

MEMORANDUM OF UNDERSTANDING

BETWEEN

THE EUCLID CONSORTIUM

AND

THE VERA C. RUBIN OBSERVATORY

**CONCERNING THE SHARING OF DATA ASSOCIATED WITH
THE EUCLID DEEP FIELD SOUTH**

PREAMBLE

The Euclid Consortium (EC), an international organization that brings together a community of scientists working in public research laboratories on the ESA-led Euclid space mission, funded by national agencies,

and

The Vera C. Rubin Observatory, funded by the United States Department of Energy (DOE) and National Science Foundation (NSF)

hereinafter individually referred to as a “Party” and jointly referred to as the “Parties,”

RECALLING that the Parties aim to carry out deep and large sky area imaging surveys and that the two surveys cover a large common sky area in complementary wavelength bands;

RECALLING that the survey data of the Parties will be released to the public after pre-set data rights periods to protect the science programs of their respective science communities;

RECALLING that both Parties intend to observe a 23 deg² common area, the Euclid Deep Field South (EDFS) with a larger depth and better spatial and temporal sampling than the nominal survey data of each Party;

RECALLING that Euclid shall perform regular observations of the EDFs distributed over the nominal mission duration according to depth and cadences given in the Euclid mission operations concept;

CONSIDERING that the sharing of data between the Parties at an early stage during their proprietary periods would enhance the science value of both surveys and readily provide mutual benefits;

CONSIDERING that early sharing of the EDFs data with Rubin implies that these Euclid data shall become public to the whole astronomical community at the same time.

HAVE AGREED as follows:

ARTICLE 1 – PURPOSE AND OBJECTIVES

1. The purpose of this Memorandum of Understanding (hereinafter referred to as the “MoU”) is to define the terms and conditions under which the sharing of the deep field data between the Parties will be conducted within the framework of the Euclid and Rubin mission programs.
2. This MoU sets forth the managerial, technical, and operational interfaces between the Parties that are necessary to ensure continuation of, and compatibility between, their respective activities; defines the roles and

responsibilities of the Parties; and identifies the other commitments of the Parties with respect to the Euclid mission.

ARTICLE 2 – DESCRIPTION OF EUCLID AND RUBIN

Euclid is an ESA-led space mission designed to probe the properties and nature of dark energy, dark matter, and cosmic inflation by performing a large area sky survey. The EC was selected by ESA in July 2012 as the single official scientific consortium in charge of deriving Euclid scientific data products and of leading the scientific exploitation of the mission until completion.

The mission is planned for a target orbit around the second Sun-Earth Lagrange point (L2). Euclid consists of a 1.2 m Korsch telescope enabling large field-of-view and diffraction-limited deep imaging in the visual and near-infrared and deep spectroscopy in the near-infrared. It directs the incoming light to two instruments built by the EC: the Visible Instrument (VIS) and the Near Infrared Spectrograph and Photometer (NISIP).

The Euclid Sky Survey is performed during a nominal period of 6 years and contains the Wide and Deep Surveys. The Euclid Wide Survey covers 15,000 deg² of extragalactic sky centered around the galactic north and south poles. Three Deep Surveys are foreseen – Euclid Deep Field North (EDFN), Euclid Deep Field South (EDFS), and the Fornax field (EDFF) – covering a total area of 53 deg² with an imaging photometric depth at least 2 mag deeper than the Wide Survey, equivalent to a depth accumulated from at least 40 independent wide survey visits.

The Euclid Wide and Deep Surveys will yield unique legacy science data in various fields of astrophysics beyond the core cosmology program, ranging from Solar System objects or nearby galaxies to very high redshifts quasars and primordial galaxies. They will form a primary database for next generation multi-wavelength surveys. Euclid is planned to produce a legacy dataset with images, photometry and spectroscopy of more than a billion galaxies and several million spectra, out to high redshifts $z > 2$. Data from the Euclid Deep Surveys are also required for Euclid's core cosmology to achieve instrumental calibrations and sample characterizations.

The EC is responsible for the production of all Euclid calibrated stacked images and catalogs, referred to as Level 2 and Level 3 data, that will be part of each Euclid public data release (DR). Ten EC Science Data Centers (SDC) are in charge of generating the Euclid data products.

