

## Study of Rates for Non-Confirmation of NEOs: Preliminary Results

Robert Crawford, senior statistical analyst on the Project ASTEROID Team, undertook a study of the rate at which newly-discovered Near Earth Objects (NEOs) fail to be confirmed, presumably due to lack of astrometric follow-up observations. The method used to perform the study was to program a computer to look each day at the Minor Planet Center's (MPC) NEO Confirmation Page (NEOCP) of new objects needing follow-up astrometry. The computer automatically downloaded and parsed the page, adding each object to a database.

At the end of the data collection period, the computer was programmed to query the MPC cross-reference service for objects previously posted to the NEOCP. This service provides the temporary designation under which the object was originally posted and the final disposition of the object, either the provisional designation that MPC assigned to it or a statement that it did not exist, was lost, or was not confirmed. Objects described as either *lost* or as *not confirmed* are categorized here as "not confirmed". Objects determined *not to exist* are counted as postings, but *not* as objects that were not confirmed.

During the period from February 2006 to December 2006, Mr. Crawford collected data on 671 objects posted on the NEOCP. Of these, 618 were confirmed (or determined not to have existed) and 53, or 8%, remained unconfirmed. Table 1 gives the NEO non-confirmation rate as a function of V magnitude:

<b>Table 1: NEOCP List (objects posted 2/2006 through 12/2006)</b> (does not cover every night each month)					
<b>V Magnitude</b>	<b>Number</b>	<b>Percent</b>		<b>Objects Not Confirmed</b>	
<b>Range</b>	<b>Posted</b>	<b>of Postings</b>		<b>Number</b>	<b>Percent</b>
< 18 mag	55	8%		6	11%
18-19 mag	119	18%		6	5%
19-20 mag	196	29%		9	5%
20-21 mag	182	27%		12	7%
> 21 mag	119	18%		20	17%
Total	671	100%		53	8%

To understand better what these numbers are telling us, Mr. Crawford devised a metric known as the "Observational Challenge" (OC). This is based on the common sense notion that: (a) the fainter the target, the more difficult it will be to detect; and (b) a target that moves during an exposure will also be more difficult to detect because it deposits fewer photons on each pixel. The number of photons recorded on a pixel during the integration is proportional to the photon flux (i.e., the object's brightness) divided by the rate the target sweeps across an individual pixel.

Because the signal-to-noise ratio of an observation is proportional to the square root of the number of photons, the observational challenge can be taken as proportional to the inverse of the square root of the number of photons recorded on a pixel. Defining the observational challenge as equal to 1.0 at  $V_{\text{mag}} = 20$  and a motion rate of 0.3 arcseconds per minute, the OC metric is then given by:

$$\text{OC} = \text{sqrt} \left\{ (\text{MotionRate}/0.3) / (10^{-0.4(V_{\text{mag}}-20)}) \right\}$$

Figure 1 gives a plot of the NEO non-confirmation rate during the study period as a function of observational challenge. Note that the rate rises as a function of OC – that is, more NEOs remain unconfirmed as the brightness of the object decreases, the rate of motion increases (and the NEO spends less time on each pixel), or both. At OC = 5, the expected non-confirmation rate reaches 15%, and for more rapidly-moving and/or fainter objects, the rate approaches 25%. *This trend does not bode well for the era of PanSTARRS and LSST, which will be finding very faint objects.*

**Figure 1: Plot of NEO Non-Confirmation Rate as a function of Observational Challenge**

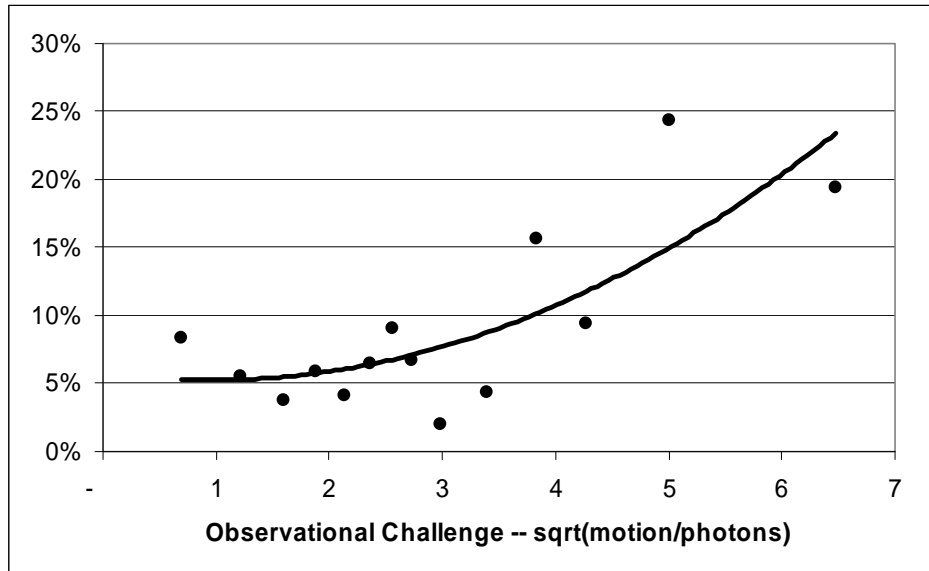


Figure 2 gives a plot of observational challenge as a function of  $V_{\text{mag}}$  for various rates of motion in order to deconvolve the roles of magnitude and motion within the metric. Noting that there is 100-fold range in photons for the 5-magnitude range between  $V_{\text{mag}} = 18$  and 23, there is a 10-fold range in the object magnitude contribution to the metric across the abscissa. The OC for slow-moving objects (0.3 arcseconds/minute) does not change appreciably over this considerable magnitude range and remains below OC = 5, at which a non-confirmation rate of 15% is expected, even for the faintest objects. However, faster rates of motion add considerably to the observational challenge, particularly for the faintest objects.

Based on the definition of OC, a telescope with twice the aperture will perform as if the OC were cut by one-half. This is why a larger telescope is needed when the OC becomes large, as it will quite soon in the era of large survey projects capable of detecting objects down to  $R \sim 25$ . In the era of PanSTARRS and LSST, faint and fast-moving objects will require a large aperture telescope, a good ephemeris for “track and stack”, or even both, for post-detection follow-up to be successful.

**Figure 2: Observational Challenge as a function of V Magnitude**

