THE NEOROCKS NEO PHYSICAL PROPERTIES DATABASE: PRESENT STATUS AND FUTURE PERSPECTIVES

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ABSTRACT

The implementation of an advanced NEO physical properties database, as foreseen by the EU funded NEOROCKS project (NEO Rapid Observation, Characterization and Key Simulations) has been completed. The access is presently restricted to the consortium partners in order to store and process the outcome of their observational activity. After migration inside the ASI Space Science Data Center (SSDC) the database will be publicly available and open to external users. In what follows the database main characteristics are summarized and its relevance within the framework of the EU SSA Programme is discussed.

1 INTRODUCTION

A major outcome of the data management activities of the NEOROCKS project [1] is the development and the deployment of an advanced NEO physical properties database. Therefore, a data model derived from well-defined IVOA (International Virtual Observatory Alliance) standards, aiming at making the NEOROCKS database compliant with existing virtual observatory (VO) services, has been designed. This implies the ability to store, maintain, give access and regularly update all different levels of processing, from raw data to final products (e.g. size, rotation, spectral type). The implementation has been completed and the database is now integrated within the project Technical Web Portal, which inlcude additional functionalities and tools. After a consolidation phase and before the end of the project (June 2023) the web portal and database will be migrated within the Space Science Data Center of the Italian Space Agency (ASI-SSDC: https://www.ssdc.asi.it/) in order to be hosted in a permenent infrastructure devoted to space-data management. As such it will be made accessible not only to the consortium partners but also to external users. Thus, by extending the maintenance and the evolution of the database well beyond the NEOROCKS project duration, one of the major goals of the EU Horizon 2020 Programme, i.e. starting R&D activities which are likely to evolve into fully operational assets, is fulfilled. In this respect the scope is to attract the scientific community involved in NEO physical characterization, offering the possibility of manage their own data (e.g. user-dedicated workspace, image archive etc), in a shared context, thus ensuring the long-term storage and the scientific exploitation of the data

2 DATA MODEL

The data modelling process aims to define the optimal data structures to represent every domain entity in order to efficiently develop the required functionalities. The development methodology is based on the following steps: Requirement Analysis, Conceptual Modelling, Logical Modelling. The Logical Data Model eventually obtained, uses the Relational Model [2] as the Target Model.

Requirements analysis: From the project high-level proposed objectives, an exhaustive list of functional and non-functional requirements was assessed. A reduced set of requirements was then defined as the baseline for the database. The criterion adopted to select these requirements was the feasibility to implement them within the project time frame. Guidelines for a full implementation of the original requirements have been also laid out.

Conceptual modelling: The requirements defined during the previous phase were analysed and logically grouped to model the application domain. Applying the Entity Relationship formalism [3], this step focused on the abstraction process inspecting all the relevant entities involved, the identification of the specific properties and the relations between them. Once the conceptual model was represented into a conceptual diagram, such diagram has been checked to verify that:

- any syntactical or semantical rules of the chosen E-R formalism is not broken (correctness). This feature was checked by inspection and comparison with definitions and specifications for the constructions used into the diagram;
- every relevant information is represented in the schema and every operation is possible within the defined concepts (completeness). This verification step is based on the requirements produced during the previous phase;
- the diagram has good readability in order to be

clearly understood by experts of the application domain. This characteristic is linked also with aesthetics decisions;
- the diagram is minimalistic, i.e. it minimizes redundancies, ensuring that each piece of information specifying some requirement about the data is represented only once.

The E-R diagram obtained is shown in Fig. 1.

Target bodies are identified through their IAU designation and represented by "NEO" as main entity to which the orbital or physical properties are assigned and observations or investigations are associated to.
Another fundamental entity of this model is the "NEO Physical Characterization", which includes all attributes related to the physical characterization of an object. This entity has the relationship "orbital description" with the NEO entity and it is externally identified through this relationship. Similarly, the "NEO Orbital Characterization" groups any attribute related to the orbital characterization of the NEO and it is externally identified through the relationship "orbital description" with the "NEO" entity. The "User" entity represents the general user identified by its name, while the "NEOROCKS User" is the user belonging to the project. In this way access to the database can be easily extended to other users. The "Observation" entity represents a planned or executed observation. In the latter case, the sub classing "Run" entity is used, which reports the actual session performed.
All data files linked to a given executed observation are described by the "Observation Data File" entity. An "Ancillary Data File" instance can be used to include any additional file which is not observational, but it is needed to create a calibrated or processed product. This further set of data is linked to the "Observational Data File" entity through the "ancillary dataset" relationship. The "Instrument" entity considers two kind of instruments to be considered: "Imager" and "Spectrometer". They are linked to the hosting infrastructure by the "hosting" relationship with only one instance of the "Telescope" entity which is identified by a unique MPC code.

