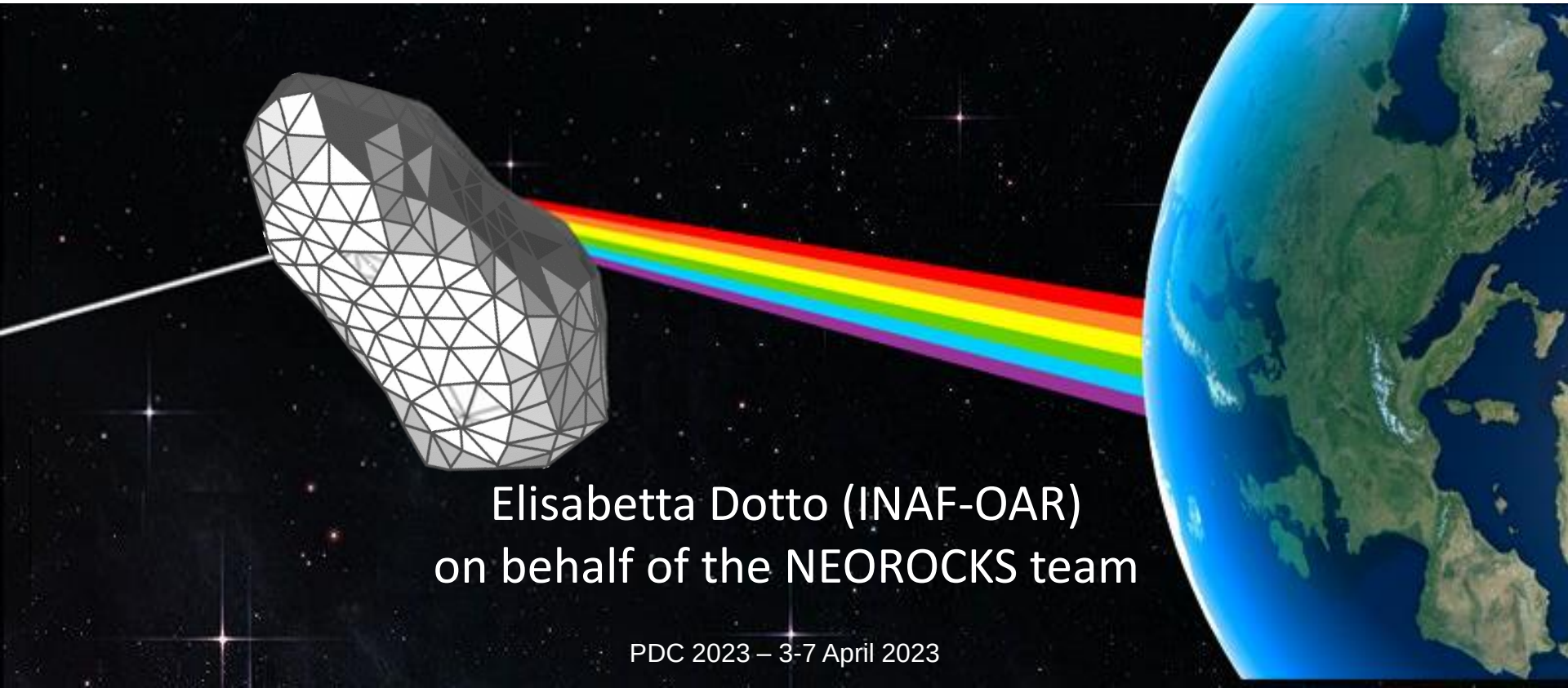
NEO ROCKS

Near Earth Object Rapid Observation, Characterization and Key Simulations

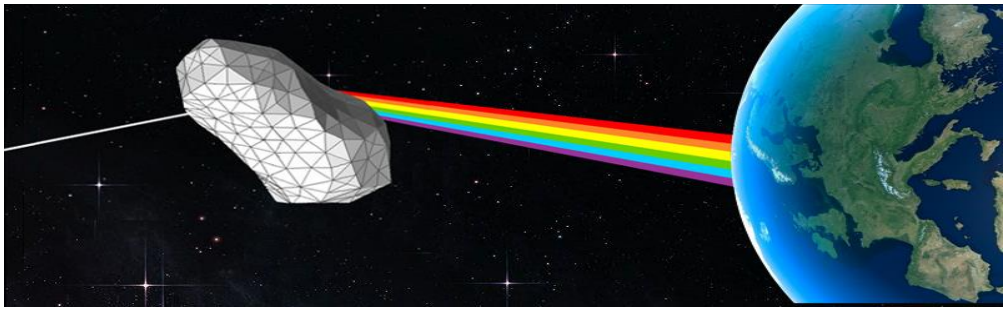
NEOROCKS - The NEO Rapid Observation, Characterization and Key Simulations



Elisabetta Dotto (INAF-OAR)
on behalf of the NEOROCKS team

PDC 2023 – 3-7 April 2023

NEOROCKS - The NEO Rapid Observation, Characterization and Key Simulations



PROGRAMME:
Horizon 2020 - Work Programme 2018-2020
Leadership in Enabling and Industrial Technologies – Space

Call: SU-SPACE-23-SEC-2019 – Advanced research in Near Earth Objects (NEOs) and new payload technologies for planetary defence.
European Commission Decision C(2018)4708 of 24 July 2018

Sub-topic: c) Improvement of our knowledge of the physical characteristics of the NEO population.

Participant organisation name	Country
Istituto Nazionale di Astrofisica (coordinator)	Italy
Agenzia Spaziale Italiana	Italy
University of Padova	Italy
LESIA-Observatoire de Paris	France
Observatoire de la Cote d'Azur	France
University of Edinburgh	UK
Astron. Inst. of Czech Academy of Sciences	Czech Rep.
Instituto de Astrofisica de Canarias	Spain
SpaceDyS s.r.l.	Italy
DEIMOS Space s.l.u.	Spain
DEIMOS Space s.r.l.	Romania
DEIMOS Castilla La Mancha	Spain
NeoSpace sp z.o.o	Poland
Resolvo Srl	Italy

TIMELINE:

Start: 1st January 2020
KOM: 20th January 2020
End: June 2023

NEO ROCKS
Near Earth Object Rapid Observation, Characterization and Key Simulations

The goal

- **NEOROCKS** addresses the challenge of improving our knowledge on the physical characterization of Near Earth Objects and of the implications for their origin and evolution as well as for planetary defense.

- This goal is achieved by linking up the expertise in performing small body astronomical observations and the related modelling, needed to derive NEOs dynamical and physical properties, to the pragmatic approach of planetary defense.

