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RECENT EVOLUTIONS IN ESA'S NEO COORDINATION CENTRE SYSTEM

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Extended Abstract—

ESA's NEO Coordination Centre (NEOCC) located at ESRIN (Frascati, Italy) is a major element of the Planetary Defence Office of ESA's Space Safety Programme [1]. One of its main goals is the generation, collection, integration and display of computed and existing NEO data in order to provide users with up-to-date information on NEO hazard monitoring. This is done by operating and maintaining a software system interfacing with the users through a technical web portal publicly available at http://neo.ssa.esa.int. The NEO System is an evolving environment. Since when it was first established in 2012, its functionalities have been steadily growing in terms of available services and data. Several functions are executed at the NEOCC:

- Follow up of asteroids in need of more observations to improve the knowledge of their orbits. For this, the ESA Optical Ground Station (OGS) is used on a monthly basis, as well as some supporting telescopes like ESO's VLT and others [2],
- The Orbit Determination System, which takes astrometric positional data of asteroids from the MPC and computes high-precision orbits from these data. Orbits are later propagated 100 years into the future and the impact risk of these objects is computed,
- The 'priority list', including a list of NEOs in need of observations. This list was developed by INAF/Rome. The complete code was migrated to ESRIN and is executed and maintained within the Centre,
- Inclusion of a physical properties database based on the EARN (European Asteroid Research Node) service, which is maintained by G. Hahn.

In summary, the following services are provided by NEOCC through its web portal:

- Risk list, with all NEOs having a non-zero impact risk in the next 100 years,
- Close approaches list, with a table of all known objects approaching the Earth in the next year and another table with the approaches of the past month,
- Priority list, with the objects in need of observations in the short term,
- Close approach fact sheets for special close approach cases,
- Search functions to find information on NEOs, other asteroids and comets,
- News and newsletter archive,
- Discovery statistics,
- Orbit visualisation tool,
- NEO Chronology, as provided and maintained by Karel van der Hucht,
- An image database linked to the Solar System Object Image Search (SSOIS) system,
- Access to two stand-alone tools that can be downloaded and executed by external users: one prepared to produce NEO population and observability data (NEOPOP) and another one designed for NEO trajectory propagation (NEOPROP).

Regarding the recent evolutions of the system, a significant addition is the incorporation of the mentioned orbit determination capabilities since the end of 2017. The Orbit Determination System (ODS) is now fully migrated to the NEOCC as an evolution of the NEODyS system. It takes astrometric positional data of asteroids from the MPC and radar measurements and computes high-precision orbits through an almost entirely automated process. In particular, the system ingests newly-published MPC Circulars (MPECs) on an hourly basis and processes them. MPC's Daily Orbit Update and possible new radar data provided by JPL are imported and processed by a daily script. After each ingestion task, a new orbit determination process is thus triggered. For each NEA having new available data, the ODS provides as output the fitted orbit, a statistical evaluation of the residuals, the computation of close approaches with the Earth and other bodies, and ephemerides in various formats. Dedicated scripts also import and process the monthly and mid-monthly data batches provided by the MPC and update the orbital data of non-NEA objects. All the above information is provided for output purposes on the NEOCC web portal and serves as input to the Impact Monitoring System.

Another relevant addition to the NEOCC system is the one associated to the migration of the Impact Monitoring System (IMS), an evolution of the NEODyS service. This application allows the propagation of the NEA trajectories for up to 100 years in order to detect possible impacts with Earth, calculate the associated probabilities and compute the expected impact corridor in cases where the impact probability value is above a given threshold. At present the system just passed the on-site acceptance tests and is currently under evaluation by the NEOCC staff. This activity is described in another presentation within this conference [3].

Other enhancements to the NEOCC information system relate to the incorporation of tools for the automated ingestion of FITS images into its image database. In 2018 a number of applications were added to the system in order to a) ingest the FITS header of the images to be uploaded to the database and repository, b) verify that those headers are compliant with the current requirements proposed for the header contents and format and c) actually upload them into the system when they comply with the expected information contents. The FITS images passing the software validation are ingested into the NEO database and then made available on the NEO web portal through a search engine. Once a given image is accessed on the web portal, a FITS preview together with the display of the primary header are offered to the registered user for download. The metadata for each valid image stored in the NEO database is gathered into a file that is made available for download to the Solar System Object Image Search (SSOIS) hosted by Canadian Astronomy Data Centre.

The NEOCC web portal also provides information on the physical properties of asteroids as collected in the EARN database, managed by G. Hahn and hosted until 2018 by DLR in Germany. The current functionality at the NEOCC allows the public to search and filter objects by their physical properties (e.g. size, rotation period and albedo) as well as their orbits, providing the functionality for complex queries. However, this data has previously been introduced manually from each EARN release, resulting in an inadequate update frequency and a lack of information on objects discovered recently. Thus, a new automatic application to process the EARN data files directly and update the NEOCC physical properties database was delivered in 2018 and is currently undergoing testing. When put into service after an adequate validation, the application will feed the NEOCC portal with the carefully curated data by Dr. Hahn, providing timely updates to the information. The application parses the EARN data files, validating their format and consistency, and makes the data and its journal references available to the rest of the portal. The development and testing effort is currently focused on the correct processing of the many special properties and values described in the EARN files, like binary objects, bounded or approximate values, radar based observations, etc.

Finally and from a purely technological perspective, since 2018 the NEOCC system has also incorporated a state of the art pipeline for continuous integration (CI) and continuous deployment (CD) of software changes and updates. The CI is used to efficiently automate the SW activities. GIT is used for the source code management. Each repository containing the source code to be delivered includes a deployment script that implements three stages: build, validation and deploy. When the push is done from the repositories, the three stages are automatically executed. If the build and validation pass, the deployment process installs the delivered software component onto the NEO System. The automatic execution of the tests with the installed software is done using tools to execute functional and performance tests. For example, for graphical elements on the Web Portal Selenium is used. The CD is an extension of CI to make sure that new system changes can be quickly and efficiently released and in a sustainable way. Continuous corrective and evolutionary maintenance ensures the improvement of already existing services at NEOCC.

A list of future developments includes: adding new visualisation tools, finalising a fireball information system, implementing an impact effects tool and including the results of the European Commission NEOShield-2 project output into the NEO system.

[1] Jehn R., et al.; Planetary Defence Activities at the European Space Agency, in this conference (2019)
[2] Micheli M., et al.; Observational Activities at ESA's NEO Coordination Centre, in this conference (2019)
[3] Bernardi F., et al.; NEODyS services migration to ESA's NEO Coordination Centre: the effort and the improvements, in this conference (2019)