Logical modelling: In order to deal with performance issues, the logical modelling considered the implementation constraints rearranging and translating the conceptual model into the logical model.

This translation consisted in the removal of any residual redundancy (if present) and the replacement with constructs available in the Relational Model. For the Physical Characterization generalization, the children entities were merged into the parent entity, adding the "Best option" to consider as best solution for a given NEO and a given User. Similarly, the generalization of the NEOROCKS User entity into the User entity merged the children entity into the parent entity and adding the boolean attribute "external" to the parent entity. A new relationship between these two entities, called "executing", generalized from Run to Observation. Finally, the generalization related to the Instrument entity is replaced by merging the children entities into the parent entity and adding the attribute "Type" to distinguish between instrument types.

Data model and database compliancy: The data model has been designed following the well-defined IVOA standards and FAIR (Findable, Accessible, Interoperable, Reusable) principles [4], i.e. using international standards which assure both the long-term archive preservation and the interoperability with other data centers. In this light, it has been envisaged the ability to store, maintain, give access and be regularly updated at all different levels of processing, from raw data to final products, in order to be compliant with existing VO services.

The NEOROCKS Data Model has been also designed to allow the rapid dissemination of the data acquired by the project. Since some available VO resources already describe observations and models focused on small bodies (through the EuroPlaNet Table Access Protocol EPN-TAP) [5]), EPN-TAP parameters are at the core of NEOROCKS Data Model. The EPN-TAP protocol envisages also the possibility to store the measurement errors in the database, by referring to them with the suffix "_error" after the name of the parameter (e.g., albedo_error) and adding dedicated columns. In the NEOROCKS project, a similar approach is followed by referring to measurement error parameters using the suffixes "_error_min"/"_error_max" (for different error bars). Similarly, the 1-sigma variation value will be introduced with the "_sigma" suffix.

Following the EPN-TAP Data Model, the NEOROCKS Data Model comprises 47 mandatory parameters that must be present (even if NULL) in any VO-compliant database. In addition to mandatory parameters, the EPN-TAP also offers the opportunity to customize the database by adding optional parameters, in order to allow including further data of interest for planetary science. A third set of parameters referred to as "additional parameters" are also foreseen, although not yet included in the EPN-TAP standard.

The NEOROCKS database is integrated within the project Technical Web Portal and presently available only to the consortium partners. The ultimate goal is to open the access to external (public and authenticated) users and ensure the maintenance of the NEOROCKS technical portal and the regular updating of the database content well beyond the end of the project. This will be achieved through partnership with the ASI SSDC which will provide the necessary HW/SW environment and experienced personnel. Over the years, SSDC has acquired, managed, processed and distributed space mission data following FAIR principles. The long-standing experience in hosting the data produced by astronomical missions and in providing the astronomical community with the necessary tools for their scientific exploitation, makes the ASI Space Science Data Center an ideal facility to preserve the achievements obtained by the NEOROCKS project.

3 USER INTERFACE

The physical properties database is integrated into the NEOROCKS Technical Web Portal, thus sharing the user interface. The web Graphical User Interface (GUI) was designed accordingly to the most recent web standards, using HTML5 JavaScript and CSS with JSTL tags. In order to guarantee portability on different client devices, page layouts were based on the front-end open source toolkit Bootstrap 4 (https://getbootstrap.com/).

Three different type of users are foreseen: the authenticated user, the public user and the portal administrator. The authenticated user is assigned a dedicated area, and can plan, input and modify the results of the observations. Any acquired observational data will be managed through the Observation Upload feature and public dissemination follows an agreed data policy. Search and Retrieval functions can be carried out using a user-friendly graphical interface to the underlying database.

The public user can take advantage of every feature available for the authenticated user, except for the Observation Upload and manage functions.

The portal administrator is able to use every portal feature, mainly for testing and maintenance tasks embracing key functionalities and web contents.

The initial page of the database user interface is shown in Fig.2. Note that search and retrieval functions can be performed throughout the whole database content, allowing complex queries including orbital properties, physical properties and observations.

