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Engineering challenges involved in reflective-aerosol delivery by a tethered-balloon system

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The SPICE project (Stratospheric Particle Injection for Climate Engineering) is investigating the benefits, risks, costs and feasibility of 'Solar Radiation Management' by the deployment of light scattering aerosols in the stratosphere. Particle choice, delivery and impact are being investigated. The preferred delivery concept, minimising economic and environmental costs, is for a modest number of tethered balloons to deliver particles from ground or sea level to an altitude of 20km, above the tropopause. The particles, or their precursors, are conveyed as a slurry via the tethers using an ultra-high pressure ($\sim$6000 Bar) pumping system, and then dispersed at altitude. It is envisaged that the tethered balloons will be deployed for months, or possibly longer, near the equator, and there would be delivery of around one to ten million tonnes per year of aerosol to combat the temperature effects of doubling the CO2 concentrations in the atmosphere.

There are many novel engineering challenges that are involved in the design, manufacture and operation of such a system. For example, the tether must be sufficiently robust to withstand both internal pressure loadings and severe intermittent wind loadings. Very large tethered balloons are needed; their launch and deployment presents substantial issues since the entire system needs to be safely deployable and recoverable. The pumping power must overcome the hydrostatic head and frictional pressure drop due to the length of the tether, while the tether terminations must allow for both axial and hoop tensions.

This paper provides a discussion of some of the major engineering challenges involved in this project, and presents possible methods of overcoming each of these challenges. It is concluded that in principle the individual pump, tether and balloon elements in this system can, with some development, be built at a modest cost (economic and environmental) compared to alternative means of substantial aerosol delivery at this altitude. For this reason, further investigation into the design and testing of a 20km tethered-balloon system is recommended.