Design and Performance of the Tethered Aerostat Subsystem of the Large Adaptive Reflector (LAR)

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The proposed Canadian design for the Square Kilometer Array consists of an array of very large antennas, each similar in size to Arecibo. The antenna design, known as the Large Adaptive Reflector (LAR), consists of a ground-supported adaptive parabolic reflector and a receiver suspended in the air by a multi-tethered aerostat, at the focus of the reflector. The location of the receiver can be actively controlled, through 360° of azimuth angle and down to a 60° zenith angle, by winches at the base of the tethers.

In order for the antenna to meet its functional requirements, the receiver must meet certain motion criteria (position, speed), even in the presence of significant wind and turbulence. This is a challenging task, given that the tethers are on the order of 1 km long. Work has been ongoing for the past few years to evaluate the feasibility of the multi-tethered aerostat concept for this task, and this paper describes that investigation. Our initial efforts centered on a computer simulation of this system (which includes the aerostat, tethers and winches) to predict its behavior and which could be used for design tradeoff studies. With encouraging simulation results we undertook the design and construction of a one-third scale proof-of-concept prototype. This scaled system is itself of imposing dimension---it has a footprint of about one half square kilometer.

In the design of the scaled system, Buckingham's Pi theorem was used to identify the relevant non-dimensional parameters, which governed the system's behavior. The scaled system components were then chosen to maintain similarity of these parameters with the full-scale system. Construction of the prototype began in the spring of 2001 and it is now operational, albeit without closed-loop winch control. A number of flights have been made with the open-loop system aimed at quantifying the system's natural motion in response to various wind speeds and turbulence. One key benefit of these flights has been the operational experience gained from them. The computer-controlled winches that will be used to control the system are presently undergoing tests and will be installed in the spring of 2003.

This paper will present some of our measured results from the prototype, as well as similar data from the simulation. It will also discuss our plans for future enhancements of the system to further improve its performance.

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