4 FUTURE PERSPECTIVES

The incoming operations of the next generation sky surveys, both from the ground [6] [7] and in space [8], will dramatically change the NEO discovery scenario. The expected sharp increase in the discovery rate calls for an equally efficient follow-up observational network in order to secure the orbit and perform physical characterization. A key issue, not only for keeping pace with the increased flow of information but also for providing high quality data products for scientific and planetary defence applications, is the onset of a direct link between orbital and physical characterization. Yet, while the detection of a moving object for astrometric purposes can be performed also by relatively small telescopes and by pushing the performances to extremely low S/N, physical characterization requires the availability of large-aperture telescopes (often undergoing lengthy time allocation procedures), sophisticated instrumentation, accurate ephemerides and has lower limiting magnitudes. This difference reflects also in the data management. The NEO orbital data policy is established by the International Astronomical Union (IAU) with the Minor Planet Centre (MPC) routinely collecting, storing and distributing all solar system small bodies astrometric observations as well as computing the corresponding orbital catalogues. On the contrary, the management of the NEO physical properties does not follow an organized data dissemination structure. The data produced by the observations and by modelling the NEO physical properties are the result of scientific research and published as such. Only a fraction is available on-line.
In this respect Europe plays a prominent role: a large scientific community performs NEO observational campaigns through competitive access to a wide variety of options, from small 1m-class telescopes to the large infrastructures ruled by international consortia (e.g. ESO). In order to support and further enhance this expertise the European Union has included NEO physical characterization in several R&D actions (e.g. [9] [10]), NEOROCKS being the most recent. The excellent results obtained have led to include NEOs in the EU 2021-27 Space Programme [11]. Harmonization with the activities carried out within the ESA Space Safety Programme has been obtained through a specific agreement [12]. According to it ESA is entrusted to manage the EU funded actions and, among them, achieving significant progresses on NEO physical characterization is a major goal.
Federating existing Member State assets is the first step for EU programmes in order to optimize the exploitation of already available technical resources. The same happened when launching the EU SST (Space Surveillance and Tracking) initiative, whose aim is to allow Europe to reach a significant level of autonomy in monitoring the space debris population. Building on that, care has been taken to consider the ESA NEO Coordination Centre [13] as a primary data source for the NEOROCKS Technical Portal and database. Moreover, since the Europlanet [14] guidelines for developing the data access services have been applied, the NEOROCKS physical properties database can be straightforwardly integrated into future open operational NEO monitoring systems.

5 ACKNOWLEDGEMENTS

The authors acknowledge funding from the EU H2020 programme under grant agreement No 870403 / project NEOROCKS.

The NEOROCKS Team is composed also by: S. Anghel, M. Banaszkiewicz, S. Banchi, M. A. Barucci, F.

Bernardi, A. Bertolucci, M. Birlan, B. Carry, A. Cellino, F. Calderini, F. Colas, J. De Léon, A. Del Vigna, A. Dell'Oro, A. Di Cecco, L. Dimare, M. Lazzarin, P. Fatka, S. Fornasier, E. Frattin, P. Frosini, M. Fulchignoni, R. Gabryszewski, J. Huntingford, T. Hromakina, S. Ieva, J.P. Kotlarz, F. La Forgia, J. Licandro, H. Medeiros, F. Merlin, J. Nomen Torres, F. Pina, G. Polenta, M. Popescu, P. Pravec, A. Rozek, P. Scheirich, A. Sergeyev, A. Sonka, C. Snodgrass, G.B. Valsecchi, P. Wajer.

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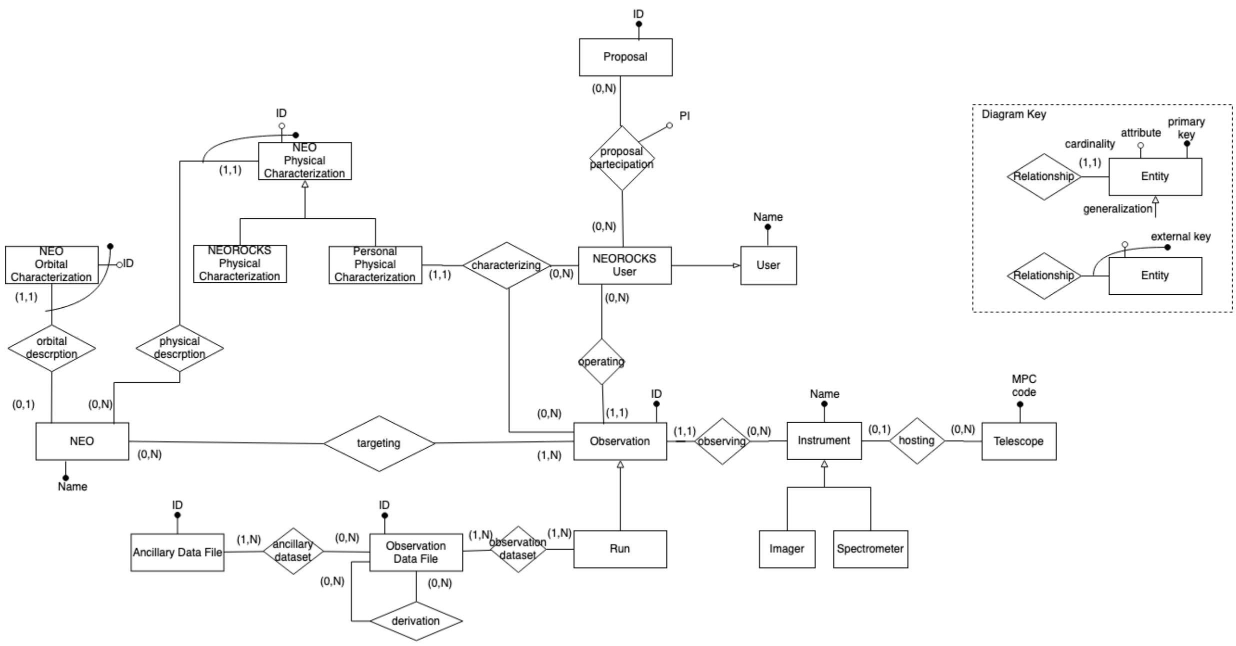