NEO ROCKS
Near Earth Object Rapid Observation, Characterization and Key Simulations

NEOROCKS proposes an innovative approach focused on:

a) performing **high-quality physical observations** and foster the related **data reduction process**;

b) investigating the strong relationship between the **orbit determination of newly discovered objects and the quick execution of follow-up observations** in order to face the threat posed by the "imminent impactors";

c) profiting of the European industrial expertise in on-going Space Situational Awareness initiatives to **plan and execute breakthrough experiments foreseeing the remote tasking of highly automatized robotic telescopes**, in order to provide a proof-of-concept rapid response system;

d) guarantee extremely **high standards in the data dissemination** through the involvement at agency level of a data centre facility already operating in a European and international context.

NEO ROCKS

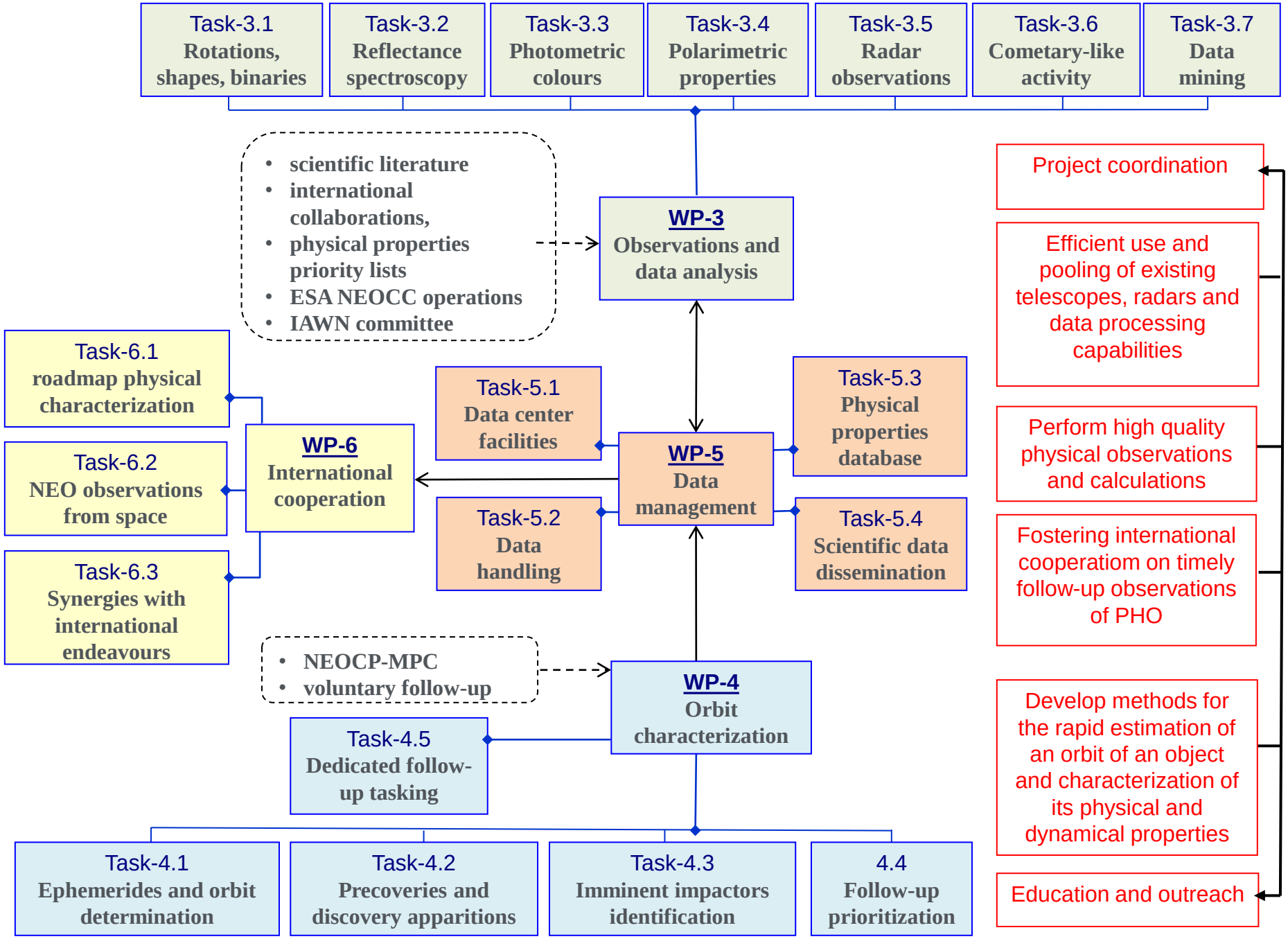
Near Earth Object Rapid Observation, Characterization and Key Simulations

Work Package Breakdown

WP1 – INAF Project Coordination and Management	WP2 – Resolvo Education and Outreach	WP3 – INAF Observations and Data Analysis	WP4 – SpaceDys Orbit Characterization	WP5 – DMS Data Management	WP6 – ASI International Cooperation
Task 1.1 – INAF General Coordination	Task 2.1 – Resolvo Development of Communication Plan	Task 3.1 – ASU Rotations shapes binaries	Task 4.1 – SpaceDys Ephemerides and orbit determination	Task 5.1 – ASI Data center facilities	Task 6.1 – ObsPM Roadmap Physical Characterization
Task 1.2 – INAF Technical & Financial Reporting	Task 2.2 – Resolvo Development & Application Off-line Communication tools	Task 3.2 – INAF Reflectance Spectroscopy	Task 4.2 – NEOSpace Precovery and discovery apparition	Task 5.2 – DMS Data handling	Task 6.2 – NEOSpace NEO Observation from space
Task 1.3 – Resolvo Responsible Innovation and Risk Management	Task 2.3 – Resolvo Development & Application On-line Communication tools	Task 3.3 – ObsPM Photometric Colours	Task 4.3 – SpaceDys Imminent Impactor identification	Task 5.3 – DMS Physical properties database	Task 6.3 – ASI Synergies with international endeavours
Task 1.4 – INAF Scientific Advisory Panel	Task 2.4 – Resolvo Participation in Asteroid Day	Task 3.4 – INAF Polarimetric properties	Task 4.4 – SpaceDys Follow-up prioritization	Task 5.4 – ASI Scientific data dissemination	
		Task 3.5 – IAC Radar Observations	Task 4.5 – DMS Dedicated follow-up tasking		
		Task 3.6 – UEDIN Cometary-like Activity			
		Task 3.7 – OCA Data Mining			

