Open-Source Science Guidance

NASA Science Mission Directorate

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Version History

#	Date	Description
1	12/08/2022	SMD produced the initial version of this guidance to provide additional information in support of the release of SPD-41a. This document will be updated as new information becomes available.
2	04/07/2023	This document has been updated to provide additional guidance relevant to open-source science requirements incorporated into ROSES-2023 solicitations and links to SMD division policies.
2.1	12/11/2023	Links that broke during NASA web modernization were fixed.
2.2	02/05/2025	Updates for new guidance

This document and previous versions of this guidance are available for download from the [SMD Science Information Policy page](#). Further development of this guidance will be conducted openly through the [SMD Open-Source Science Guidance GitHub repository](#), where community contributions are welcome.

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Background and Motivation

NASA's [Open-Source Science Initiative (OSSI)](#) is a comprehensive program of activities to enable and support moving science towards openness, and it aims to implement [SMD's Strategy for Data Management and Computing for Groundbreaking Science 2019-2024](#). OSSI includes a commitment to the open sharing of software, data, and knowledge (algorithms, papers, documents, ancillary information) as early as possible in the scientific process. The principles of open-source science are to make publicly funded scientific research transparent, available, and reproducible.

As part of the OSSI, [SMD's Scientific Information Policy](#) provides guidance on the open sharing of publications, data, and software created in the pursuit of scientific knowledge. [SPD-41a: Scientific Information Policy for the Science Mission Directorate](#) updates the previously released [SPD-41](#), which consolidated existing Federal and NASA policy on sharing scientific information. SPD-41a was developed in light of federal guidance, studies from the National Academies, and input from the SMD scientific community.

This document provides guidelines, best practices, and examples of open-source science to support the SMD scientific community in implementing the requirements of SPD-41a and achieving the broad OSSI goal of moving science towards openness. This guidance represents general recommendations and best practices for the SMD scientific community and should be considered alongside any additional guidance provided by SMD Divisions or specific funding solicitations. For additional information about SPD-41a and other scientific information policies that correspond to SMD Divisions, see the [Scientific Information Policy website](#) and [Frequently Asked Questions (FAQ)](#). For additional open science resources, see the [Open Science website](#).

Limitations

This document does not establish policy requirements related to SMD funded activities. While this guidance is consistent with [SPD-41a: Scientific Information Policy for the Science Mission Directorate](#), it may not be comprehensive or complete, and there may be other ways in which to comply with existing or future agreements or requirements not described here.

For specific requirements related to scientific information produced from SMD-funded scientific activities, please see [SPD-41a](#), NASA policies, and/or any requirements in the solicitation or agreement associated with the activity.

Contributions

This guidance will be developed as new information becomes available, with future updates made openly on [the Open-Source Science Guidance GitHub repository](#). Following the best practices of open science, this material can be best built through the collective knowledge of the community. To report something that needs to be fixed or to suggest an addition, please [contribute to the GitHub repository](#) or send an email to [HQ-SMD-SPD41@mail.nasa.gov](#).

SMD Division Policies and Guidance

SPD-41a ensures that requirements for sharing scientific information are consistent across SMD. Additionally, SMD divisions developed the following policies and guidance to put the requirements of SPD-41a into context for specific scientific communities. These policies and other resources were developed with input from the relevant research communities and provide additional details and examples to support the implementation of SPD-41a.

SMD divisions coordinated with one another and the SMD Chief Science Data Office to ensure consistency across policies. If you have questions about which policies or guidelines are applicable to your work, contact the Program Officer for your solicitation or award, division representatives, or the Chief Science Data Office at HQ-SMD-SPD41@mail.nasa.gov.

Astrophysics Division
- Astrophysics Data Centers Page
- Astrophysics Scientific Information Management Policy

Biological and Physical Sciences Division
- Biological and Physical Sciences Open Data Page
- Biological and Physical Sciences Scientific Data Management Policy

Earth Science Division
- Earth Science Open Data, Services, and Software Policies
- Earth Science Data and Information Policy
- ESDS Open Source Software Policy
- Data Management Guidance for ESD-funded Researchers
- How to Create and Maintain a Data Management Plan for Proposals

Heliophysics Division
- Heliophysics Data Page
- Heliophysics Division Science Data Management Policy

Planetary Science Division
- Planetary Data Science Overview Page
- Planetary Science Division Information and Data Management Policy
- Planetary Data System
- PDS Information for Data Proposers

Open Science and Data Management Plan

An Open Science and Data Management Plan (OSDMP) describes how the scientific information that will be produced from SMD-funded scientific activities will be managed and made openly available. At a minimum, the OSDMP should include sections on data management, software management, and publication sharing that describe how these categories of scientific information will be managed and openly shared to comply with applicable SMD scientific information policies. The OSDMP may also include a description of other types of scientific information that will be shared openly and other open science activities associated with the project.

