Formation Flying Satellites: Control By an Astrodynamicist

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Satellites flying in formation is a concept being pursued by the Air Force and NASA. One of the purposes is to have many satellites in precise formation replace one large, expensive satellite. An example is that many satellites operating cooperatively could emulate a large antenna. Reliability and survivability of the system would increase because failure of a few satellites would just result in gradual degradation of the performance of the system. N addition, development time and hopefully, cost, would be reduced. In order to achieve this the system needs to operate autonomously.

Potential periodic formation orbits have been identified using Hill's (or Clohessy Wiltshire) equations. Unfortunately the gravitational perturbations destroy the periodicity of the orbits and control will be required to maintain the desired orbits. Since fuel will be one of the major factors limiting the system lifetime it is imperative that fuel consumption be minimized. The gravitational perturbations effect each satellite differently, consequently the fuel requirement to negate the gravitational perturbations will be different for each satellite. To maximize lifetime we not only need to find those orbits which require minimum fuel we also need for each satellite to have equal fuel consumption and this average amount needs to be minimized. Thus, control of the system has to be addressed, not just control of each satellite.

The one advantage we have in this problem is that the physics are well known and the there is considerable knowledge on how optimal maneuvers for satellites, e.g., the Hohmann transfer. Control of the system will be approached not as a standard LQG problem but from an astrodynamics perspective utilizing all the knowledge we have in celestial mechanics (orbit theory) and optimal satellite maneuvers. This approach leads to some interesting new results.