NEO ROCKS

Near Earth Object Rapid Observation, Characterization and Key Simulations


Task-3.1 Rotations, shapes, binaries
Task-3.2 Reflectance spectroscopy
Task-3.3 Photometric colours
Task-3.4 Polarimetric properties
Task-3.5 Radar observations
Task-3.6 Cometary-like activity
Task-3.7 Data mining
scientific literature
international collaborations,
physical properties priority lists
ESA NEOCC operations
IAWN committee
WP-3 Observations and data analysis
Project coordination
Efficient use and pooling of existing telescopes, radars and data processing capabilities
Perform high quality physical observations and calculations
Fostering international cooperatiom on timely follow-up observations of PHO
Develop methods for the rapid estimation of an orbit of an object and characterization of its physical and dynamical properties
Education and outreach
Task-6.1 roadmap physical characterization
Task-6.2 NEO observations from space
Task-6.3 Synergies with international endeavours
WP-6 International cooperation
Task-5.1 Data center facilities
Task-5.2 Data handling
WP-5 Data management
Task-5.3 Physical properties database
Task-5.4 Scientific data dissemination
NEOCP-MPC
voluntary follow-up
WP-4 Orbit characterization
Task-4.5 Dedicated follow-up tasking
Task-4.1 Ephemerides and orbit determination
Task-4.2 Precoveries and discovery apparitions
Task-4.3 Imminent impactors identification
4.4 Follow-up prioritization

Ambitions

optimize observational activities, enhance modelling and simulation tasks, foster international coordination and speed-up response times

Ambition 1: Networking large aperture telescopes

Ambition 2: Advancing NEO physical properties modelling and simulations

Ambition 3: Improving the orbit determination process

Ambition 4: Addressing the imminent impactors monitoring

Ambition 5: Establishing a NEO physical properties data centre

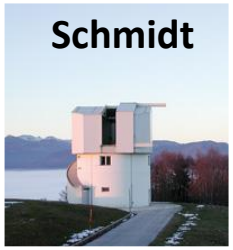
Ambition 6: Fostering international cooperation for follow-up

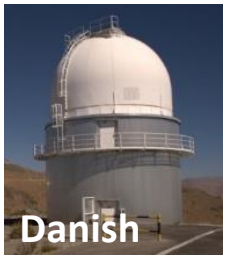
Ambition 7: Raise the public awareness on NEO and impact hazard

NEO ROCKS

Near Earth Object Rapid Observation, Characterization and Key Simulations

Ambition 1: Networking large aperture telescopes





Task 3.1 – Rotation, shapes, binaries (Task Leader: ASU)

Task 3.2 – Reflectance spectroscopy (Task Leader: INAF)

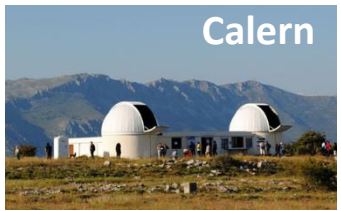
Task 3.3 – Photometric colours (Task Leader: ObsPM)

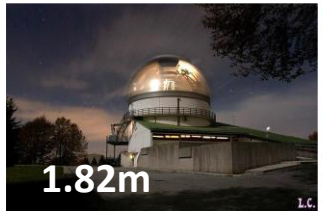
Task 3.4 – Polarimetric properties (Task Leader: INAF)

Task 3.5 – Observational support to the Arecibo Planetary Radar Program (Task Leader: IAC)

Task 3.6 – Cometary-like activity (Task Leader: UoE)

Task 3.7 – Data mining (Task Leader: OCA)





Ambition 2: Advancing NEO physical properties modelling and simulations

Task 3.1 – Rotation, shapes, binaries: lightcurve data for > 100 NEOs

Task 3.2 – Reflectance spectroscopy: visible spectra obtained for > 220 NEOs (small, newly-discovered targets)

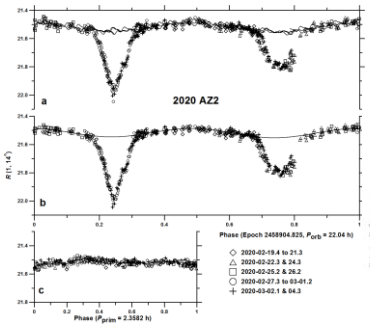
Task 3.3 – Photometric colours: 150 NEOs observed with photometric filters

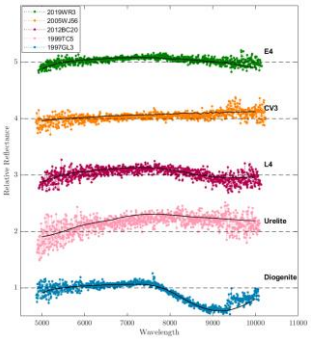
Task 3.4 – Polarimetric properties: new polarimetric data for 23 NEOs

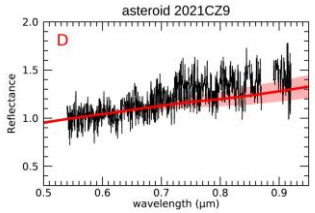
Task 3.5 – Observational support to the Arecibo Planetary Radar Program: 187 NEAs observed with different techniques

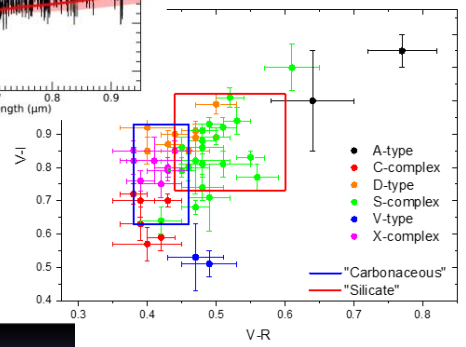
Task 3.6 – Cometary-like activity: observations (with Task 3.1) and development of open-source software for detection of faint cometary-like activity in images

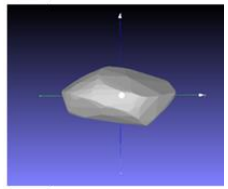
Task 3.7 – Data mining: Compiled data from SDSS, SkyMapper, ground-based spectral archives, ESA Gaia Data Release 3

