachment point. This coupling increases with longer tether lengths, smaller platform inertias and more massive subsatellites. Longitudinal tether oscillations superimpose high frequency oscillations on the platform pitch response which could disrupt sensitive experiments or even damage equipment. Retrieval of the tether results in large tether pitch oscillations even for small initial disturbances.

The offset control method developed is effective in damping both rigid body pitch oscillations of the platform and the tether, as well as the tether's longitudinal vibrations due to its flexibility. Its performance improves with shorter tether lengths. For a 100 meter tether, relatively large pitch disturbances are damped in about 3 orbits.
Chapter 5. Concluding Comments

Longitudinal oscillations are damped quickly by the vertical offset. This is encouraging since applications such as NASA’s proposed microgravity laboratory [2] would require precise vertical positioning.

The feasibility of controlling high and low frequency motions separately is established. The approach improves the speed of the control program and allows the control weights to be determined more easily. It is shown that improvement in the control performance can be obtained by varying the weights in the Linear Quadratic Regulator method. This is especially useful when the physical limit on the offset motion is reached.

Recommendations for Future Work
The model used here could be generalized to include the out of plane motion and transverse oscillations of the tether. The presence of transverse oscillations in the model will help evaluate effectiveness of the offset control method in regulating this degree of freedom. It will be of interest to assess the effect of offset motions in actually inducing tether transverse oscillations. Flexibility of the platform could also have a large effect on an offset control strategy and should therefore be investigated. An optimal method of choosing the LQR weights could dramatically improve the control performance. Satoh and Yuhara [12] did some work on this but for a fixed tether length using tension control.

Ultimately, ground or space based experiments of this and other models will be necessary to verify that they capture the system dynamics.