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SPACE SYSTEMS SYMPOSIUM (D1)
Innovative and Visionary Space Systems Concepts (1)

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GEO-ENGINEERING USING DUST GRAINS IN HELIOTROPIC ELLIPTICAL ORBITS

Abstract

This paper analyses the efficiency of geo-engineering using a new family of non-Keplerian Earth orbits under the effects of solar radiation pressure and the Earth oblateness J2 perturbation. A swarm of reflectors, or alternatively unprocessed dust, is deployed in a sun-synchronous orbit in the ecliptic plane with a fixed sun-facing apogee to maximise the dwell time along the sun-line and so the reduction in solar insolation.

There is a general consensus within the wider scientific community that climate change is occurring. Despite this, little progress is being made towards the reduction of greenhouse gas emissions to the extent that it is expected that a "point of no return" will be reached where severe climate change will become unstoppable. Thus, it is prudent that geoengineering methods be investigated which can be used to offset the worst effects of global warming. It has been shown that a 1.7% reduction in solar insolation can lead to a reduction of global mean temperature by two degrees. This paper will focus on the use of space based solar radiation management to achieve this insolation reduction. Several methods have previously been proposed e.g. solid reflectors or dust clouds positioned at Lagrange points or in a circular Earth orbit. For all methods the mass efficiency increases with area-to-mass ratio. However, with larger area-to-mass ratio the perturbing effect of surface forces, in particular solar radiation pressure, become significant to the extent that conventional orbits are rendered infeasible and new non-Keplerian stable orbits must be considered.

A new family of elliptical orbits with a frozen sun-facing apogee have been shown to exist which offer high efficiency for geo-engineering methods since the fraction of the orbit spent between the Earth and the sun is larger than in other perturbed orbits. A model is introduced to determine the optimum dust cloud grain-size/solar reflector thickness and initial orbit to optimise the mass efficiency of the scheme. By varying the area-to-mass ratio, initial orbit eccentricity and launch date, a cloud of dust or a swarm of passive reflectors can be modelled and propagated using the Gauss equations. The resulting steady state cloud can then be used to calculate the attenuation of the solar radiation reaching the Earth. The engineering challenges will then be discussed to determine the overall feasibility of generating the dust clouds in the selected orbits. Finally, the results of this study will be compared to other space-based geoengineering concepts.