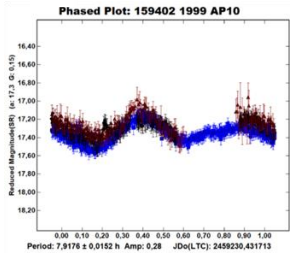


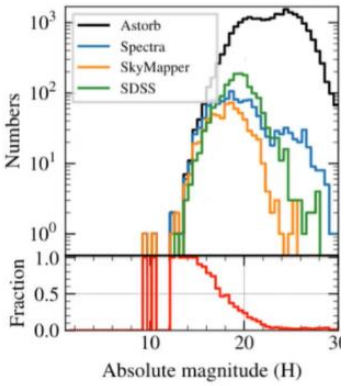












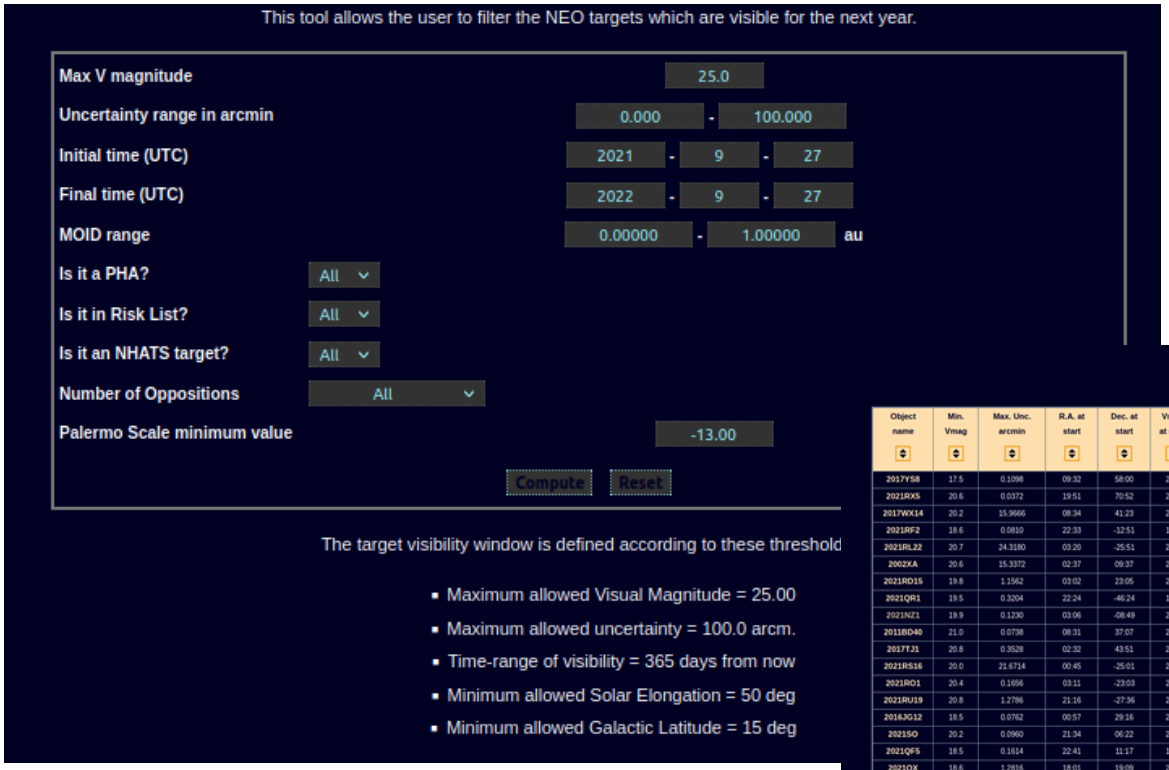
Ambition 3: Improving the orbit determination process

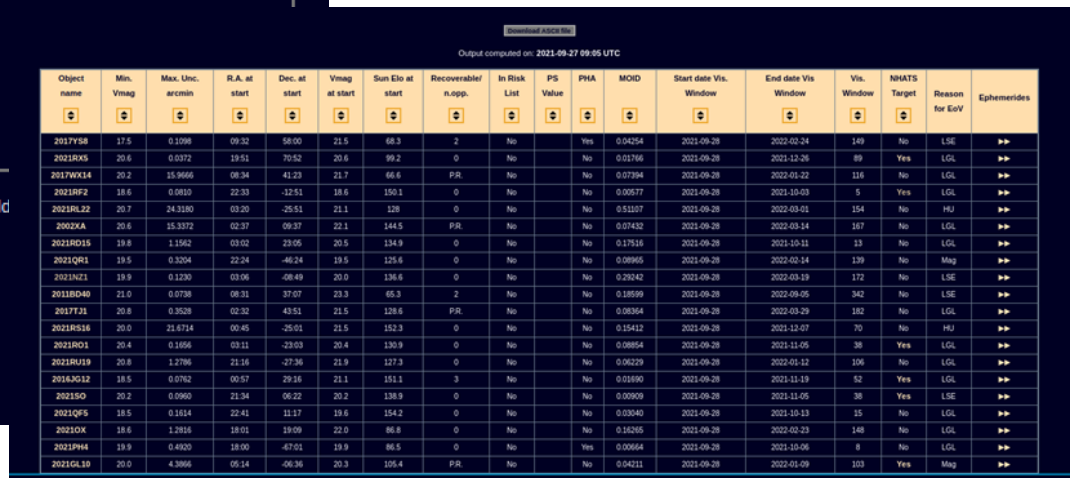
Opportunities filter service: input/output