SPD-41a requires a data management plan and a software management plan for all SMD-funded scientific activities but does not require an OSDMP. However, many SMD funding opportunities starting with ROSES-2023 will require an OSDMP instead of the previous requirement for a data management plan. The [ROSES Open Science and Data Management Plan page](#) provides additional guidance for proposers.

OSDMPs should reflect the practices of specific research communities, and SMD divisions and/or specific ROSES program elements may provide additional guidance on components such as data management plans and software management plans.

Data Management Plan

All SMD-funded scientific activities that are expected to produce scientific data shall include a data management plan describing how data will be managed, preserved, and released to comply with the requirements of SPD-41a. General guidance on the components of data management plans for SMD is provided in the [Data Management and Sharing](#) section of this guide.

Software Management Plan

All SMD-funded scientific activities that are expected to produce software shall include a software management plan describing how software will be managed, preserved, and released to comply with the requirements of SPD-41a. General guidance on the components of software management plans for SMD is provided in the [Software Management and Sharing](#) section of this guide.

Open Science Plan

This section should describe the types of publications that are expected to be produced from the SMD-funded scientific activities, including peer reviewed manuscripts, technical reports, conference materials, and books. The plan should also outline the methods expected to be used to make the publications publicly available, which will likely include options listed under '[How to Share Publications](#)' in this Open-Source Science Guidance.

This section may also include a description of additional open science activities associated with the project. This may include:

- Holding scientific workshops and meetings openly to enable broad participation

- Preregistering research plans in advance of conducting scientific activities

- Providing project personnel with open science training or enablement (if not described elsewhere in a proposal)

- Integrating open science practices into citizen science activities

- Contributions to or involvement in open-science communities

OSDMP Templates

Appendix B of this guidance provides one general example of an [OSDMP template](#) for SMD.

OSDMPs should reflect the practices of specific research communities, and SMD Divisions and/or specific ROSES program elements may provide additional templates or guidance. These include:

- [Earth Science Division OSDMP template](#)

- [Heliophysics Division OSDMP template](#)

- [Planetary Science Division OSDMP template](#)

Sharing Publications

The preservation of and public access to publications produced from SMD-funded scientific activities supports the scientific process, assures the widest dissemination of the information that NASA produces, and supports anyone, anywhere in reading the results of NASA scientific activities. This section contains supplemental guidance to support the implementation of requirements for public access to publications established by SPD-41a.

Requirements for Public Access to Publications

SPD-41a defines publications as scientific and technical documents released through print, electronic, or alternative media. This includes peer reviewed manuscripts, technical reports, conference materials, and books. This does not include laboratory notebooks, preliminary analyses, drafts of scientific papers or preprints, plans for future research, peer review reports, or communications with colleagues.

Under SPD-41a, all publications resulting from research funded by SMD shall be made publicly available to the extent allowed by applicable law and existing NASA policies. Peer reviewed manuscripts resulting from SMD-funded scientific activities shall be made freely available to the public by default, without any embargo or delay after the publication date.

Authors may meet this requirement in a number of ways (see How to Share Publications), whether or not their manuscript is published as Open Access (see Open Access Publishing). Ultimately, SMD-funded publications must be made publicly available at the time of publication via the NASA Scientific and Technical Information (STI) Repository.

How to Share Publications

Authors have several options for how to make their publications publicly available in compliance with SPD-41a:

For articles that are published as Open Access (see Open Access Publishing), the final published article (*i.e.*, the publisher's version of record) may be made publicly available in the STI Repository through one of the following mechanisms:

- For articles published as Open Access by journal publishers participating in the Clearinghouse for the Open Research of the United States (CHORUS), the published article will be made publicly available in the STI Repository on behalf of the authors. Authors should verify that their article is available in the STI Repository following its publication, in which case no further action is required by the author. View a list of journal publishers participating in CHORUS.

- For articles published as Open Access that are indexed in the NASA Astrophysics Data System (ADS), no further action is required by the researcher to comply with public access requirements for the article at this time.

- For articles published as Open Access that are not covered by CHORUS or ADS, authors must submit either the final published article or the author's copy of an accepted manuscript to the STI Repository via the [PubSpace submission page](#) no later than the article's publication date.

For articles that are not published as Open Access, the author's copy of an accepted manuscript may be made publicly available in the STI Repository at the time of the article's acceptance for publication. The accepted manuscript is the final, peer-reviewed version of the article that has been accepted for publication by a publisher. The accepted manuscript includes all changes made during the peer review process and contains the same content as the final published article, but it does not include the publisher's copyediting, stylistic, or formatting edits that will appear in the final journal publication (*i.e.*, the version of record). In this scenario, authors must submit accepted manuscripts to the STI Repository via the [PubSpace submission page](#) no later than the article's publication date.

Further examples for how to make publications available will be provided as they are developed.

