EARTH OBSERVATION SYMPOSIUM (B1)
Future Earth Observation Systems (2)

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# MONITORING EARTH'S NORTHERN FORESTS FROM SPACECRAFT IN MOLNIYA ORBITS

**Abstract**

The Earth's forests have been imaged and extensively studied by several Earth-observing spacecraft. But these have all been in relatively low circular "Low-Earth" orbits (LEO) that have relatively long revisit times over a given area. This paper will describe a set of satellites in Molniya orbits with apogees above areas of interest continuously taking general images of large portions of the whole Earth's surface with low resolution (on the order of 1 km), thus monitoring the overall state of the surface. When required, for example, if a forest fire has been identified, a sensor with much higher resolution can be pointed at the area of study. We will consider the requirements for the spacecraft in Molniya orbits for general monitoring of the Earth's surface, especially the northern forests of Russia, Canada, and other northern countries. The 12-hour Molniya orbits at the critical inclination of 63.4 deg will have a perigee height around 300 km with an argument of perigee of -90 deg.; then the apogee height (where the spacecraft spend most of their time) will be about 40,000 km, similar to the distance to a geosynchronous spacecraft, over the northernmost latitude of the orbit, 63.4 deg. A total of four spacecraft, with two of them in each of two orbit planes with their longitude of ascending node 180 deg. apart, will give good coverage of all of the northern regions, since there will always be two satellites near apogee over longitudes 180 deg. apart. But twice a year, all of the orbits will be near the Earth's terminator, with poor illumination for visual images. To avoid this problem, six satellites are needed, two each in three orbit planes with longitudes of ascending node separated by 120 deg. One satellite in each orbit (total of 3) is possible; with proper phasing, two of the spacecraft would be close enough to apogee most of the time for good coverage of most areas of interest. Results will be presented for launch windows that avoid decreasing perigee heights caused by lunisolar perturbations. Also, realistic force models show that the longitudes of ascending node, and thus the sub-Earth apogee points, drift from their initial positions. A strategy will be presented for minimizing the total delta-V for stationkeeping maneuvers needed to counter-act the longitude drift.