https://newton.spacedys.com//neodys2/index.php?pc=10.4.0

…this is still hidden

User can set input data





Object name	Min. Vmag	Max. Unc. arcmin	R.A. at start	Dec. at start	Vmag at start	Sun Elo at start	Recoverable/ n.opp.	In Risk List	PS Value	PHA	MOID	Start date Vis. Window	End date Vis Window	Vis. Window	NHATS Target	Reason for EoV	Ephemerides
2017YS8	17.5	0.1098	09:32	58:00	21.5	68.3	2	No		Yes	0.04254	2021-09-28	2022-02-24	149	No	LSE	▸▸
2021RX5	20.6	0.0372	19:51	70:52	20.6	99.2	0	No		No	0.01766	2021-09-28	2021-12-26	89	Yes	LGL	▸▸
2017WX14	20.2	15.9666	08:34	41:23	21.7	66.6	P.R.	No		No	0.07394	2021-09-28	2022-01-22	116	No	LGL	▸▸
2021RF2	18.6	0.0810	22:33	-12:51	18.6	150.1	0	No		No	0.00577	2021-09-28	2021-10-03	5	Yes	LGL	▸▸
2021RL22	20.7	24.3180	03:20	-25:51	21.1	128	0	No		No	0.51107	2021-09-28	2022-03-01	154	No	HU	▸▸
2002XA	20.6	15.3372	02:37	09:37	22.1	144.5	P.R.	No		No	0.07432	2021-09-28	2022-03-14	167	No	LGL	▸▸
2021RD15	19.8	1.1562	03:02	23:05	20.5	134.9	0	No		No	0.17516	2021-09-28	2021-10-11	13	No	LGL	▸▸
2021QR1	19.5	0.3204	22:24	-46:24	19.5	125.6	0	No		No	0.08965	2021-09-28	2022-02-14	139	No	Mag	▸▸
2021NZ1	19.9	0.1230	03:06	-08:49	20.0	136.6	0	No		No	0.29242	2021-09-28	2022-03-19	172	No	LSE	▸▸
2011BD40	21.0	0.0738	08:31	37:07	23.3	65.3	2	No		No	0.18599	2021-09-28	2022-09-05	342	No	LSE	▸▸
2017TJ1	20.8	0.3528	02:32	43:51	21.5	128.6	P.R.	No		No	0.08364	2021-09-28	2022-03-29	182	No	LGL	▸▸
2021RS16	20.0	21.6714	00:45	-25:01	21.5	152.3	0	No		No	0.15412	2021-09-28	2021-12-07	70	No	HU	▸▸
2021RO1	20.4	0.1656	03:11	-23:03	20.4	130.9	0	No		No	0.08854	2021-09-28	2021-11-05	38	Yes	LGL	▸▸
2021RU19	20.8	1.2786	21:16	-27:36	21.9	127.3	0	No		No	0.06229	2021-09-28	2022-01-12	106	No	LGL	▸▸
2016JG12	18.5	0.0762	00:57	29:16	21.1	151.1	3	No		No	0.01690	2021-09-28	2021-11-19	52	Yes	LGL	▸▸
2021SO	20.2	0.0960	21:34	06:22	20.2	138.9	0	No		No	0.00909	2021-09-28	2021-11-05	38	Yes	LSE	▸▸
2021QF5	18.5	0.1614	22:41	11:17	19.6	154.2	0	No		No	0.03040	2021-09-28	2021-10-13	15	No	LGL	▸▸
2021OX	18.6	1.2816	18:01	19:09	22.0	86.8	0	No		No	0.16265	2021-09-28	2022-02-23	148	No	LGL	▸▸
2021PH4	19.9	0.4920	18:00	-67:01	19.9	86.5	0	No		Yes	0.00664	2021-09-28	2021-10-06	8	No	LGL	▸▸
2021GL10	20.0	4.3866	05:14	-06:36	20.3	105.4	P.R.	No		No	0.04211	2021-09-28	2022-01-09	103	Yes	Mag	▸▸

Output example

Table is sortable

Notice the “Download” button for local use

NEO ROCKS

Near Earth Object Rapid Observation, Characterization and Key Simulations

Ambition 3: Improving the orbit determination process

- The **Priority List** is for **targets visible NOW** and are listed according to a priority value determined by an algorithm
- The **Priority List** is meant for **real time observers** who need to prepare the nightly program

- The **Opportunity List** lists **all visible NEOs** within the year
- The **Opportunity List tool** is meant for observers who need to **program their observing schedule on a longer term**. This is particularly useful to professional astronomer who need to support the observing proposals they are willing to submit to telescope TACs

NEO ROCKS
Near Earth Object Rapid Observation, Characterization and Key Simulations

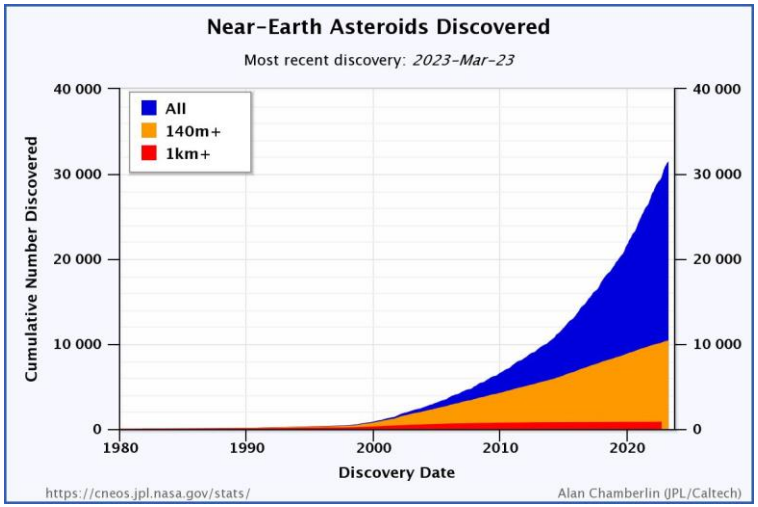
Ambition 4: organize a rapid response experiment

The discovery rate of NEOs is exponentially increasing and nowadays exceeds 3000 objects per year.

Current discoveries mainly concern “small” NEOs close approaching the Earth.

Such small asteroids become bright enough to be studied in detail only for short time spans (≈ weeks) around their discovery during close approaches with the Earth, whereupon they could become too faint for years or even decades.

The lack of dedicated, early-response physical observations is then causing the NEO characterization rate to fall further and further behind the discovery rate.