Open Access Publishing

Open Access publications are defined here as those in which the publisher makes the article and related content available online, free of charges or other barriers to access, immediately at the time of publication. Such articles are often licensed for sharing and reuse under a [Creative Commons](#) or similar license-type agreement that allows the authors to retain copyright while allowing others to copy, distribute, and reuse their work. A short description of common Open Access publishing methods (*e.g.*, Gold or Diamond/Platinum) is available from [Framework for Open and Reproducible Research Training](#).

Open Access publishing is not required to meet the public access requirements for peer-reviewed publications under SPD-41a. However, many publishers in Earth and Space science are moving toward Open Access models, and SMD-funded researchers are encouraged to publish their peer-reviewed manuscripts as Open Access (*e.g.*, Gold or Diamond Open Access) in reputable journals. Costs for Open Access publishing may be included in the budgets of proposals for SMD funding.

Preprints

SMD-funded researchers are encouraged to share their manuscripts as preprints as a best practice in open science, though this is not a requirement under SPD-41a. Common methods for sharing preprints include posting to community-appropriate preprint servers such as [arXiv](#) or the [Earth and Space Science Open Archive](#). Because the content of an article may change substantially during the peer-review process, authors must ensure that the accepted version of their peer-reviewed publication is made available via one of the options described above even if they previously shared a pre-acceptance preprint.

Data Management and Sharing

Consistent with the principles of open-source science, data resulting from SMD-funded scientific activities shall be made publicly available through methods that are transparent, availabile, and reproducible. This section provides guidance to support the implementation of requirements for data management and sharing established by SPD-41a. Researchers also should reference any relevant data policies and guidance provided by SMD divisions, which include more specific information on topics such as data repositories, metadata requirements, and recommended data formats.

Data in Scope of SPD-41a

Data are defined as scientific or technically relevant information that can be stored digitally and accessed electronically. This includes any scientifically useful data associated with an award. In particular, the information needed to validate the scientific conclusions of peer-reviewed publications must be shared at the time of publication. This does not include laboratory notebooks, preliminary analyses, intermediate data products, drafts of scientific papers, plans for future research, peer review reports, communications with colleagues, or physical objects, such as laboratory specimens.

Data subject to specific laws, regulations, or policies (*e.g.*, Export Administration Regulations (EAR) or International Traffic in Arms Regulations (ITAR)) that would prevent the release of this information are exempt from requirements for making data publicly available. Section II-C of SPD-41a lists additional laws, regulations, and policies that generate exceptions to data sharing requirements.

Data Management Plans

All SMD-funded scientific activities that are expected to produce scientific data shall include a data management plan describing the management, preservation, and release of data to facilitate implementation of relevant scientific information policies. The data management plan may be one component of a broader OSDMP. Though not required under SPD-41A, the OSDMP is a required component of many proposals for SMD funding starting with ROSES-2023.

At a minimum, a data management plan for SMD-funded research should include:

- Descriptions of the data expected to be produced from the proposed activities, including types of data to be produced, the approximate amount of each data type expected, the machine-readable format of the data, data file format, and any applicable standards for the data or associated metadata

- The repository (or repositories) that will be used to archive data and metadata arising from the activities and the schedule for making data publicly available

- Description of data types that are subject to relevant laws, regulations, or policies that exclude them from data sharing requirements

- Roles and responsibilities of project personnel who will ensure implementation of the data management plan

Data management plans should reflect the practices of specific research communities, and SMD Divisions and/or ROSES program elements may provide additional guidance on format and content. See SMD Division Policies and Guidance.

Timeline for Sharing Data

Scientific data resulting from SMD-funded scientific activities shall be made publicly available, to the extent allowed by applicable law and existing NASA policies, according to the following timeline:

1. Scientific data needed to validate the scientific conclusions of peer-reviewed manuscripts resulting from SMD-funded scientific activities shall become publicly available no later than the publication date of the corresponding peer-reviewed article. This includes data required to derive the findings communicated in figures, maps, and tables, as well as scientifically useful data from models and simulations.

2. Any scientifically useful data associated with a SMD research award shall be made publicly available by the end of the period of performance, whether or not the data would be needed to validate the scientific conclusions of a peer-reviewed publication.

Where to Share Data

Data must be shared and archived in locations that ensure the availability and preservation of the data. Repositories should meet the guidelines for SMD-acceptable data repositories in Appendix D of SPD-41a, which are based upon the Desirable Characteristics of Data Repositories for Federally Funded Research. The method for sharing the data must be described as part of the data management plan.

NASA Science Data Archives

SMD-funded researchers should follow any guidance for how to share data provided in their solicitation or in SMD divisions-specific policies. Examples of these repositories include GeneLab, NExScI Science Data Archives, and HLSP Data Collections. If no repository is specified by the funding solicitation or SMD division, researchers are encouraged to select an appropriate NASA Science Data Archive whenever possible.

