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1. Data Summary

1.1 What is the purpose of the data collection/generation and its relation to the objectives of the project?

Within the framework of Horizon 2020 Open Research Data Pilot, the associated projects are required to elaborate their Data Management Plan (DMP), with the aim to improve and maximize the exploitation, access to and re-use of research data generated during the course of these Horizon 2020 funded projects.

This document aims to provide the SOLARNET consortium members with a coherent unified approach and guidance to data management which will involve research data collection, curation, the publication of primary research and supporting data. The DMP is intended to be a living document in which information can be made available on a finer granular level through harmonized updates as the project progresses along with the implementation of the project work packages and tasks, and when significant changes occur.

This DMP follows the H2020 Template for the Data Management Plan and draws on the [Guidelines on FAIR Data Management in Horizon 2020](#)

(http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-data-mgt_en.pdf).

This initial version of the DMP is provided in month 6 since the start of the project and will be updated as necessary as the project advances.

The main purpose of SOLARNET is fully coherent with the specific challenge and scope detailed in the INFRAIA-01-2018-2019 call of Integrating Activities for Advanced Communities: The need of the high-resolution solar physics community in terms of efficient and convenient access to the best research infrastructures is the creation of an open route towards generating best science data in this field, making high quality research data and data analysis tools available to scientists, and providing for state-of-the-art theoretical models required for advancing the understanding of the processes on the sun.

1.2 What types and formats of data will the project generate/collect?

Data generation is planned for the following WPs:

- WP2 will generate scientific-data metadata standards, protocols, reports, guidelines for co-observations.
- WP3 will generate scientific data acquired during Training Activities at Observatorio del Teide, reports from Young and Experienced Researchers benefitting from the Mobility Programme, conference proceedings and presentations, lecture notes provided to the students attending the Schools and questionnaires compiled by students attending the schools.
- WP5 will generate open-source software codes (data curation, data visualisation, data analysis), manuals for the use of the Solar Virtual Observatories (SVOs) and reports on developments.
- WP6 and WP7 will generate demonstrators, science-test-data during instrumentation development, data reduction software and reports.
- WP8 will produce test-data during the development of the instruments and collect observations from the sun. Task 8.1 Design of telescope and instrument platform - Optical Layout of telescope & instrument platform and Calculations of Point-spread-function; Task 8.2 - Technical concepts for instruments VTT/HELLRIDE producing filtergrams in optical and near-infrared wavelengths of features on the Sun, various polarization states, flatfield and dark images needed to calibrate the data in FITS standard format; Task 8.3 - Data taken at Kanzelhöhe and Brussel Observatory, Lucky Imaging data, i.e. high-cadence observations in white light.

- WP9 will generate (1) scientific 'raw' data (observations), partially-processed data and science-ready data from the ground-based telescopes, (2) scientific and science-ready data by the SUNRISE 3 mission and (3) simulated data at the computing facilities offered in the Access Programme.
- Other data will be originated from software development, protocols from networking discussions, publications from scientific research and meetings, manuals and demonstrators from instrumentation development.

Data will vary in formats, most of which will be non-proprietary: (1) Text documents and data/tool documentation, typically in plain ASCII format (.txt, markdown) but including also DOC, ODF, and PDF. (2) Image data in FITS standards, as well as other image standards (jpg, tif, png, .IMG). (3) Vector data. (4) 3D data (e.g., ASCII, DDS, DXF, PLY, GOCAD). (5) Rendered Videos, for science interpretation and outreach (MP4). (6) Structured data within web portals (HTML, JSON, TEX, XML). (7) Tabular data (CSV). (8) Source code (Python, CSS, JavaScript). Some complementing formats for spreadsheets, graphics and audio-visual data may be generated. Some examples include but are not limited to .xlsx (Microsoft Excel), .ppt (Microsoft PowerPoint) and .avi (video).

1.3 Will you re-use any existing data and how?

Data-reuse and integration:

(1) WP2.1 will offer via coordination of the Virtual Access Programme (WP10) the access to archived data for scientific purposes. (2) With the start of the Solar VO in full-operation mode, it will ingest the archived solar data thus fostering data discovery and consequent re-use. (3) WP2.2 action on metadata definitions and advanced databases for simulated data will be the first steps towards building up an archive for solar-like simulations envisioned for future simulated-data dissemination.