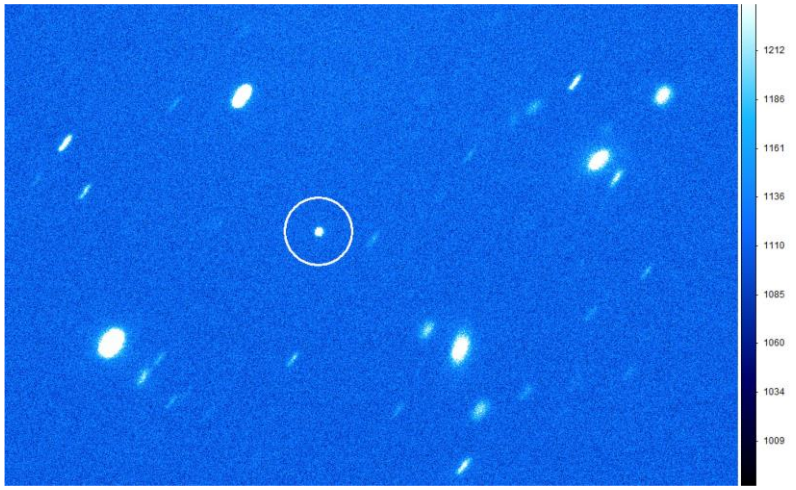
NEO ROCKS

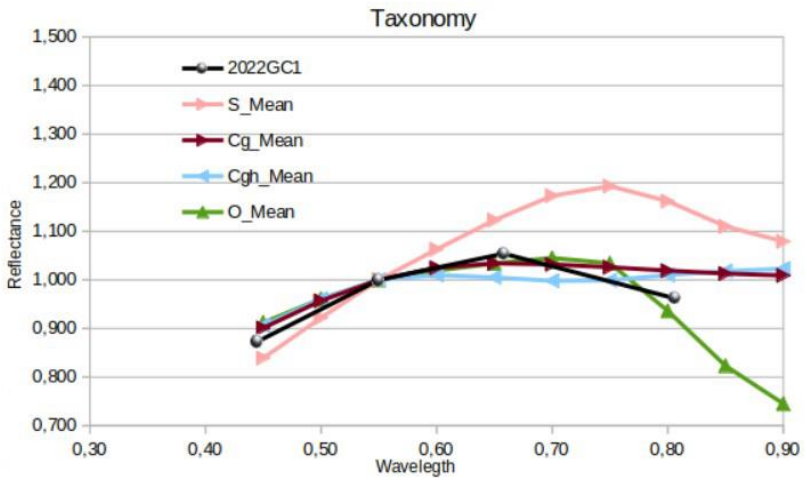
Near Earth Object Rapid Observation, Characterization and Key Simulations

Ambition 4: organize a rapid response experiment

An innovative tasking experiment of a rapid-response system was organized profiting of the experience gained by the DEIMOS Sky Survey (DeSS) in providing space debris observations in an operational environment:

- ✓ astrometric observations of newly discovered NEOS were performed by highly automatized telescopes.
- ✓ the information was quickly disseminated within the consortium
- ✓ to allow rapid follow-up observations of the targets' physical properties.



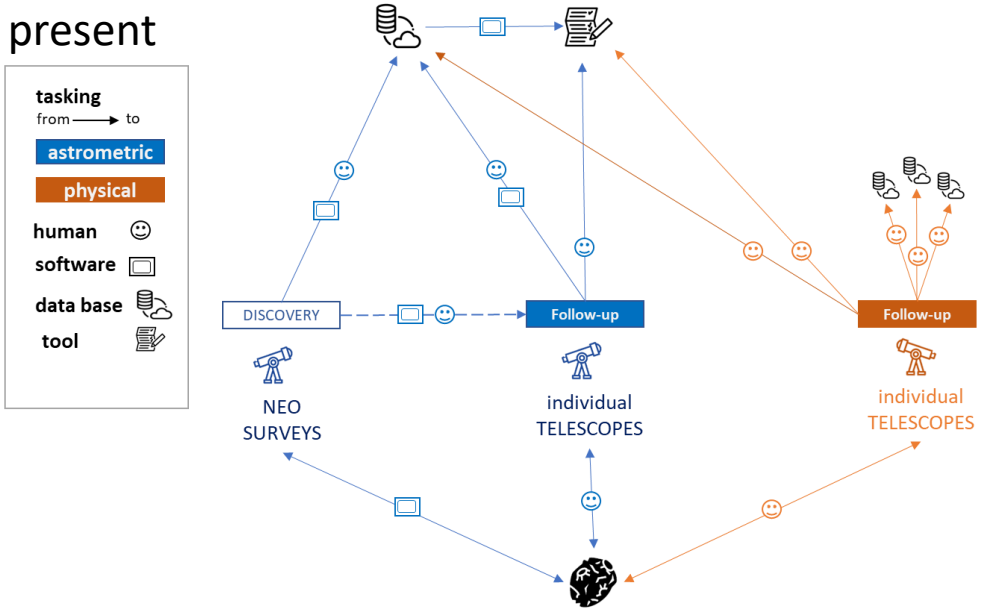


Ambition 4: organize a rapid response experiment

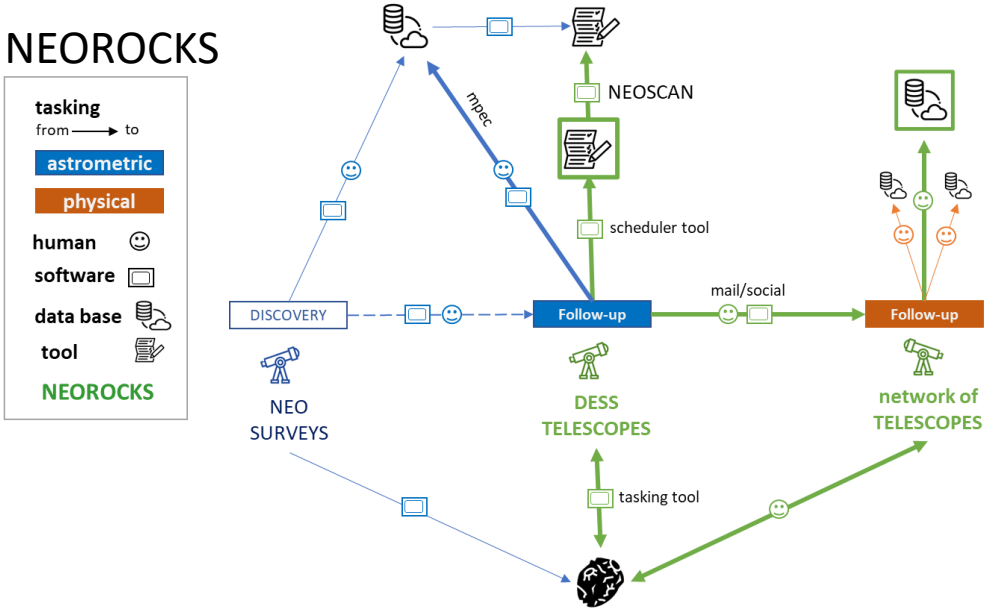
EXPECTED IMPACTS

NEOROCKS provided a proof-of-concept rapid response system **to pave the way for the engineering developments** in prototyping a system able to task ground based telescopes, linking together for the first time astrometric and physical characterization follow-up observations.

present



NEOROCKS



Ambition 5: Establishing a NEO physical properties data centre

Technical Web Portal

DEPLOYMENT

- A project technical web portal has been realized (and its **functionalities** are **progressively implemented)**.
    - The web portal (…) initially encompasses **only the basic functionalities** needed to immediately support the observational activity (priority lists, data repository).
    - A requirements definition activity has been performed in order to **evolve the technical portal toward its final configuration** (full set of observation support tools, physical characterization database).
- The **migration** of the technical portal **into the ASI Space Science Data Center** completes the activity in order to increase the visibility of the technical portal and its long-term maintenance/evolution

