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Preservation Content Implementation Guidance

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STATUS OF THIS MEMO

This memo provides information to the National Aeronautics and Space Administration (NASA) Earth Science Data Systems (ESDS) community. This memo describes a "Suggested Practice" and does not specify an ESDS standard of any kind. Distribution of this memo is unlimited.

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ABSTRACT

This Preservation Content Implementation Guidance was produced for the Earth Observing System Data and Information System (EOSDIS) as a companion document for the NASA Earth Science Data Preservation Content Specification. This guidance is primarily intended for the EOSDIS Distributed Active Archive Centers (DAACs) which receive data from various data producers for archiving and distribution.

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1 Introduction

This document is intended to provide guidance for implementing the content specifications listed in Section 3 of the "NASA Earth Science Data Preservation Content Specification (423-SPEC-001)" [1]. Some variation is expected in the degree to which these specifications are met, as well as in the phase/stage at which they are addressed, depending on the nature of the projects implementing the specification. In what follows, the word "project" is used as a general term to refer to the different types of NASA-funded activities resulting in data and derived products. Projects include on-orbit/satellite missions, suborbital/airborne and field investigations, and other data producing activities (e.g., projects under the MEaSUREs Program). The more specific terms are used only where needed to refer to the particular type of projects. The data resulting from NASA's projects are a valuable resource that needs to be preserved for the benefit of future generations. This document also provides guidance on how to collect and organize the various items meeting the specifications called for in [1]. Such items are referred to in the following sections as "preservation items" or "preservation artifacts". The guidelines common to all types of projects are covered first and those specific to the different types of projects are covered in individual sections that follow.

1.1 Expected Compliance

The specifications categorized in sections 3.1 through 3.8 of the Preservation Content Specification (PCS) [1] are intended to be comprehensive such that each is required to completely describe the provenance and context (lineage and background) for each data product coming from a project. We want to preserve complete transparency into what was done to make the Earth observation products. Through this transparency we support their verifiability, validity, and trustworthiness for integration into the long-term climate record or for other future analyses. The expected compliance with the specifications varies depending on the type of NASA-funded program/project and the agreements between the funding program and the executing project. It is also to be noted that the PCS [1] provides requirements for active and future missions, but best efforts are to be used to meet the specifications in the PCS for completed and on-going missions. If at any time DAACs are concerned about resources to complete the preservation activities, they should consult with the Earth Science Data and Information System (ESDIS) Project. Further, DAACs are encouraged, but not expected to comply with the PCS for community submitted data sets. Examples of types of programs and projects are shown in Table 1, with expected degrees of compliance, shown as Complete, Partial and Basic. These degrees are analogous to the three levels (comprehensive, standard, and basic) used in the Level of Service model utilized by NASA's Earth Science Data Systems (ESDS) Program [2]. Complete compliance is highly desirable; however, showing the three levels recognizes potential resource limitations that may preclude complete compliance. Brief comments are included about the Commercial Smallsat Data Acquisition Program and the Citizen Science for Earth Science Program in Sections 6 and 7 below. Since these programs are relatively new, more detailed guidance for preserving data from these programs will need to await until some experience is gained with them. Guidance for these programs will be included in a later version of this document.

Table 1 Degree of required compliance for different program types (with project/product examples)

Compliance →	**Complete**	**Partial**	**Basic**
Program Types	Earth Systematic Missions Earth Venture (Missions/ Instruments/Suborbital) Facility Instruments (used for multiple investigations)	Data Producing Activities Research and Analysis (R&A) funded investigations;	Community submitted or applied science products Multi-organizational investigations
Example Projects/ Products	Terra, Aqua, Aura, ICESat TROPICS, ECOSTRESS, MAIA MASTER	MEaSUREs Projects; Solid Earth Science ESDR System; Fundamental Data Records for Precipitation FIREX-AQ	Community submitted: SUMER Antarctic Iceshelf Buttressing data at NSIDC DAAC Multi-Org: LISTOS at ASDC DAAC

Not all preservation specifications are applicable to the various types of airborne and field investigations (also frequently referred to as campaigns) as indicated in Table 1. There are a variety of investigations with various funding levels and goals. Investigation examples in Table 1 show that there can be airborne and field investigations in any of the three categories of expected compliance (Complete, Partial and Basic). Some investigations are funded under the Earth Venture program and are considered NASA-funded missions that must maintain Complete conformance to the specifications, while other investigations may be multi-organizational investigations of which NASA is but one partner, and therefore can meet only the Basic compliance levels. There are also Research and Analysis investigations that may be either smaller, regional, science-focused investigations in which a Basic level of conformance may be expected or larger science-focused investigations in which a Partial compliance level is expected. Investigations focused on development of a new instrument or on validation, calibration, or development of an algorithm for a satellite instrument may be provided only sufficient funds to meet the Basic level of expected conformance. The funding source and Level-of-Service designation are both possible indicators of the expected preservation compliance level for investigations.

