USING OPEN INNOVATION TO SOLVE NASA PLANETARY DATA CHALLENGES. L. Buquo[1], S. Rader[1], C. Woolverton[1], A. Wolf[1], C. Galica[2], K. Becker[2], M. Ching[2] , [1]NASA Center of Excellence for Collaborative Innovation (NASA Johnson Space Center, 2101 NASA Parkway, Houston, TX, 77058, Lynn.Buquo-1@nasa.gov) for first author, [2]Stellar Sollutions, Inc (NASA Heaquarters, 300 E St SW, Washington, D.C., Carol.A.Galica@nasa.gov)

Introduction: In 2011, the Administration launched the Center of Excellence for Collaborative Innovation (COECI), a NASA-led, government-wide center of excellence to provide agencies guidance on all aspects of implementing prize competitions: from effective problem definition, to the design of incentives that attract solvers, to evaluation of submitted solutions. CoECI helps NASA generate ideas and solve important problems by using challenges, to increase creative capacity and reach by tapping into diverse talent from around the world. As a pioneer and active user of open innovation methods and tools, the NASA CoECI provides organizations with a cost-effective and complementary means of extending their innovation boundaries. CoECI will highlight four successful challenges related to planetary data that were conducted in partnership with the planetary data community. Through COECI, NASA helps other Federal agencies follow in its footsteps. For select agency pilots conducted through interagency agreements or through informal support, COECI leverages existing NASA open innovation infrastructure to provide a full suite of services, allowing agencies to rapidly experiment with these new methods before standing up their own capabilities. During 2014, COECI helped numerous agencies implement challenges, including CMS, the Office of Personnel Management (OPM), USAID, DOE, and EPA.

Lunar Mapping and Modelling Portal (LMMP) Challenge: The LMMP challenge focused on technology development. It required development of a Mosaicking Service tool to perform image processing that transforms the raw images taken by the Lunar Reconnaissance Orbiter (LRO) to geo-referenced and mosaicked images that can be displayed on the Lunar Mapping and Modelling website. Solvers were required to take parameters describing a set of images, do the image fetching and conversion, and perform mosaicking. They utilized a modified version of the Planetary Data System (PDS) Application Programming Interface (API) to handle the image fetching from Orbital Data Explorer (ODE), and will store the output files somewhere that the caller (Tiling service) can retrieve it from. The solution should reduce the time required to create high resolution geo-referenced mosaics of images taken from the LRO.

Planetary Data System (PDS) Cassini Rings Challenge: The Cassini Rings Challenge was launched to advance scientific research. It leveraged the PDS API, as well as the rich archive of Cassini data at the PDS-Rings Node hosted by SETI, and the Appirio-Topcoder community of competitors afforded by the NTL, in an effort to develop an algorithm that can identify possible anomalies in Saturn ring patterns. The algorithm employs machine learning techniques to automatically "learn" image annotation from a set of images previously annotated by researchers, and will apply this learning to accurately annotating a new set of unprocessed images. The completed algorithm may also be applied to previously annotated images, to identify other possible anomalies, and will be able to learn from new annotations as they are provided. To accomplish these goals, the algorithm will leverage the PDS API, Cassini image and meta data, and will be able to parse sequential image sets to detect cross-image anomalies.

Asteroid Tracker Challenge: The Asteroid Data Challenge created an algorithm that can continuously determine the optimum selection of subsets of antennas within an array for a given track observation. This is a complex analysis and goes directly to development of the concept of operations and cost of operations (in terms of maintenance and total capacity required). The requirements for this algorithm were as follows: be able to model phased array antenna beams using a predetermined set of dish and beam properties, take, as input, trajectories of a number of NEO and for each, be able to provide the optimal selection of sub-arrays to track the object for its entire visible path (or, if defined, a minimum time period of observation that gives sufficient scientific observation value); and be able to read properties from configuration files – i.e. dish properties, array configuration, trajectory data, etc.

Asteroid Data Hunter: The Asteroid Data Hunter Challenge provided a new algorithms to promote science. Scientists find asteroids by taking images of the same place in the sky and find the star-like objects that move. With many telescopes scanning the sky during the time around the new moon, the large data volumes prevent individual inspection of every image. Traditionally, the identification of asteroids and other moving bodies in the Solar System has been achieved by acquiring images over several epochs and detecting changes between frames. This general approach has been used since before the discovery of Pluto and continues to this day. With the vast amount of data available now flowing from modern instru-

ments, there is no good way for professional astronomers to verify every detection. In particular, looking in the future as large surveys grow ever larger, the ability to autonomously and rapidly check the images and determine which objects are suitable for follow up will be crucial. Current analysis implies that at best the CSS data pipeline is 80 – 90% accurate and there are (based on CSS discovery numbers) several thousand additional objects that could be recovered per year. Starting from a fresh position allows specific optimizations of data analysis, which would be useful as a general moving object pipeline system for other observatories as well. The Asteroid Data Hunter Challenge developed an original algorithm that allows the discovery of new asteroids by analyzing images, created an app that is so easy that citizen scientists, hobbyist astronomers and even professional organizations/institutions will want to download it and ensured that the new algorithm can help to increase the amount of asteroids being detected.