1.4 What is the origin of the data?

SOLARNET will generate: Observational solar data, science-ready solar data, metadata recommendations, scientific publications, conference/workshop proceedings, conference/meeting talks, reports, evaluation surveys, videos, manuals for instrumentation, observing protocols.

1.5 What is the expected size of the data?

The SOLARNET project foresees generation of intensive data via experiments and modelling, and is expected to have maximum file sizes altogether (total volume) in the hundreds of terabytes range.

1.6 To whom might it be useful ('data utility')?

Datasets generated by SOLARNET is targeted towards:

- Consortium members and Joint Research Activities participants
- Members of the scientific community working in the field of solar physics and astrophysics.
- Professional optical, mechanical, software and electronic engineers involved with the development of solar telescopes and instrumentation.
- Other research projects that can continue to build on or combine their work with SOLARNET datasets.

2. FAIR data

2. 1. Making data findable, including provisions for metadata

During the course of SOLARNET there will be several data-intensive activities across all WPs. A large amount of data will be made available in the existing archives (BASS, GRIS, IBIS-A and HINODE) as well

as in the new archives that will be developed (The Stockholm SST Archive and ALMA) and designed (simulated data – from codes like BIFROST, CO5BOLD, MURAM) within the project.

How will this data be exploited and/or shared/made accessible for verification and re-use?

All data generated by SOLARNET will be made public and will in alignment with the four main aspects of FAIR (Force 11, 2018) policy, i.e., making the data Findable, Accessible, Interoperable and Re-usable.

(a) The data generated in the Access Programme (TA observations & simulated data) will have a proprietary phase and will become available one year after data delivery of science-ready data products.

(b) Science-ready data will be accessible via the operation of the Solar VO.

(c) Publications, talks, videos, manuals, protocols, reports will be accessible via the SOLARNET webpage.

Exception: (a) In WP3, surveys on the evaluation of the schools and in WP4, surveys on the scientific impact of workshops will be carried out among schools and workshop participants. The results will be publicly reported, however, the surveys themselves will not become public since they are intended to be anonymous.

(b) Industry developments in JRAs partially need to be confidential, because in some cases the companies need to protect their know-how.

To ensure this open access (free of charge, online access for any user) to all peer-reviewed scientific publications resulting from this Horizon 2020 project, the SOLARNET consortium will implement the following procedure:

- Deposit a machine-readable electronic copy of the published version or final peer-reviewed manuscript accepted for publication in a repository for scientific access (e.g. arxiv.org and the SOLARNET website). At the same time the research data needed to validate the results presented in the deposited scientific publications will be also deposited in the SOLARNET Data Repository.
- The consortium will ensure open access to the deposited publication by Open access publishing (Green or Gold Open Access mode). Green open access is where authors publish their articles in journals and then self-archives a copy in a freely accessible institutional or specialist online archive known as a repository or on a website (for example ResearchGate and Academia). Gold open access, on the other hand, is where the authors publish their articles in an online open access journal. In case of SOLARNET, the partner Science Media Network GmbH (SMN) will provide the repository where all the scientific publications and generated media will be deposited in addition to SOLARNET's website (<http://solarnet-project.eu/>). Besides, the project participants are further encouraged to create free accounts in <http://www.researchgate.net> and in <http://www.academia.edu> and upload their publications in order to disseminate the results from the project making them widely available to the research community.
- The metadata needed to clearly identify publications will be provided following a bibliographic standard format and containing the acronym, the grant agreement number, the terms (European Union (EU) and Horizon 2020) among others so as to maximize the discoverability of publications and to ensure the acknowledgement of EU funding.

Data will be promptly shared with the science community during and after the project (via WP4/WP5) as well as the wide public and educational institutions. Integration of data and metadata for efficient data discovery and retrieval through the project portal and external archives will allow for effective dissemination.

2.1.1 Are the data produced and/or used in the project discoverable with metadata, identifiable and locatable by means of a standard identification mechanism (e.g. persistent and unique identifiers such as Digital Object Identifiers, DOI)?

The requirement of identifiable and registered DOI numbers for scientific data (observations and simulations) will be discussed and decided within the course of the project (WP2) and updated in the later version of the DMP.

