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NEO FOLLOW-UP, RECOVERY AND PRECOVERY CAMPAIGNS AT THE ESA NEO COORDINATION CENTRE

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We summarize the goals and results of the observational activities and campaigns organized by the ESA SSA-NEO Coordination Centre (NEOCC), which directly address the mitigation of the impact threat by using a network of collaborating observatories to obtain follow-up and recovery observations of high-importance objects, specifically faint Virtual Impactors (VIs).

Introduction

Follow-up observations are one of the most fundamental components of the NEO observational process, essential to improve our knowledge of the orbit and future dynamics of the object, and to prevent newly discovered objects from becoming lost.

As of March 2015, approximately 12000 NEOs are known, and about 500 of them are considered Virtual Impactors, having non-zero probability for an impact with Earth in the next century. However, a large fraction of these VIs (~90%) is currently considered lost; their orbits are not known well enough to constrain their position in the sky at the next apparition to a level sufficient to obtain new observations. Therefore, the estimate of their actual threat cannot be improved, unless they happen to be rediscovered by chance in the future.

While large scale surveys are devoted entirely to the discovery of new objects, and some specific projects are focusing on physical characterizations, until now a centralized effort to coordinate the follow-up of important objects has been lacking. The recently established ESA SSA-NEO Coordination Centre in Rome, Italy, has among its goals the direct execution of follow-up observations of the highest-priority targets, and the coordination of a network of observatories that are being alerted when high-relevance objects need observations.

Immediate follow-up

The first and most direct way to prevent an object from becoming lost is to ensure an adequate observational coverage during the discovery apparition. This should be done both immediately after discovery and over subsequent weeks and months, before the object recedes too far to collect additional observations.

The first part of this process is usually based on the information distributed by the Minor Planet Center (MPC) on the so-called NEO Confirmation Page (NEOCP)[1]. Most of the objects on this list are moderately bright (in the V<22 range), and easily accessible to meter-sized telescopes. However, over the past few years the average number of entries has grown significantly, and it is now becoming problematic to obtain confirmation of all of them with the observational resources available worldwide.

To support this effort the NEOCC makes use of dedicated telescope time on the 1.0-meter ESA Optical Ground Station (OGS) telescope in Tenerife, Spain. The NEOCC usually manages 4–8 nights every month dedicated to NEO observations, enough to observe 10–15 NEO candidates on any given (clear) night, with a specific focus on objects that are ideally suited for a 47' FoV and a typical depth of V~22 (moderately large uncertainty targets at the faint end of the NEOCP brightness distribution).

The telescope is also used for the activities of the Teide Observatory Tenerife Asteroid Survey (TOTAS), which already led to the discovery of a few NEOs, including 2014 QN266, a small VI in an accessible Earth-like orbit. Thanks to TOTAS, the OGS was the tenth most prolific NEO discovery site in the world in 2014.

The second part of the follow-up process happens after the object is designated and announced as an

[1] http://www.minorplanetcenter.net/iau/NEO/toconfirm_tabular.html

NEO. Due to the high prominence of the NEOCP among the NEO follow-up community, it is not unusual for an object to be mostly ignored after it is removed from the page, and therefore be poorly observed even if the visibility is good.

To mitigate this problem, and allow observers to properly choose the best targets for follow-up, the NEOCC also maintains the Priority List, a publicly available list of NEOs in need of urgent follow-up, originally developed by the Spaceguard Consortium and now hosted on the SSA portal: http://neo.ssa.esa.int/web/guest/priority-list. The List is also directly used to select targets for follow-up observations during the runs at the OGS telescope.

Faint follow-up and arc extension

Although the follow-up activities with meter-class telescopes are essential to ensure a good observational coverage for the largest possible number of new discoveries, in some cases an object may quickly become too faint for telescopes of such class. This is especially worrisome for VIs, because it implies that the remaining impact solutions will not be clarified until the next future observational opportunity arises (which may never happen, if the object is about to become lost).

