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## THE NEAR-EARTH OBJECT SEGMENT OF ESA'S SSA PROGRAMME

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### Introduction

The Near-Earth Object (NEO) segment of ESA's Space Situational Awareness (SSA) Programme is addressing the prediction and detection of the potential impact of a near-Earth object. The following information needs are defined:

- a) knowledge of the current and future positions of all NEOs above a given size threshold or risk level, in particular their minimum flyby distance to the Earth and time of this event;
- b) maintained awareness of collision risks with the Earth;
- c) access to verifiable, dependable, timely data with integrity and known accuracy.

Additionally, the SSA-NEO segment supports all aspects of NEO mitigation in close international coordination.

The SSA-NEO Coordination Centre (NEOCC) is located at ESA's site in Italy, ESRI. A so-called precursor system has been built up there. This system is reachable via a 'technical web portal' at <http://neo.ssa.esa.int>.

The paper gives an overview of ongoing and planned SSA-NEO activities in its main areas: Observations, orbit prediction and impact monitoring, and mitigation support.

### NEO Observations

The SSA-NEO segment uses the 1-meter telescope of ESA's Optical Ground Station (OGS), located on Tenerife, for NEO follow-up measurements and surveys. This work is done in close cooperation with amateur astronomers. The OGS is shared with other applications (optical communication with satellites, space debris

observations) and typically used for 4-6 nights per months for NEO observations.

In addition, agreements have been established with existing cooperating sensors. These cooperation are of different forms (paid contracts, informal cooperation for ad-hoc use in special cases). Past and present co-operations include the following entities with additional agreements planned:

- The La Sagra Sky Survey
- The DLR telescope on Calar Alto
- The Klet observatory
- ESO telescopes
- The Large Binocular Telescope
- The Faulkes telescopes

#### *Planned telescopes and observations*

The SSA-NEO segment plans to survey the complete visible sky every night down to a limiting magnitude of 21.5 for moving objects. This so-called 'wide survey' concentrates on smaller objects which only become briefly visible in the vicinity of Earth. The aim is to detect objects in the tens of meters size range 2-3 weeks before a potential impact. For such a task telescopes of the 1-meter class with a large field of view are required. The development of such a telescope with an innovative fly-eye design has been initiated. An architectural design has been developed for a complete NEO survey system. Such a system will require 4-5 telescopes of the fly-eye type plus a limited number of follow-up telescopes. A centralized scheduling and tasking function, data storage and processing system with initial tracklet analysis for astrometric data at the telescope site is seen as optimum.

## Data and information provided by the NEOCC

The SSA-NEO segment provides information on all known NEOs and on asteroids with good orbital information. The following specific data and information is provided by the SSA-NEO system (some capabilities are still under development):

- Orbital information on NEOs, other asteroids and comets
- A risk list with information on all NEOs that have a non-zero impact probability with Earth during the predictable future (typically 100 years). This risk list includes information on the potential impact with the highest risk. A table with the full list of all potential impacts within the analysed time period is available as well.
- Close approaches with Earth (within 0.05 au) during the past month and upcoming year. The information includes the encounter velocity and the maximum apparent brightness at closest approach.
- The priority list with objects in need of further observations to confirm their discovery or improve their orbits.
- NEO discovery statistics for different time intervals and object sizes.
- Physical information on objects if available.
- An interactive tool for the visualization of orbits.
- An image database with sky images obtained during NEO observations.
- A chronology on Near-Earth Asteroid activities which had previously been hosted by the IAU.
- A fireball database which aims to collect information on all observed fireballs brighter than magnitude  $m=-10$ .
- Tools for users to calculate the sky positions of objects and other parameters.
- A tool to predict the ground corridor of a potential impactor, including confidence contours.
- News archives, image gallery, animations and background information.

A large part of the information is obtained from federating European assets:

- The NEODyS system of the University of Pisa/SpaceDyS.
- The 'priority list', a list of NEOs in need of observations.
- The physical properties database, EARN (European Asteroid Research Node), from DLR Berlin.

The information on comet orbits is obtained from JPL.

The NEO data are updated daily. The asteroid data once per month. Most of the data is available online. In addition a monthly NEO newsletter is sent to interested users.

## NEO mitigation and impact warnings

### *International Coordination*

The NEO impact risk concerns the whole world. NEO observations and predictions are usually shared openly. Warning and mitigation issues have to be addressed in international coordination. For these reasons the International Asteroid Warning Network (IAWN) and the Space Mission Planning Advisory Group (SMPAG) have been established. Both groups were formed following a recommendation of the UN-COPUOS. IAWN deals with exchange of information and potential impact warnings while SMPAG addresses potential NEO deflection space missions. The SSA-NEO segment actively participates in both groups.

### *Impact warnings*

In case of a real impact threat warnings will be issued to a list of previously identified contact points. Workshops are held with civil protection Agencies, decision makers and communication experts to identify the information needs and communication procedure to follow in such a case. The final warning procedure will be defined in close coordination with IAWN.

### *Impact effects and mitigation measures*

NEO mitigation includes the assessment of impact effects and potential measures like warnings, evacuations or deflection missions. The SSA-NEO segment initiated studies to review the existing knowledge in the areas of impact effects and mitigation measures. Roadmaps were established in each of these areas. The main recommendation on impact effects is the establishment of an operational tool which allows an assessment of the effects of a specific impactor in near real time. This tool should be based on a set of realistic pre-calculated reference cases. The roadmap on mitigation measures identified existing and required technologies for a NEO deflection mission and identified the Asteroid Impact & Deflection Assessment (AIDA) mission as a promising candidate for a demonstration mission. AIDA should deflect the moon of the double asteroid (65803) Didymos and consists of 2 spacecraft, the Asteroid Impact Mission (AIM) and the impactor DART (Double Asteroid Redirection Test). AIDA could be realised in international cooperation for an asteroid encounter in 2022.

Mitigation activities of the SSA-NEO segment consider related activities and results from the NEOShield project of the EU. Other NEO mitigation activities take place within the IAWN and SMPAG groups.