2.1.2. What naming conventions do you follow?

File naming convention and versioning in the EU participant portal: In order to ensure transparency of file contents and versioning in the EU participant portal, the following naming convention is to be used for files generated during the project. It will consist of:

SOLARNET	Project name, fixed
D[x.y]	Deliverable identifier, if relevant
V[Version]	Version number in x.y format
[Short Title]	Short descriptor for easy identification, maximum 40 characters
[Status]	Draft, Final, Public, Restricted, Confidential
[Date]	Date in format YYYYMMDD
.[extension]	File extension

As far as the file naming convention and versioning for DOI version is concerned, if necessary, will be decided during the course of the project and updated in later versions of the DMP.

2.1.3 Will search keywords be provided that optimize possibilities for re-use?

For each dataset, the responsible beneficiary (leading the sub-work package) has to indicate a set of selected keywords aiming to maximise findability so that it can be optimally re-used.

2.1.4 Do you provide clear version numbers?

Yes, all public deliverables uploaded in the EU Participant portal and the Solarnet Project Website (<http://solarnet-project.eu/>) will be provided with a clear version number.

2.1.5 What metadata will be created? In case metadata standards do not exist in your discipline, please outline what type of metadata will be created and how.

Metadata creation: WP2.2 will have an activity specifically dedicated to further developing metadata recommendations in solar physics data, especially for handling with the strongly heterogeneous ground-based datasets and aiming at eventually adjust to the IVOA standards. The recommended metadata will be implemented from the low (raw data) level to the high-level data products.

What standards will be used? Open-source software development standards (i.e., SunPy), SOLARNET-defined-metadata standards in conjunction with the International Virtual Observatory Alliance (IVOA, <http://www.ivoa.net/documents/index.html>) will be used.

2.2. Making data openly accessible

2.2.1 Which data produced and/or used in the project will be made openly available as the default? If certain datasets cannot be shared (or need to be shared under restrictions), explain why, clearly separating legal and contractual reasons from voluntary restrictions.

As set out in the SOLARNET Consortium Agreement, each beneficiary has the right to publish the outputs it generates. This also means that partners have to explicitly agree to the publication of datasets to which

they have contributed. SOLARNET will comply with the open access clause in the Grant Agreement and uses the H2020 principle of "as open as possible, as closed as needed". In practise, this means that the default approach is to make datasets public.

2.2.2 Note that in multi-beneficiary projects it is also possible for specific beneficiaries to keep their data closed if relevant provisions are made in the consortium agreement and are in line with the reasons for opting out.

Until a dataset is fully finalised and ready for publication, the private area of the SOLARNET website is the default platform for data exchange. As long as there is consensus among all contributors to a dataset and any restrictions on sensitive data are respected, other forms of data exchange are also allowed, such as email or cloud services.

2.2.3 How will the data be made accessible (e.g. by deposition in a repository)?

WP2, which coordinates the Access Programme and the Joint Research Activity will define the standards for operating the telescopes and for co-observation in addition to the standards for metadata for observational and numerical data that will be generated. The related documents will be made publicly available. In addition, dedicated workshops will be organized to share the information about these definitions and best practices.

In WP3, a major activity is organizing conferences, workshops and schools. Provision of sustainable access to the scientific presentations, to lecture notes and discussions at these events will be facilitated by making use of the dedicated open access repository for scientific conferences provided by the professional services of the partner SMN. There, all videos, slides of presentations, posters, and further publications (e.g. conference proceedings and lecture notes) will be made available besides the general information about a scientific event and cross-referenced to the project website.

All software developed in WP5 (*Towards a European Solar Data Centre* activities) for data curation, high-level products and visualization tools will become publicly available via Github and/or as contribution to the SunPy (<http://sunpy.org/>) open-source libraries. Furthermore, one of the main activities in WP5 is especially dedicated to the dissemination of observational data from the solar infrastructures by bringing the Solar Virtual Observatory (SVO) prototype (FP7 funded, 2013-2017) into a fully operational service. The data will be accessible via Python, IDL and a RESTful API. In addition, a manual will be delivered and publicly available for external tool developers on the interface with the SVO's underlying metadata database via the RESTful protocol. The access to the SVO will be advertised in meetings, workshops, schools and the SOLARNET webpage. This action will be pioneering in disseminating ground-based solar data to the scientific community.

2.2.4 What methods or software tools are needed to access the data?

In order to access the data, the requirements are online connection, browser, software client, software tools such as IDL-Python and MATLAB.

2.2.5 Is documentation about the software needed to access the data included?

Yes, documentation about the software needed to access the data will be included.