Table 2 provides further details of the expected degrees of compliance as they apply to subsections 3.1 through 3.9 of the PCS. The following color-coding and symbols are used to identify compliance for each individual PCS section:

- Required (R) - must be completed
- Suggested (S) - complete if information is available and appropriate
- **Not Applicable (N/A)** - does not need to be completed.

The degrees of expected compliance are noted as Complete, Partial, and Basic. The numbers shown in the first column of the table, with the heading "Content Specification", correspond to subsection numbers in the PCS.

Table 2 Degrees of compliance with PCS (by subsection)

Compliance → **Content Specification**	**Complete**	**Partial**	**Basic**
3.1.1 Instrument and Platform Description	R	S*	S*
3.1.2 Pre-flight/ Pre-operational Instrument Calibration Data	R	S	N/A
3.2.1 Raw Data and Derived Products	R	R	R
3.2.2 Data Product Metadata	R	R	R
3.3.1 Instrument and Science Team	R	R	R
3.3.2 Data Product Requirements and Designs	R	S	N/A
3.3.3 Processing and Algorithm Version History	R	R	S
3.3.4 Data Product Generation Algorithms	R	R	S
3.3.5 Data Product Quality**	R	R	R
3.3.6 Data Product Application	R	S	S
3.4.1 On-orbit, in-flight, in-the-field Calibration Methods	R	R	S

Compliance → Content Specification	Complete	Partial	Basic
3.4.2 Calibration Data	R	S	S
3.5 Science Data Product Software	R	R	S
3.6 Science Data Product Algorithm Inputs	R	R	S
3.7 Science Data Product Validation	R	R	R
3.8 Science Data Access and Analysis Tools	R	S	S
3.9 Deliverables Checklist	R	R	R

*Minimum requirement is to have metadata that describe these instruments for accurate database mapping and identification.

**It is to be noted regarding Data Product Quality (item 3.3.5 above), that Ramapriyan et al [3] define four aspects of "Information Quality" – Scientific Quality, Product Quality, Stewardship Quality and Service Quality associated with measurement data and derived data products. In the context of this document, the first two are of the most interest. *Scientific quality* is defined in terms of accuracy, precision, uncertainty, validity, and suitability for use (fitness for purpose). For a given data product, the *product quality* takes the following into account: the degree to which the scientific quality is assessed and documented; how accurate, complete, and up-to-date the metadata and documentation are; the manner in which the data and metadata are formatted; and the degree to which the associated information including provenance are published and traceable throughout the data lifecycle. The term "Data Product Quality" as used in this document and the PCS [1] cover both the scientific quality and the product quality aspects of information quality.

2 COMMON GUIDELINES

The following guidelines apply to all types of projects. The topics covered include: identifying and gathering preservation items, responsibility of organizations for identifying and gathering preservation items, provision of pointers to locations of items when not all are archived by a given DAAC, use of persistent identifiers, ensuring future usability and the need for on-going updates to preservation items, actions to be taken when some artifacts are unavailable, organization and presentation of preservation checklists (also referred to below as PCS checklists), presentation of preservation items on DAAC websites, preservation of information from project websites, and special cases such as complex instrument assemblies. Subsection 2.11 shows a figure illustrating the general flow of preservation items from their sources to end users. The concluding subsection provides guidelines on long-term care and maintenance of the PCS checklists and artifacts.