Generalist Repositories

While SMD encourages the use of domain-specific data repositories when possible, such repositories are not available for all data sets. In this case, researchers may select a generalist data repository that is already in use by the scientific community and follows the characteristics

of acceptable data repositories in Appendix D of SPD-41a. Generalist repositories include data.nasa.gov, as well as others provided by other federal agencies and by nongovernmental institutions.

SMD does not recommend any specific generalist repositories at this time. Following the examples of the NIH and USGS, the non-exhaustive list below is provided as a starting point for locating commonly used generalist repositories that may be suitable for archiving SMD-funded research data.

- Zenodo

- Open Science Framework

- Dryad

- Figshare

- Dataverse

The USGS provides a helpful list of criteria to consider when selecting an external repository.

Journal Supplementary Material

For some scientific data, such as small data sets or individual tables that accompany a journal article, the supplemental material of a published journal article may be an appropriate location for making the data available. To be compliant with data sharing requirements in SPD-41a, the journal must not restrict usage or require a fee to access the supplemental material, and any data provided as supplemental material must be machine readable. While sharing data as supplemental material may be appropriate in some cases, SMD encourages archiving data in community-recognized data repositories as a best practice. In some cases, this is done automatically by the journal and community repositories as part of the publication process.

How to Share Data

When sharing data, SMD-funded researchers should follow the FAIR Guiding Principles for scientific data management and stewardship. The FAIR Principles include ensuring that data are:

- **F**indable - consistent and persistent descriptions make scientific data easy to find by both humans and computers

- **A**ccessible - use of standard, open protocols ensure data and metadata can be accessed by all.

- **I**nteroperable - formal, accessible, and widely adopted semantics and vocabularies are used to expand data usability across systems and communities

- **R**eusable - data are richly described according to standards to ensure they can be combined or replicated, and usage rights are clarified

The following items are required (denoted using "shall") or recommended (denoted using "should") when publicly sharing research data developed using SMD funding. These items help ensure that data are preserved and available to support reproducibility and reuse, and they are consistent with the FAIR Principles.

- Open availability: Publicly available, SMD-funded data shall be made available without fee or restriction of use. The data shall be shared in a repository that provides broad, equitable, and maximally open access to datasets and their metadata free of charge in a timely manner after submission, consistent with legal and policy requirements related to maintaining privacy and confidentiality, Tribal and national data sovereignty, and protection of sensitive data. The data will be availabile to the public (lay and scientific) without pre-approval.

- Format: SMD-funded data and metadata shall be made available for access, download, or export in non-proprietary, modifiable, open, and machine-readable formats consistent with standards used in the disciplines the repository serves.

- Metadata: SMD-funded data shall include robust, standards-compliant metadata that clearly and explicitly describe the data. Use of metadata by the repository enables discovery, reuse, and citation of SMD-funded data.

- Clear guidance on use: Publicly available SMD-funded data shall be reusable with a clear, open, and available data license. If there are no other restrictions on the data, the data should be released with a [Creative Commons Zero](#) License. This provides a clear license for the user that the scientific data is in the worldwide public domain and that they may use it freely. In some cases, there might be existing restrictions on releasing the data due to intellectual property rights, contract restrictions, underlying licenses, or other issues. If unsure, contact your counsel that can help with intellectual property rights or ask for clarifications at HQ-SMD-SPD41@mail.nasa.gov.

- Persistent identifiers: Publicly available SMD-funded data collections shall be citable using unique persistent identifiers (*e.g.,* DOI) assigned by the repository to support data discovery, reporting, and research assessment. Authors of publications developed using publicly available, SMD-funded data should cite the data sources used to conduct the research. This may include data made publicly available by the author of the publication using methods described in this section or other SMD-funded data.

- Findability: SMD-funded data shall be findable, such that the data can be retrieved, downloaded, indexed, and searched. The data must be shared in a repository that will ensure that data are searchable and be provided with descriptive metadata along with the data collections.

Software Management and Sharing

Consistent with the principles of open-source science, software developed using SMD funding shall be made publicly available through methods that are transparent, availabile, and reproducible. The open sharing of research software improves the reproducibility of research, enables other scientists to use and build upon software developed using public funds, and allows the researchers who share the software to be cited and recognized for the impact of their work. As software has become increasingly more important to the scientific process, scientific manuscripts do not always capture all of the nuance that is in the source code that supports the paper. Sharing the software ensures that others can better understand and reproduce the results reported in the manuscript.

This section contains supplemental guidance for researchers to support the implementation of requirements for software management and sharing established by SPD-41a. Researchers also should reference [any relevant software policies and guidance provided by SMD divisions](#).

Software in Scope of SPD-41a

Software is defined as computer programs, including source and object code, that provide users some degree of utility or service. Scientific software in scope of SPD-41a is software that provides users some degree of scientific utility or produces a scientific result or service. Further definitions and examples of software are provided in [Types of Research Software and Expectations for Sharing](#). The guidance provided here is most relevant for research software that is produced by investigations funded via SMD research awards. This software should be developed and released as described in the project's software management plan.