The first data release, DR1, will be issued worldwide 26 months after the end of the Euclid commissioning phase and will be followed by DR2 after two years, and DR3 taking place 3 years after DR2. Prior to DR1, an early small data set referred to as Q1 will be issued 14 months after the end of the commissioning phase. Q1 will contain Wide and Deep observations including first EDFS data.

The EC community will have access to calibrated data earlier than the DR and Q dates and with a higher cadence than the DR plans. All Euclid calibrated data and

all releases will be archived at the Euclid Science Archive System (SAS) hosted by the European Space Astronomy Center (ESAC) in Spain.

The EDFs data will be collected differently than for each single visit Wide observation, but with the same exposure time per visit. This strategy will enable accurate early instrumental calibration and sample characterization and will also provide useful data to projects that may demand high detection cadence.

Vera C. Rubin Observatory, its staff, and community will soon be ready to address some of the biggest questions in science: What is the nature of dark matter and dark energy? When and how did the Milky Way and other galaxies form? What processes shaped our Solar System and what risk do some Solar System objects, like asteroids, pose to life on Earth? And what can we learn from the time-dependent changing Universe—not by studying the remnants left behind, but by detecting these changes as they happen? Like its pioneering namesake, Vera C. Rubin Observatory will observe the sky using the most state-of-the-art technology available to answer existing scientific questions and produce unprecedented data to inspire queries into brand new ones.

For the first ten years of operations, Rubin Observatory will carry out the Legacy Survey of Space and Time (LSST), using the Simonyi Survey Telescope and the Rubin Observatory LSST Camera. It will take repeated images over more than 18,000 deg² of the southern sky in six broad-band optical filters (*ugrizy*). The resulting dataset will provide a static census of approximately 40 billion objects as well as a dynamic time-domain census over an unprecedented range of time scales and flux limits. The primary deliverables for Rubin Observatory include a real-time stream of “alerts” of transient events, prompt data products, annual data release data products, and a science platform specifically developed to reduce the barrier of entry to Rubin Observatory data and to shorten the path to science for the user community.

The Rubin system consists of facilities located at several distinct geographic sites—the Summit Facility on Cerro Pachón, Chile; the Base Facility in La Serena, Chile; the US Data (processing and archiving) Facility at SLAC National Accelerator Laboratory (SLAC) in California; the French Data Facility in Lyon, France; The UK Data Facility in Edinburgh, Scotland; and the headquarters facility in Tucson, Arizona—as well as the high-speed networks connecting these sites.

Only a revolutionary system could address so many science goals with one survey, and Rubin Observatory was uniquely designed to accomplish this. Rubin Observatory boasts a higher information throughput, or *étendue*, than any previous telescope. This is achieved by combining a three-mirror optical system with an 8.4-m primary (6.4-m effective aperture) having a stunning 9.6 deg² field of view with a camera that has a 3.2 gigapixel focal plane array. The total effective system *étendue* of more than 300 m² deg² is much larger than any existing facility, and will allow Rubin Observatory to make unprecedented contributions to science.

While the Euclid and Rubin surveys on their own are poised for breakthrough science, their combination is likely to be truly transformative across a wide range of astrophysical fields, as demonstrated in, e.g. Guy et al. 2022.

ARTICLE 3 – EC PROGRAMMATIC RESPONSIBILITIES

To implement this cooperation, EC, in agreement with ESA, will use all reasonable efforts to:

1. Make available the EDFS scheduling information **to Rubin** before the observations take place;
2. Make available to Rubin the following Level 2 imaging data products of the EDFS:
 - Calibrated VIS imaging products and associated calibration data products that are necessary to derive astrometric and photometric information on each source;
 - Calibrated NISP imaging products and associated calibration data products from the three near-infrared photometric bands of the NISP instrument necessary to derive photometric information of each source;
 - Extracted imaging and photometric catalog data
3. Start sharing the above data products as soon as photometric coverage of the entire EDFS region can be made available by both Euclid and Rubin regardless of the Euclid DR release dates but not before the first Euclid public release Q1;
4. Make publicly available the relevant Euclid data products through the Euclid Science Archive which is run by ESA.

ARTICLE 4 – RUBIN PROGRAMMATIC RESPONSIBILITIES

To implement this cooperation, Rubin will use all reasonable efforts to:

1. Attempt to schedule observations of the EDFS as close in time as possible to Euclid observations (ideally within 24 **hr** if possible);
2. Make available the following imaging data products of the Rubin observations in the EDFS:
 - Calibrated imaging products and calibration data from LSSTCam
 - extracted catalog data for object and source catalogs
3. Start the combined releases as soon as data of the entire EDFS region can be made available by both Euclid and Rubin, but not before the first Euclid public release Q1.
4. Make available the relevant Rubin data products to both Rubin Data Rights Holders and Euclid Consortium Members through the Rubin Science Platform, and/or through a public website.