NEO ROCKS

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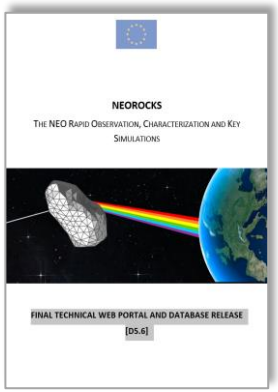
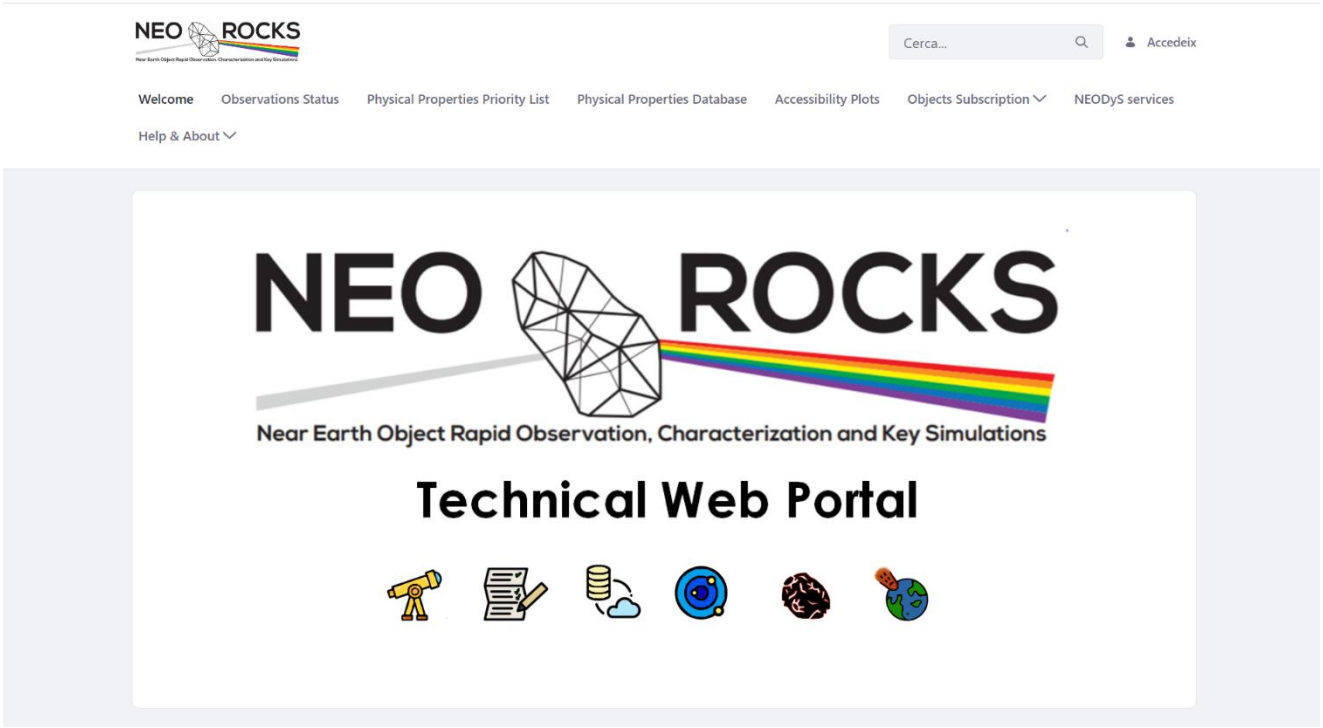
Ambition 5: Establishing a NEO physical properties data centre

Technical Web Portal

- ❑ **Orbital catalogue**
- ❑ **Ephemerides**
- ❑ **Physical properties**





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Ambition 6: Fostering international cooperation for follow-up

Probing the engagement of European and international partners in a proactive contribution to the detection and observations of NEO.

- **Analyse the European and international initiatives and the potential collaborations at an institutional level**
- **Identify the opportunities of data-sharing with other projects (e.g. ESA NEOCC, NASA CNEOS, UNOOSA, EU, others)**
- Highlight the possibility of continuing and further extending the network of observational assets, the contribution to the NEO physical properties database and the rapid response system scenario established during the project.

NEO ROCKS

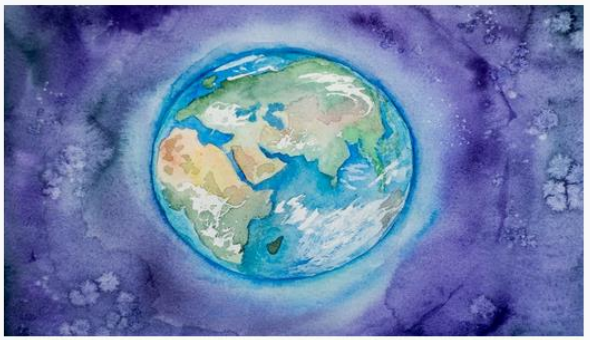
Near Earth Object Rapid Observation, Characterization and Key Simulations

Ambition 7: Raise the public awareness on NEO and impact hazard

ASTEROID DAY
30 JUNE

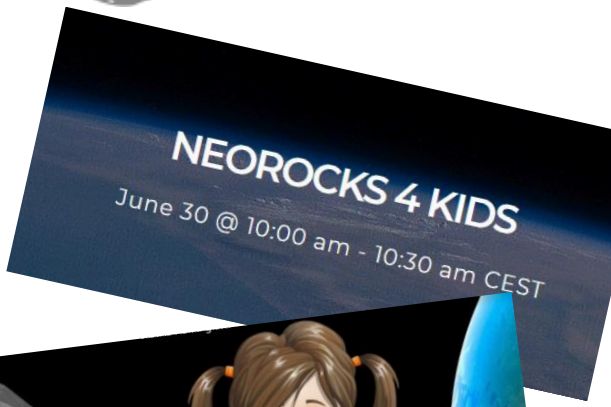
Agosto 30, 2021 / Outreach♡0Share:

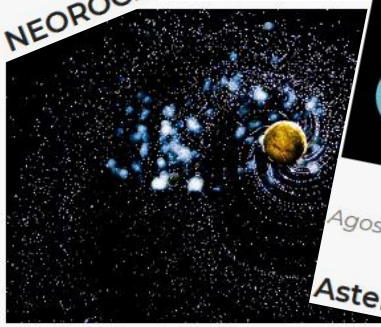
NEOROCKS at Superquark!



Aprile 15, 2021 / Outreach♡0Share:

NEOROCKS in Horizon Magazine





Agosto 6, 2021 / Outreach♡0Share:

Asteroids at the AstroValberg festival

Aprile 2, 2021 / Outreach♡0Share:

NEOROCKS @ 7th IAA PDC Conference 2021

Neorocks4Kids - Alla Scoperta degli Asteroidi -...