Software developed only for preliminary analysis, plans for future research, or communication with colleagues is not required to be released.

Restricted software, that is software that is subject to specific laws, regulations, or policies (*e.g.*, Export Administration Regulations (EAR), International Traffic in Arms Regulations (ITAR), intellectual property laws, license restrictions) that would prevent the release of this information, is exempt from the requirements for making software publicly available. Section II-C of SPD-41a lists additional laws, regulations, and policies that generate exceptions to software sharing requirements. This includes scientific software for which release is limited by patent rights, as described in the governing document of the funding mechanism, including "Patent Rights for Small Business Firms and NonProfit Organizations."

Commercial software, that is software that is produced for the purposes of sale and includes software that would be classified as commercial-off-the-shelf (CoTS), is not included in the types of software that must be released as part of research awards. Software developed in a proprietary or commercial language, such as IDL or MATLab, is expected to be released if allowed by the license.

Software Management Plans

All SMD-funded scientific activities that are expected to produce software shall include a software management plan describing how software will be managed, preserved, and released to comply with the requirements of SPD-41a. The software management plan may be one component of a broader OSDMP. Though not required under SPD-41a, the OSDMP is a required component of many proposals for SMD funding starting with ROSES-2023.

At a minimum, a software management plan for SMD-funded research should include:

- Description of the software expected to be produced from the proposed activities, including types of software to be produced, how the software will be developed, and the addition of new features or updates to existing software. This can include the platforms used for development, project management, and community-based best practices to be included such as documentation, testing, dependencies, and versioning.

- The repository(ies) that will be used to archive software arising from the activities and the schedule for making the software publicly available

- Description of software that are subject to relevant laws, regulations, or policies that exclude them from software sharing requirements

- Roles and responsibilities of project personnel who will ensure implementation of the software management plan

Software management plans should reflect the practices of specific research communities, and SMD divisions and/or ROSES program elements may provide additional guidance on format and content. See SMD Division Policies and Guidance.

Timeline for Sharing Software

Scientific software resulting from SMD-funded scientific activities shall be made publicly available, to the extent allowed by applicable law and existing NASA policies, according to the following timeline:

1. Scientific software needed to validate the scientific conclusions of peer-reviewed manuscripts resulting from SMD-funded scientific activities shall become publicly available no later than the publication date of the corresponding peer-reviewed article. This includes software required to derive the findings communicated in figures, maps, and tables, as well as scientifically useful software from models and simulations.

2. Any scientifically useful software associated with a SMD research award shall be made publicly available by the end of the period of performance, whether or not the software would be needed to validate the scientific conclusions of a peer-reviewed publication.

Where to Share Software

Software must be shared and archived in locations that ensure its availability and preservation. Researchers should follow the guidance for how to share software as described in the relevant solicitation or under the [division software policies](#) if applicable.

If there is no specific guidance on how to share software, options for where to share software include:

- In the supplemental material of a publication. This is ideal for small scripts, notebooks, or spreadsheets that include calculations necessary for reproducing the paper.

- Publishing the source code in a software specific journal.

- If shared on a version controlled platform (e.g. [GitHub](#)), it is also important to archive the software at a designated repository.

  - [GitHub has integration with Zenodo](#) to make it easy to create an archived copy of the software.

- In public repositories already used in the community such as [Zenodo](#), [Astrophysics Source Code Library](#), and [Software Heritage](#).

The method for archiving and sharing the software should be described in the Software Management Plan.

General Expectations for Open-Source Software

Unrestricted software developed using SMD-funding is expected to be shared openly. There are many different types of software and the expectations for software sharing are different for missions and researchers (See [Types of Research Software and Expectations for Sharing](#)).

When released, SMD-funded software should follow best practices in the relevant open source and research communities. For example, providing documentation and testing, which are not required to be provided under SPD-41a, alongside the source code increases the quality of the software and reusability of the software.

For publicly available software projects, SMD-funded software projects must include a code of conduct and guidelines for how to make contributions. A code of conduct provides clear guidelines for the conduct of those participating in the development of the software. The guidelines for how to make contributions provide clear expectations for how to contribute to the project. This may include how to make contributions, the type of contributions that the project is accepting, or even that the project is currently not accepting contributions. This can also include the expectations for support for the software project and for responding to questions about the project.

When released as open source software, source code for SMD-funded software shall be made available in a publicly accessible repository that is widely recognized by the community. See

'[Where to Share Software](#)' for more information and examples of how to make the software available.

Publicly available SMD-funded software must be citable using a persistent identifier. A persistent identifier such as a DOI provides an easy method for software to be cited in the scientific literature and for the developers of the software to receive credit for their work. It also provides a way to track the usage of the software and to make reporting on the software easy.