Figure 1. The NEOROCKS physical properties database E-R diagram.

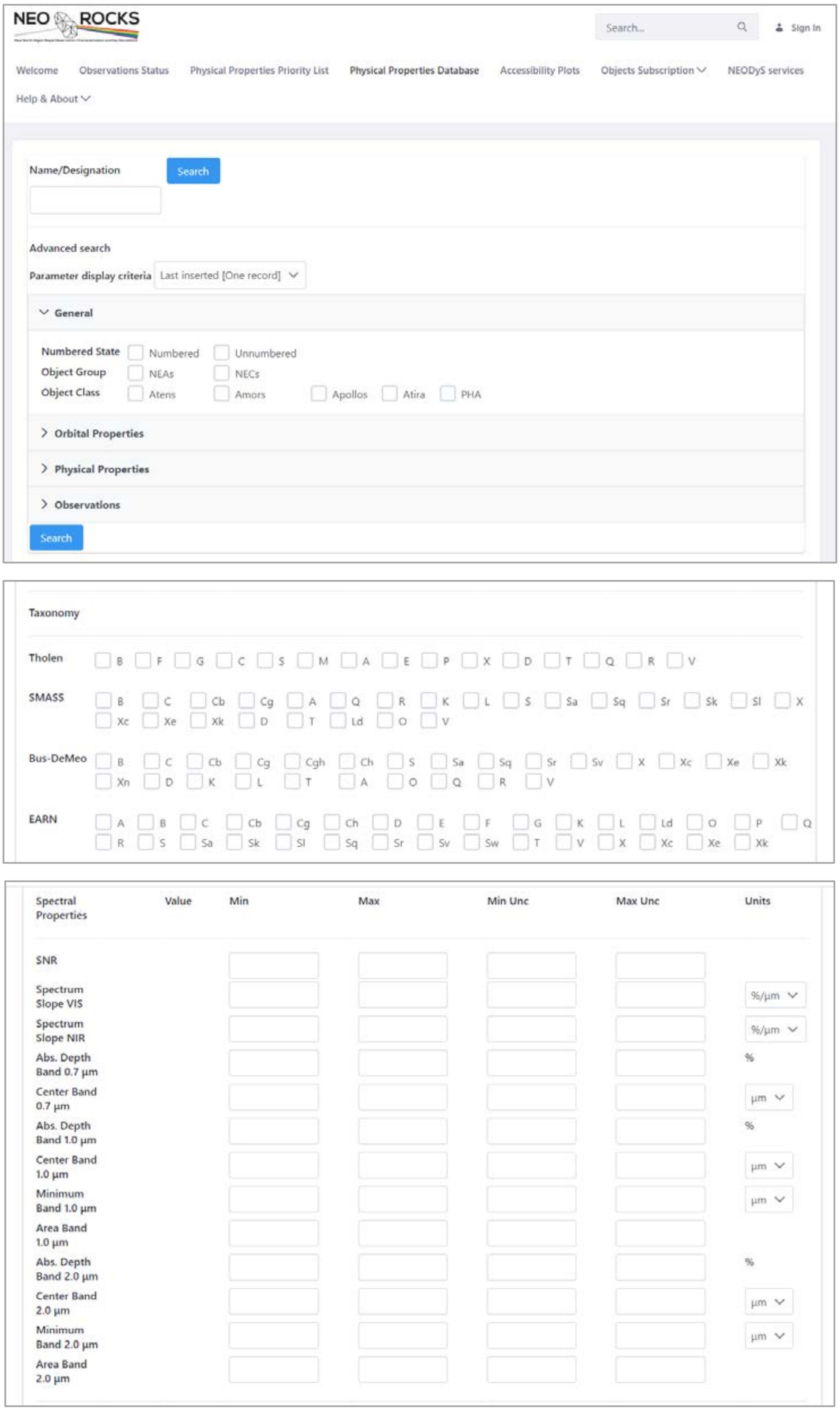

Figure 2. The NEOROCKS technical web portal interface to the physical properties database (upper diagram) and a snapshot of some search and retrieve forms (lower diagrams).