To address this issue directly, a very fruitful collaboration was established with the European Southern Observatory (ESO) to observe faint VIs, down to magnitude ~26, with the 8.2-meter Very Large Telescope on Cerro Paranal. During 2014 and the first part of 2015 almost 30 VIs were observed, most of which were removed from the risk list thanks to the resulting astrometry. As an example of the capabilities of this system, our observations of 2014 WF6 in January 2015 (Fig. 1) likely qualify among the faintest detections of an NEO ever achieved, at V~26.4.

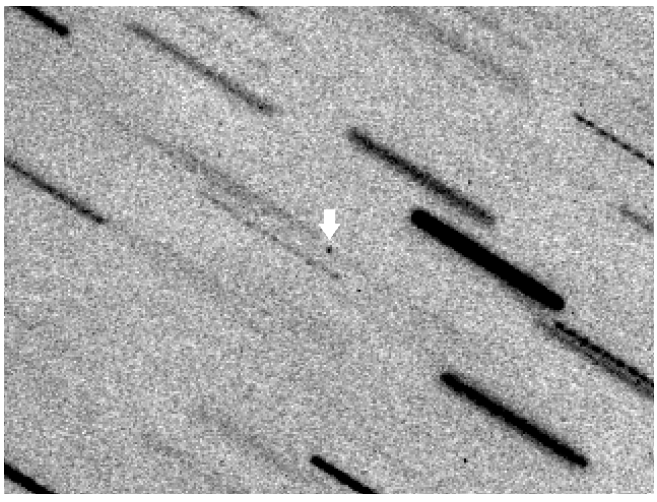

Figure 1: VLT detection of 2014 WF6 at V~26.4

Recoveries

The follow-up activities outlined in the previous sections are essential to prevent the loss of the highest possible number of NEOs. However, in some cases the observational geometry at the discovery apparition is simply too poor to allow for the collection of enough observations, and the object will become unobservable before sufficient information has been collected to allow for its easy localization at the next apparition.

Occasionally, an important object such as a VI becomes observable in a configuration where its uncertainty is significant but not prohibitive (e.g. a few degrees). In this case, it is therefore possible to image the entire uncertainty region, down to an appropriate depth, and recover the object. These recovery observations usually require a large FoV (to efficiently cover the uncertainty), and a reasonable aperture (to reach the required depth, often significant since the apparition may not be ideal).

Unfortunately, the ESO VLT, with its small FoV of only 7', is not the ideal instrument for this type of work. Therefore, we recently started a new collaboration with the 8.4-meter Large Binocular Telescope in Arizona, with the support of INAF, one of the main partners of the telescope. LBT, with its twin wide-field cameras and large aperture, is the ideal instrument to recover large-uncertainty NEOs; as a first direct proof of its capabilities, in October 2014 we obtained recovery observations of 2014 KC46, at V~26.3 and with an uncertainty of almost half degree.

In addition to LBT, we also attempt recoveries of brighter NEOs (especially PHAs) with the OGS telescope, when appropriate targets are available.

Precoveries

When all of these options fail, an object becomes unobservable and no future recovery opportunity is available, the only remaining option is to search for existing unrecognized detections of the object in image archives. Nowadays, most professional telescopes make their data available in public online archives a few months to years after the data are taken, when the proprietary period expires. Most of these images are obtained for science goals that do not include asteroid, and have not been inspected to locate moving objects. Some of them may therefore include unrecognized detections of an important asteroid, which if properly identified and measured could allow for a significant improvement of the orbit.

As a part of the NEOCC effort to ensure the best observational coverage to important objects, we routinely check for archival observations of VIs. This effort resulted in a good number of detections, including a few impactors that were otherwise lost, but were removed from the Risk List thanks to these data.

At the NEOCC we are in the process of implementing an ESA-based archive of astronomical images from collaborating European observatories, which will increase the resources available for this kind of searches.