Pan-STARRS: First Solar System Results.
R. Jedicke[1] and the Pan-STARRS team[1], [1]Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI, 96822, jedicke@ifa.hawaii.edu.

Introduction: The prototype telescope (PS1) for the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS, [1]) is the first of the next generation of large synoptic surveys. We will present solar system results from PS1 commissioning data.

Discussion: The PS1 1.8m telescope is located on Haleakala, Maui, Hawaii. The telescope and camera system will provide an ~7 deg^2 field of view that has been instrumented with the largest camera in the world – 1.4 billion pixels at about 0.3''/pixel. Despite the large number of pixels we expect to read the camera out in <7 seconds with a read noise of about 5 electrons. The large field of view and rapid readout at low noise is achieved at reasonable cost using orthogonal transfer array (OTA) CCDs [2]. These CCDs can move the charge on the pixels in real-time as the exposure takes place in order to compensate for image motion due to seeing, wind buffeting or drive irregularities. With this technology we expect to regularly achieve sub-arcsecond PSFs from Halekala and 0.5'' PSFs for the four telescope Pan-STARRS system that we hope to install on Mauna Kea in a few years.

We will image about 3,000 deg^2 twice/night in order to identify moving solar system objects – roughly two 2.8 GB images every minute. Thus, we could survey the entire sky visible from Hawaii in about a week. The actual survey pattern is somewhat more complicated. For the discovery of solar system objects the survey must recover the objects on at least 3 days/lunation in order to identify the objects and fit orbits to the detections. Thus, most of the solar system surveying takes place in a large opposition region (±30° from opposition in R.A. and from -30°≤Dec≤+90°) and in the 'sweet spots' [3] from 60°≤solar elongation≤+90° and ±10° in ecliptic latitude. At the limiting magnitude of PS1 the sky-plane density of potentially hazardous objects (PHO) is higher in the sweet spots than at opposition.

The images will be processed in nearly real time by the Image Processing System (IPP). All the 'normal' processing of CCD images will be applied along with the modifications necessary to handle the effect of the OTA shifting charge on the CCD at up to 30Hz. High S/N 'static sky' images will be subtracted from each individual image to provide images containing only transient detections (solar system objects, supernova, etc.) and noise. The IPP then runs a source detection algorithm over the difference image and provides a list of transient detections (and noise) to the Moving Object Processing System (MOPS).

The MOPS [4] is the first 'integrated' moving object detection and processing system in the sense that it processes data at the telescope through to providing and updating orbits of the derived objects. We expect that PS1 and MOPS will identify more than a million solar system objects over the course of its 3.5 year mission. On any single night it may have to process tens of thousands of objects. Aside from the system integration the most innovative feature of the MOPS is that it incorporates a synthetic model of the solar system [5] to measure the system's detection efficiency automatically and in real time. The synthetic solar system objects are injected into the incoming transient data stream at the same time as the real data and processed 'blindly' so that the efficiency of detecting real solar system objects can be determined from the synthetic objects.

MOPS has already been tested on several real data sets including Spacewatch [6], TALCS [7] and CFHT Megaprime data. On synthetic data samples MOPS achieves >90% efficiency at discovering solar system objects when there exist at least 6 detections of an object in a lunation. We believe that the realized PS1-MOPS efficiency will not be as high due to surveying inefficiencies (e.g. weather) and other effects such as chip gaps and dead OTA CCD 'cells'. Despite these problems we expect to discover tens of thousands of asteroids and/or comets each lunation. Of particular interest is the NEO population for which we will discover hundreds/month.

References: [1] Hodapp *et al.* (2004) Astron.Nach. 325, p.636 [2] Burke *et al.* (2004) S.P.I.E. 5499, p.185 [3] Chesley and Spahr (2004)*, Cambridge U.P., p.22*.. [4] Jedicke *et al.* (2006) IAU Symposium 236. [5] Grav *et al*. (2008), submitted to Icarus [6] Larsen *et al*. (2001), A.J. 1212, p.562 [7] Masiero *et al*. (2008), in prep. and at ACM 2008.