Neorocks4Kids - Los Telescopios - SUB ES

Near Earth Object R

Ambition 7: Raise the public awareness on NEO and impact hazard

Project Website

Maggio 14, 2020 / Project, Team

Last NEO observations before lockdown

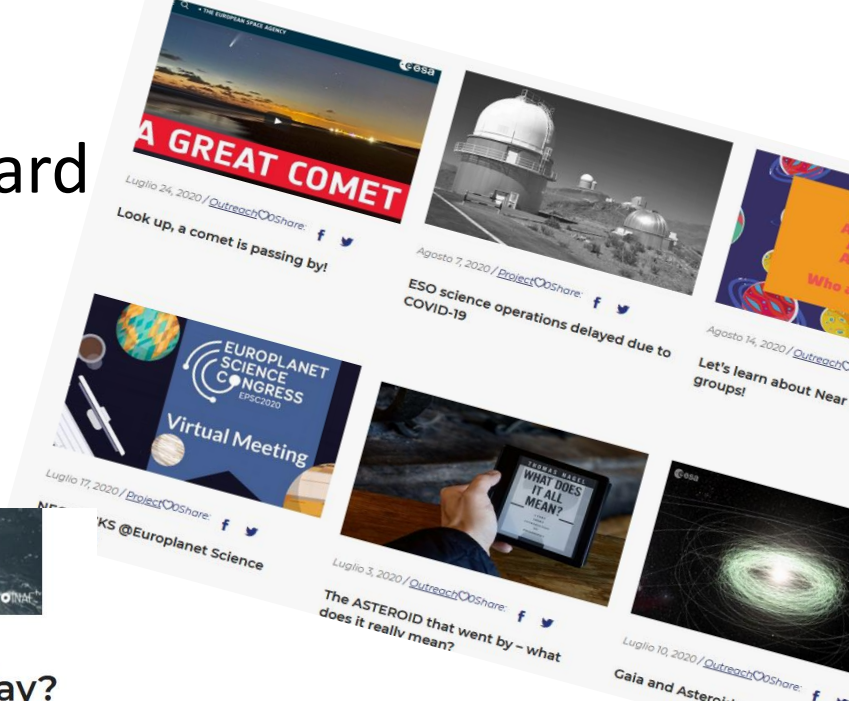
Our Neorocker, Astronomical Institute of the Czech Academy of Sciences (CAS), was at the European Southern Obse
temporarily shut down, due to the global health emergency.

CAS had an observing run at the 1.54-m Danish telescope on the La Silla station of the European Southern Observat
to 23. They took rich photometric observations for several Near-Earth Asteroids (NEAs).

Giugno 28, 2020 / Outreach

Doing anything for Asteroid day?

NEOROCKS is!



- Linked to
- Updated with news related to Space/Asteroids
- Updated with articles and videos shared by partners
- Updated with information on presentations delivered
- Newsletter

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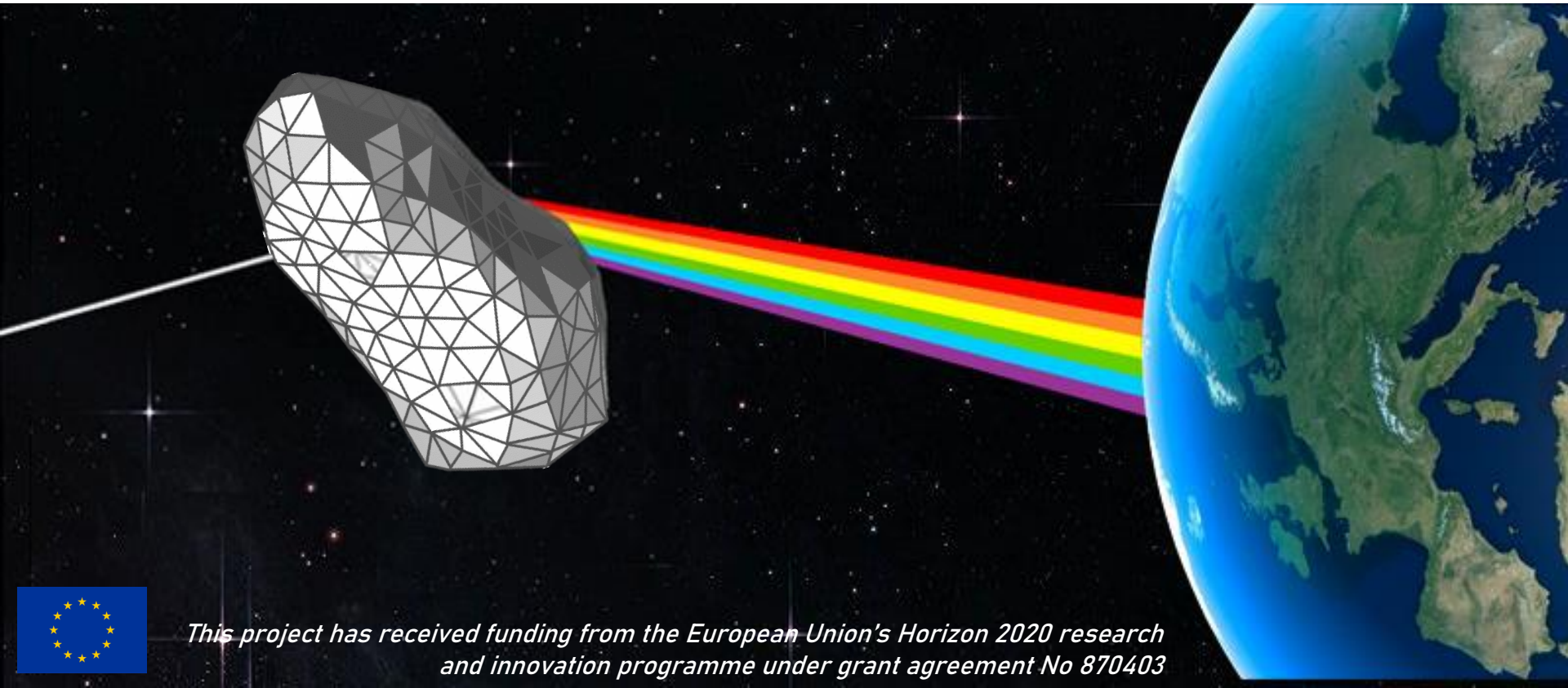
NEO ROCKS

Near Earth Object Rapid Observation, Characterization and Key Simulations

THANK YOU!



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