For software developed under research grants, there is no expectation that the software is maintained. Some scientific software is developed for a single purpose, and there is no benefit in further development or maintenance of the software. Providing it openly does help to further the understandability of the scientific work that it supports as a manuscript may not capture all of the details in the processing or analysis required to reproduce the results.

Reporting Open-Source Software

Publicly available SMD-funded software shall be indexed as part of the NASA catalog of software. Developers of software packages that are developed as part of SMD-funded activities must catalog the software in NASA's [New Technology Reporting System](#). Single use software and commercial software do not need to be reported for indexing as part of the NASA catalog of software.

Intellectual Property and Licenses for Software

If there are no other restrictions, publicly available SMD-funded software should be released under a permissive license that has broad acceptance in the community. Restrictions that may prevent release under a permissive license include, but are not limited by, software governed by incompatible licenses or restricted computer software. Seek specific advice from the Chief Science Data Office or Intellectual Property Counsel, as needed. Questions can be submitted to HQ-SMD-SPD41@mail.nasa.gov.

For software developed at NASA Centers and released through the NPR 2210 process, Center Intellectual Property Counsel shall be consulted in the selection of the license to be used in the release of software, which may include Apache 2.0, BSD, or MIT.

Types of Research Software and Expectations for Sharing

Different types of research software have different expectations and practices for being shared openly, as defined in Appendix F of SPD-41a.

Single use: Software written for use in unique instances, such as making a plot for a paper or manipulating data in a specific way. Single-use software developed from SMD-funding shall be released no later than with the publication it supports. It can be released as supplementary material to the publication or shared in a data repository that produces a permanent identifier that is linked to from the publication.

Libraries: Generic tools, often with a larger user base, implementing well known algorithms, providing statistical analysis or visualization, etc., that are incorporated in other software

categories. Libraries developed using SMD funding shall be released no later than the publication it supports. Libraries should be developed openly in a version-controlled platform and SMD-funded researchers are encouraged to contribute to existing, open source libraries. Major versions or releases of the software should be archived in a NASA designated repository.

Analysis software: Generalized software (not low-level libraries) used to manipulate measurements or model results to visualize or gain understanding. This software often evolves from single-use utility software and may incorporate libraries. Analysis software developed from SMD-funding shall be released no later than the publication it supports. Analysis software should be developed openly in a version-controlled platform and SMD-funded researchers are encouraged to contribute to existing, open source analysis software. Major versions or releases of the software should be archived in a NASA designated repository.

Model and Simulation software: Software that either implements solutions to mathematical equations given input data and boundary conditions or infers models from data. Includes first-principles models, data-assimilation tools, empirical models, machine learning, mission planning and engineering tools, among others. They often use libraries.

Model and Simulation software developed from SMD funding shall be released no later than the peer-review publication it supports. Model and Simulation software should be developed openly in a version controlled platform and SMD-funded researchers are encouraged to contributed to existing, open source software. Major versions or releases of the software should be archived in a NASA designated repository.

Data processing: Software for processing uncalibrated sensor measurements into calibrated sensor data and derived data products. This software type applies calibration coefficients, corrections or algorithms, which may be dependent on forward modeling, simulated observations, equations, and data filtering. It may include modeling and simulation software and libraries.

Data processing software developed under research grants from SMD funding shall be released no later than the peer-review publication it supports. Data processing software should be developed openly in a version-controlled platform and SMD-funded researchers are encouraged to contribute to existing, open source software. Major versions or releases of the software should be archived in a NASA designated repository.

Commercial software: Software produced for the purposes of sale. This includes software that would be classified as commercial-off-the-shelf (CoTS) and software that NASA does not have a license to distribute. Commercial software is not required to be released. SMD-funded research software developed in a commercial language (a programming language that requires a license to compile or run software) is not considered commercial software and shall be shared in a similar manner as other types of software developed in open languages.

Persistent Identifiers for Investigators

How to Obtain a Persistent Identifier

SPD-41a requires SMD-funded investigators to have a persistent identifier that meets the standards of a digital persistent identifier service defined in the NSPM-33 Implementation Guidance. Many SMD-funded researchers meet this requirement using ORCID, an organization that provides a unique, persistent identifier (the ORCID iD) to distinguish among researchers. Register for an ORCID iD here.

Using a Persistent Identifier

Starting with ROSES-2023, PIs and Co-Is must provide their persistent identifiers (e.g., ORCID iD) via the NSPIRES submission process.

SMD encourages researchers to include their ORCID iDs in scientific outputs, which provides a mechanism for researchers to document their unique scientific records, improve the discoverability of their work, and gain recognition for reviews, awards, and more. Learn more about using ORCID here.

Sharing Materials from Science Events

The movement toward open-source science requires a shift to make science more transparent and collaborative at all stages of the scientific process, including scientific conferences, workshops, and symposia. This page contains supplemental guidance for researchers to support the implementation of requirements for sharing scientific publications produced for science events established by SPD-41a. In the future, this guidance will be expanded to include additional recommendations for event organizers on making SMD-funded science events more open.