ARTICLE 5 – MANAGEMENT, DOCUMENTATION AND REVIEWS

1. ESA is responsible for the management of the Euclid space mission.

2. The Euclid Consortium is responsible for the production and delivery of the Euclid EDFS data products that will be shared with Rubin.
3. The Vera Rubin Observatory is responsible for the production and delivery of Rubin EDFS data products that will be shared with Euclid.
4. Each Party will designate a Cognizant Scientist for the purpose of implementing the activities under this MOU.
5. The Cognizant Scientists will be charged with developing an implementation plan for the joint data releases that will be approved by Rubin and Euclid leadership and include community input.
6. The Cognizant Scientists will cooperate in the implementation of the Parties' activities under this MOU. Each of the Parties will manage, in accordance with its own rules and procedures, its activities under this MoU.
7. The Cognizant Scientists will be charged to develop a shared EDF-S data release plan that contains the management details for the activities described in this MOU.
8. The Cognizant Scientists will meet on a regular basis to review the progress of the implementation of the Parties' respective activities under this MOU and to resolve any issues that may have emerged. Each Cognizant Scientist will report to their respective consortium leadership.

ARTICLE 6 – RIGHTS IN AND DISTRIBUTION OF DATA

1. The first data sharing release shall contain the data of both Parties; subsequent releases can be decoupled depending on the observing plan.
2. The Euclid data falling under this MoU shall be made available to the Euclid Consortium and the general community in a way consistent with the Euclid Science management Plan.
3. The Rubin data falling under this MoU shall be made available to the Rubin community and the general community in a way consistent with the Rubin Operations Plan.
4. The Parties shall have the right to use their data (processed and unprocessed) at any time, in support of their respective responsibilities.

ARTICLE 7 – TRANSFER OF GOODS AND TECHNICAL DATA

There is no exchange of hardware or processing software envisioned under this MoU, but that does not preclude sharing in the future to mutual benefit of the Parties.

ARTICLE 8 – RELEASE OF RESULTS AND PUBLIC INFORMATION

1. The Parties retain the right to release public information regarding their own activities under this MoU. However, the Parties will coordinate with each other in advance concerning public information that relates to the other Party's responsibilities or performance under this MoU.
2. In all media activities, the contributions of each Party will be acknowledged.
3. The Parties will make the results available to the general scientific community through publication in appropriate journals or by presentations at scientific conferences as soon as possible and in a manner consistent with good scientific practices.

ARTICLE 9 – FINANCIAL ARRANGEMENTS

1. Each Party will bear the costs of discharging its own respective responsibilities under this MoU, including travel and subsistence of its own personnel and transportation of goods and associated documentation, for which it is responsible.
2. The Parties' obligations under this MoU are subject to the availability of appropriated funds. Should either Party encounter budgetary problems that may affect the activities to be carried out under this MoU, the Party encountering the problems will notify and consult with the other Party in a timely manner and will take appropriate steps to minimize any negative impact of the budgetary problem on the cooperation.

ARTICLE 10 – ACCESS TO FACILITIES

Access by a Party to the other Party's facilities or property, or to each other's Information Technology (IT) systems or applications, is contingent upon compliance with each other's respective security and safety policies and guidelines including, but not limited to: standards on access to premises, credentials, and facility and IT system application/access.

ARTICLE 11 – AMENDMENT

This MOU may be amended by written agreement of the Parties.

ARTICLE 12 – ENTRY INTO FORCE, DURATION, AND TERMINATION

1. This MoU will enter into force upon signature by both Parties. It will remain in force until both surveys have finished taking data in the EDF-S
2. Either Party may terminate this MoU at any time by giving the other Party at least 12 months written notice of its intent to terminate. In the event of termination, the Parties will endeavor to minimize any negative impact of such termination on the other Party.

IN WITNESS WHEREOF, the undersigned duly authorized representatives of the Parties have signed this MoU, in two originals, in the English language.

Done in Tucson AZ

this 31st day of January, 2023

For the Euclid Consortium

For Rubin



Jason Rhodes
EC representative

Bob Blum
Rubin Observatory