Solar system goals with LSST include cataloging small Potentially Hazardous Asteroids (PHAs), surveying the main belt asteroids to extraordinarily small size (where radiation pressure effects may play a dominant role in sculpting orbital distributions and spin states), discovering comets far from the sun where their nuclear properties can be discerned without coma, and surveying the Centaur and Kuiper Belt populations. The present planned observing strategy is to “visit” each field (8 sq. deg. net non-overlapped) with two successive exposures of ~10 sec, reaching to at least V magnitude 24. An infra-red revisit time is not less than ~20 minutes with negligible stationary transients from even very distant (~70 AU) solar system bodies. The nightly cadence should be two, or possibly three, visits spaced by about half an hour. In order to link observations and determine orbits, each sky area must be visited on two, or better three, nights during a month, spaced by about 5 days. Fortunately, two visits on two nights (2/2) is sufficient for orbit determination, but 2/3, 3/2, or 3/3 cadences would yield detection threshold improvements nearly enough to offset the additional time taken, provide redundancy for missed detections, and result in better orbit determination. We therefore recommend the 2/3 cadence.

We have explored the efficiency of the PHA survey with less than all-sky coverage. It appears that covering a band of the ecliptic plane, is sufficient to achieve nearly “all-sky” efficiency of surveying, requiring only ~4,000 sq. deg. per month. However, much of this area must be imaged at an air mass ≥1.5, unsuitable for some of the other scientific goals of LSST. It appears that a survey in r band only of ~<2000 sq. deg. per month that must be reached at higher air mass, combined with coverage in g, r, and i filters done as a part of the astrophysical survey, can meet the goals of the solar system survey. We thank Bruce W. Keoh and Lawrence H. Wasserman for assistance, and NOAO for financial support, in this research.

Survey Cadence, object linkage, and orbit determination

The limiting SN (and limiting magnitude) for the discovery of moving objects depends primarily on the tolerable number of false detections (association of an image on one frame with an image on another frame) due to statistical noise, and on the loss of real linkages because one or more detections slip below the detection threshold. A cadence for PHA discovery will define the number and spacing (the integration time is predetermined) of frames within a lunation. The cadence parameters lead directly to the effective limiting magnitude that is achievable in such a search. When the limiting magnitude is known, a figure of merit based on the number of observable PHAs can be calculated, and the best cadence can be selected.

Orbital accuracy considerations suggest that observations of a given PHA need cover an arc no longer than 10 days during any given lunation. Linkage of one night’s detections with another is best accomplished if the shortest interval between observations does not exceed about five days, although in specific cases the cadence can be less intensive.

Therefore, our modeling effort has concentrated on cadences comprising two and three nights/lunation and spanning 10 days. In the table below, we assume that 50 hours/lunation are available for a PHA search; that each visit to a region comprises two back-to-back 10-s exposures separated by 1 sec readout time, and that visits are separated by a 5-s step-and-settle time. Pairs of visits are, somewhat arbitrarily, separated by 1 hour (the results are not sensitive to this interval). The effective rate of sky coverage per hour is 83% of the total sky coverage because of hexagonal tiling of frames on the sky. B is the half-width (in latitude) of an ecliptic-centered zone extending ±Δλ deg east and west from opposition (assuming a Mercator projection). The purpose of this calculation is to determine the relative advantage of various survey cadences, but 2/3, 3/2, or 3/3 cadences are sufficient to achieve nearly “all-sky” efficiency of surveying, requiring only ~4,000 sq. deg. per month that must be reached at higher air mass, combined with coverage in g, r, and i filters done as a part of the astrophysical survey, can meet the goals of the solar system survey. We thank Bruce W. Keoh and Lawrence H. Wasserman for assistance, and NOAO for financial support, in this research.

Limiting magnitude degrades with increasing zenith distance due to three effects:

- Atmospheric extinction reduces the signal received
- Degradation in seeing leads to more background light (noise) underlying the signal
- Sky background generally increases with zenith distance, e.g. increasing path length of air glow, light pollution

The combination of these effects can be well represented as a log function of air mass, \(d_m = -2.5\log I\). For various reasonable models of extinction, seeing degradation, and sky background, we find values of I in the range from 1.7 to 3.1. In the survey models presented here, we adopt a value of 2.0.