Requirements

Under SPD-41a, participants sponsored with SMD funding to attend conferences, workshops, or symposia shall deposit scientific publications produced for the event in an appropriate NASA designated repository. This includes conference proceedings, slide decks, poster presentations, and any other publications produced for the event.

This requirement does not apply to restricted information, nor does it apply to laboratory notebooks, preliminary analyses, drafts of scientific papers or preprints, plans for future research, peer review reports, or communications with colleagues.

How to Share Publications Produced for an Event

A specific repository may be identified by a SMD solicitation. If no repository is specified, event participants have several options for sharing their scientific publications produced for SMD-funded events. These include:

- Submitting to NASA STI Repository. For those with a NASA identity who have completed the STRIVES process for their scientific publications produced for an event, these publications will be archived in the STI Repository and no additional action is required by the researcher.

- Sharing through an external, community-accepted repository (*e.g.*, Zenodo or arXiv). This option is recommended for those without a NASA identity.

Appendix A: Glossary of Open-Source Science Terms

Most terms in this section are copied from Appendix B of [SPD-41a](). Additional terms are noted here with a caret (^).

Archive: The process of storing data to ensure long term retention.

Accessible: As per the definition in the [FAIR]() principles, data are retrievable by their identifier using standardized communications protocols.

Commercial Software: Software produced for the purposes of sale. This includes software that would be classified as commercial-off-the-shelf (CoTS) and software that NASA does not have a license to distribute.

Data: Scientific or technically relevant information that can be stored digitally and accessed electronically.
- Information produced by missions include observations, calibrations, coefficients, documentation, algorithms, and any ancillary information. Further definitions of mission data and examples are provided in Appendix E.
- Information needed to validate the scientific conclusions of peer-reviewed publications. This includes the data required to derive the findings communicated in figures, maps, and tables.
- This does not include laboratory notebooks, preliminary analyses, intermediate data products, drafts of scientific papers, plans for future research, peer review reports, communications with colleagues, or physical objects, such as laboratory specimens.

Data Management Plan (DMP): A document that describes whether and how data will be shared and preserved. A DMP should be compliant with NASA policies.

Findable: As per the definition in the [FAIR]() principles, metadata and data should be easy to find for both humans and computers.

Interoperable: As per the definition in the [FAIR]() principles, data are able to work with other applications or workflows for analysis, storage, and processing.

^ Machine readable: Refers to information or data that is in a format that can be easily processed by a computer without human intervention while ensuring no semantic meaning is lost. (Source: https://resources.data.gov/glossary/machine-readable-file/)

^ Open Access publication: Although there are various uses of the term 'open access', this guidance document uses the term to refer to a method of publication in which the publisher makes the article and related content available online, free of charges or other barriers to access, immediately at the time of publication. Such articles are often licensed for sharing and reuse under a [Creative Commons]() or similar license-type agreement that allows the authors to retain copyright while allowing others to copy, distribute, and reuse their work.

Open Format: A file format for storing digital data that is defined by an openly published specification, usually maintained by a standards organization and that can be used and implemented by anyone. Open file format is licensed with an open license.

^ Open Science and Data Management Plan (OSDMP): A document that describes how scientific information produced from a scientific activity will be shared and preserved in accordance with relevant policies. The OSDMP should include plans for sharing data, software, and publications. It may also include a description of other types of scientific information that will be shared openly and other open science activities associated with the project. An OSDMP replaces the data management plan (DMP) in some funding proposals.

Open Source Software (OSS): Software that can be accessed, used, modified, and shared by anyone. OSS is often distributed under licenses that comply with the definition of "Open Source" provided by the Open Source Initiative or meet the definition of "Free Software" provided by the Free Software Foundation.

Persistent Identifier: A long-lasting reference to a digital source. The digital object identifier (DOI) system is an example of a persistent identifier.

Permissive License: Guarantees the free use, modification, and redistribution of software, while still permitting proprietary derivative works. Examples include the Apache License 2.0, the BSD 3-Clause "Revised" License, and the MIT License.

Publication: Document released through print, electronic, or alternative media. This includes peer reviewed manuscripts, technical reports, conference materials, and books. This does not include laboratory notebooks, preliminary analyses, drafts of scientific papers or preprints, plans for future research, peer review reports, or communications with colleagues.

Report: Document produced through print, electronic, or alternative media containing scientific and technical information. These documents are typically not peer reviewed. Examples include technical publications, technical memorandums, contractor reports, conference publications, special publications, and technical translations. It does not include interim research grant reports.

Repository: An organized storage location that makes data findable and available.

Restricted Software: Software that shall not be released due to an existing Federal law or guidance, NASA policy, or security concern. This includes software supporting security requirements described in STD-1006. For Mission software, projects should engage with the software release authority to determine status. Examples of software that may be restricted are command related software, instrument control, authentication, or communication software.