2.2.6 Is it possible to include the relevant software (e.g. in open source code)?

Yes, at least partially.

2.2.7 Where will the data and associated metadata, documentation and code be deposited? Preference should be given to certified repositories which support open access where possible.

Science results and presentations will be made available in open access repository of the SMN platform which is certified by EU

Possibility to make available large science data volumes like observational data and data products on an EU data centre for solar physics will be explored.

Data acquired in the Trans-National Access Programme will be deposited and made publicly available in ways that differ among the installations and instruments as described below.

GREGOR/GRIS: For GRIS data there is a public repository at <http://sdc.leibniz-kis.de>

GREGOR/GFPI and GREGOR/HiFI: Public data sets are deposited and accessible at <https://gregor.aip.de/cms/>

SST: The Stockholm SST Archive that is currently being set up will contain the reduced data sets. As an intermediate solution in anticipation of the final Solar Virtual Observatory, they will be searchable from the prototype virtual observatory developed by SOLARNET and maintained by ROB.

THEMIS: The existing solar data archive <http://bass2000.obspm.fr> will be used.

VTT: Data from VTT will be hosted at KIS in a similar way as GREGOR/GRIS data, though that archive is not yet developed.

SUNRISE3: The mission is planned to fly in 2021 and the data repository solutions are not yet decided on.

Piz Daint: We expect that the bulk of the data produced will be results from radiative magnetohydrodynamic simulations of the solar atmosphere. Recommendations for metadata similar to those already agreed on for observational data will be developed in WP2 and the details for how data will be made public are still to be worked out.

The Solar Virtual Observatory developed in the SOLARNET project will, when it is available, serve as a single point of access to all public data.

We note that when it comes to observational data, most of what is referred to above pertains reduced, calibrated, data. Raw, uncalibrated, data volumes from many of the instruments are very large and not easily made available via network downloads. We expect that to the extent raw data are requested, that must be handled via on-demand, case-to-case procedures.

2.2.8 Have you explored appropriate arrangements with the identified repository?

Yes.

2.2.9 If there are restrictions on use, how will access be provided?

A distinction can be made between research datasets supporting peer reviewed academic publications and datasets forming the basis on which the project deliverables will be elaborated. The research data underlying project deliverables requires a big investment in terms of human resources, therefore the main aim of making this data public is for others to use and build on this data, preventing duplication of work and

improving efficiency, quality and speed of research. This also holds true for scientific publications, but for these validation and reproducibility are key considerations as well.

2.2.10 Is there a need for a data access committee?

The decision will be taken by the Executive Board involved as a supervisory body in the governance and execution of the project and updated in a later version of the DMP.

2.2.11 Are there well described conditions for access (i.e. a machine-readable license)?

So far not, however the requirement of a machine-readable license will be accessed by the Executive Board of the Project and updated in a later version of the DMP.

2.2.12 How will the identity of the person accessing the data be ascertained?

Since SOLARNET will produce scientific data that will be made public, the identity of the people accessing them need not be ascertained.

2.3. Making data interoperable

2.3.1 Are the data produced in the project interoperable, that is allowing data exchange and re-use between researchers, institutions, organisations, countries, etc. (i.e. adhering to standards for formats, as much as possible compliant with available (open) software applications, and in particular facilitating re-combinations with different datasets from different origins)?

Yes.

2.3.2 What data and metadata vocabularies, standards or methodologies will you follow to make your data interoperable?

For observational data, the SOLARNET metadata recommendations developed in SOLARNET (FP7) are already implemented for several instruments (<http://sdc.uio.no/open/solarnet/>). The recommendations will evolve within the current project (WP2) and implementation of the recommendations will continue.

2.3.3 Will you be using standard vocabularies for all data types present in your data set, to allow inter-disciplinary interoperability?

Yes.

2.3.4 In case it is unavoidable that you use uncommon or generate project specific ontologies or vocabularies, will you provide mappings to more commonly used ontologies?

Not applicable.

2.4. Increase data re-use (through clarifying licences)

2.4.1 How will the data be licensed to permit the widest re-use possible?

At this initial stage it is not possible to precisely define the copyright licences arrangement for each of the project datasets, software and algorithms generated. With the exploitable results obtained and better characterized with the advancement work packages 2,5,6, 7 and 8, the DMP will be updated accordingly to that effect.