Review: Assessment of SMD-funded activities by an individual or group. This may include a panel, standing review board, or senior review.

Reusable: As per the definition in the [FAIR](#) principles, metadata and data should be well-described so they can be replicated and/or combined in different settings. This includes releasing the data with a clear and accessible data usage policy.

Scientific Information: Scientific knowledge produced as part of a research activity. This can include, but is not limited to, publications, data, and software.

Scientific Software: Software that provides users some degree of scientific utility or produces a scientific result or service.

Scientific Utility: Information that is necessary to validate research findings or beneficial for future research activities.

Single Use Software: Software written for use in unique instances, such as making a plot for a paper or manipulating data in a specific way.

Software: Computer programs in source and object code that provide users some degree of utility or produce a result or service.

Software Project: An activity to develop software. A software project typically has a version control platform on which development can occur collaboratively.

Source Code: A human-readable set of statements written in a programming language that together compose software. Programmers write software in source code, often saved as a text file on a computer. The terms code and source code are often used interchangeably.

Appendix B: Open Science and Data Management Plan Sample Template

Italicized text is included for explanatory purposes throughout this template and should be omitted from the Open Science and Data Management Plan (OSDMP). This template provides one example of the format and contents of an OSDMP. For most proposals, the OSDMP should not exceed a total length of two pages. If there are costs associated with performing the tasks described in the OSDMP, those costs should be accounted for in the proposal budget and/or budget justification.

Please follow any specific instructions for the OSDMP in your funding solicitation. SMD divisions may provide additional OSDMP guidance or templates that are tailored to specific research communities. General guidance on the OSDMP is available in the SMD Open-Source Science Guidance and on the [ROSES OSDMP web page](). Questions regarding this template may be directed to [HQ-SMD-SPD41@mail.nasa.gov]().

1. Data Management Plan

A data management plan is required for all SMD-funded activities that are expected to produce scientific data. Here it is incorporated into the broader OSDMP. Follow any specific requirements for the data management plan that are provided by the funding solicitation or relevant SMD Division. At a minimum, the DMP includes the following elements:

1.1 Expected data types, formats, volumes, and standards

Describe the data expected to be produced from the proposed activities. Include the types of data to be produced, the approximate amount of each data type expected, the machine-readable format of the data, data file format, and any applicable standards for the data or associated metadata.

1.2 Repositories and timeline for sharing data

Specify the repository(ies) that will be used to archive and provide public access to data and metadata arising from the activities and the schedule for making data publicly available. Include a description of how data will be archived to enable long-term preservation.

1.3. Description of data types that are exempt from data sharing requirements

Specify data types that are excluded from requirements to make the data publicly available and cite the relevant laws, regulations, or policies that generate the exclusion.

2. Software Management

A software management plan is required for all SMD-funded activities that are expected to produce software. Here it is incorporated into the broader OSDMP. Follow any specific requirements for the software management plan that are provided by the funding solicitation or SMD Division.

If the activity is not expected to produce software, include a statement such as:
"No software development is anticipated for this effort. If software is created, it will be made publicly available to the extent legally permitted per the Scientific Information Policy for the Science Mission Directorate."

2.1 Expected software types

Describe the software expected to be produced from the proposed activities, including types of software to be produced, how the software will be developed, and the addition of new features

or updates to existing software. This can include the platforms used for development, project management, and community-based best practices to be included such as documentation, testing, dependencies, and versioning.

2.2 Repositories and timeline for sharing software
Specify the repository(ies) that will be used to archive software arising from the activities and the schedule for making software publicly available. This should include the license under which the software will be made available. If there are no other restrictions, the software should be released under a permissive license.

2.3 Description of software that are exempt from software sharing requirements
Specify software types that are excluded from requirements to make the software publicly available and cite the relevant laws, regulations, or policies that generate the exclusion.

3. Open Science Plan

3.1 Publication Sharing
Describe the types of publications that are expected to be produced from the activities (e.g., peer reviewed manuscripts, technical reports, conference materials, and books). Outline the methods expected to be used to make the publications publicly available, which will likely include options listed under 'How to Share Publications' in the SMD Open-Source Science Guidance. This may include posting manuscripts to community-appropriate preprint servers, making accepted manuscripts publicly available in NASA's STI Repository, or publishing manuscripts as Open Access in reputable journals. Note that costs for Open Access publishing may be included in proposal budgets.

3.2 Other Open Science Activities
Optionally, the OSDMP may include a description of additional open science activities associated with the project (if not described elsewhere in a proposal). This may include: holding scientific workshops and meetings openly to enable broad participation, providing project personnel with open science training or enablement, and contributions to or involvement in open-science communities.

4. Roles and Responsibilities
Specify the project personnel who will ensure the implementation of the OSDMP. This may be its own section or integrated into the sections above.