2.4.2 When will the data be made available for re-use? If an embargo is sought to give time to publish or seek patents, specify why and how long this will apply, bearing in mind that research data should be made available as soon as possible.

The research data generated under the Trans-National Access Programme will be made public one year after the data have been delivered to the PI.

Research data, algorithms and instrumentation data generated under Work Package 8 will be made public as soon as possible or at least immediately after the completion of the project.

For research data generated under Joint Research Activities, which are intended to be publicly available in the form of scientific publications, the collaborators should agree how they will ensure the integrity, access and stewardship of fair collaboration, complying with the rules of good practices in collaborative research and innovation. SOLARNET aims not only to achieve the project's scientific objectives, but also to strengthen the partnership with the collaborating researcher(s) so that by the end of the project there remains a legacy of goodwill which translates into a willingness to enter future collaborations.

Where research findings are to be published in a journal or other scientific periodical, in most cases a copyright agreement with the publishers needs to be considered, which may involve an embargo period as well.

The protection of Intellectual Property Rights (IPR) that might arise through the work of individual partners or the consortium as a whole in the legal framework of the project or in case of joint ownership, has been set out in the Consortium Agreement.

2.4.3 Are the data produced and/or used in the project useable by third parties, in particular after the end of the project? If the re-use of some data is restricted, explain why.

Yes, the data produced and/or used in the project may be useable by third parties. It must be noted here that although there are no restrictions, however the third parties might need some data processing requires expertise.

2.4.4 How long is it intended that the data remains re-usable?

As stated in the grant agreement, the SOLARNET Consortium will guarantee the preservation of the data during the whole duration of the project and in addition to at least 10 years after the end of the project.

2.4.5 Are data quality assurance processes described?

Quality of data during production/use will be assured by Work Package leaders in their respective domains as well as via both informal internal review and formal (upon publication) peer review.

Further to the FAIR principles, DMPs should also address:

3. Allocation of resources

3.1 What are the costs for making data FAIR in your project?

It will be discussed in the Executive Board Meeting and updated in the future versions of the DMP.

3.2 How will these be covered? Note that costs related to open access to research data are eligible as part of the Horizon 2020 grant (if compliant with the Grant Agreement conditions).

It will be discussed in the Executive Board Meeting and updated in the future versions of the DMP.

3.3 Who will be responsible for data management in your project?

The WP leaders, the telescopes providers and the project office will be responsible for data management in the Project.

3.4 Are the resources for long term preservation discussed (costs and potential value, who decides and how what data will be kept and for how long)?

Yes, further exploitation measures for data preservation and curation has been discussed. The project results and the information collected as well as the knowledge generated will be saved beyond the funding of this project, at least 10 years after the completion of the project.

With a successful operation of the Solar Virtual Observatory (SVO, WP5.3 activity), the access to solar research data will be guaranteed beyond the SOLARNET project: There is a plan to create a second European node of the SVO with broader bandwidth for data distribution, within the spirit of further developing the European Solar Data Centre for EST.

The commercial partner SMN will develop the framework for ensuring that all training and conference materials (videos, slides of presentation, posters and complementary documents) can be accessed for future reference on their project dedicated platform. This will allow to keep the information of the project public, as no further cost for a web domain or software and hardware maintenance of a webserver are required.

4. Data security

4.1 What provisions are in place for data security (including data recovery as well as secure storage and transfer of sensitive data)?

Institutional hard disks with some levels of robust back-ups as countermeasures will be provided for research data. Personal data collected as a part of Work Package 1 (General Management) and WP3 (Network activities to foster synergistic collaborations) will be treated in accordance to the EU General Data Protection Regulation. Data exchange between the project partners will be performed with their consent. Data will be stored in the project intranet and at the project office during the project lifetime. The information will be used only for the project purposes.

Is the data safely stored in certified repositories for long term preservation and curation?

No, however storage of big-data in the framework of the European Open Science Cloud (EOSC) will be considered/ explored and recommendations will be written (WP2.2.6)

5. Ethical aspects

5.1 Are there any ethical or legal issues that can have an impact on data sharing? These can also be discussed in the context of the ethics review. If relevant, include references to ethics deliverables and ethics chapter in the Description of the Action (DoA).

No.

5.2 Is informed consent for data sharing and long term preservation included in questionnaires dealing with personal data?

No.

6. Other issues

6.1 Do you make use of other national/funder/sectorial/departmental procedures for data management? If yes, which ones?

No.