2.1 Identifying and Gathering Preservation Items

The individual sub-items within the item descriptions in the PCS are examples, and as such may not be required for every project since they cover a broad range of data products, instrument types, and science objectives. The Principal Investigators (PI)/Science Teams(ST) of the projects are asked to provide guidance to the DAAC regarding what content exists or is needed in each preservation category to ensure future data usability. The PIs and STs are expected to know best what content they have that is needed for future users to understand and reuse their data. Therefore, they can guide the DAACs by telling them what they have. The DAACs need to work with them to gather, organize and preserve such content. Furthermore, the DAACs may know of additional data/information that will ensure future use of the data. Such data/information could be internal to the DAAC as well as those that should be obtained from the PI/Science Teams. In addition, DAACs should work with their User Working Groups (UWG) to obtain an independent review of preservation content fulfilment. When applied to older activities where the projects have ended and the principals are no longer accessible, it may not be possible to fully satisfy these content specifications. However, projects that are still in planning stages should be able to fully meet the specifications. The details of implementation should be worked out while developing the project and DAAC Data Management Plans (DMPs), Operation Agreement, Submission Agreement, Interface Control Document, etc. between the project and the DAAC.

Identifying and gathering preservation items are a shared responsibility between the project and the "assigned DAAC", which is the DAAC responsible for archiving the data during the active phase of the project (i.e., period during which the project is funded) as well as for long term care of and access to the data and preservation information. The assigned DAAC is designated by NASA HQ's ESDS Program. The assignment of the DAAC is normally indicated in an appropriate formal document such as the Program Level Requirements Appendix (PLRA) or the Investigation Implementation Plan (IIP). The names of assigned DAAC's for specific data products are further documented in the Common Metadata Repository's (CMR) collection level metadata. It is suggested that the PCS checklist (see section 3.9 in [1]) be created by the assigned DAAC as a spreadsheet early in the project[1], kept updated as the project progresses, and maintained into the future. Initial versions of some living document items (e.g., DMPs, Interface Control Documents) may be gathered in the earlier phases and updated in the later phases. The assigned DAAC is the keeper of the checklist, and it is the duty of the project to respond to the DAAC's requests for the information which the checklist calls for. At the end of the project, future

[1] The appendices in the PCS document [1] indicate *when* the various artifacts should be collected, based on the mapping between PCS and ISO 19165-2. The checklist should be initiated before gathering the earliest applicable artifacts for a given project.

updates may need to be made by the assigned DAAC when any documentation gets updated, data reprocessing occurs and/or important user feedback becomes available. User feedback about the data products that would be valuable to share with others should also be gathered and preserved. Other items that may need to be updated include: ST members' names and roles (and ORCID when available), publications, and calibration/validation information.

Given the recent push by NASA towards Open Source Science [4], it is to be noted that where this document refers to software, the expectation is that the policy explained at https://earthdata.nasa.gov/collaborate/open-data-services-and-software/esds-open-source-policy is followed. This includes license requirements when gathering software from the projects and PIs/STs for preservation. The procedures for implementation of the policy are currently under development.

2.2 Curation and Preservation Responsibility

The assigned DAAC is responsible for ensuring that all the information necessary for future data usability is gathered, organized, and preserved in accordance with the PCS. This responsibility applies to all NASA data products. Non-NASA organizations may be the source of data products used in a NASA project. In this case, if the non-NASA organization does not preserve the needed preservation artifacts, then the NASA DAAC should collect and preserve them. The following situations are examples of this:

- ESA Sentinel data hosted at the DAACs
- Ancillary data products used for NASA product generation where the organization creating the data does not assure preservation and on-going long-term access
- Data products submitted by non-NASA funded investigators that were accepted for archival via the DAAC UWG approval process
- Data products from a non-NASA instrument that participated in a NASA investigation

In the case of large multi-organizational projects in which NASA participates, the responsibility of gathering, organizing, and providing preservation content artifacts falls on each organization that holds[2] data during the active phase of the project. Beyond the active phase of the project, the DAAC that is assigned to archive the data is responsible for preserving the data's provenance information. Before the project goes inactive, provenance artifacts need to be identified and preservation responsibility transferred to the assigned DAAC. This may involve physical transfer of artifacts to the DAAC or a partner archive. For example, if a DAAC is assigned to archive data products that originated from a multi organization project, the assigned DAAC is responsible for identifying and ensuring archive of the needed preservation artifacts for those data products. The assigned DAAC would provide users with a PCS checklist that includes links to the pertinent artifacts, whether archived by the DAAC or located at other partner archives. In some cases, there will be data products assigned to a DAAC that were inputs used in generating multiple higher-level product collections assigned to different DAACs. In these cases, each DAAC assigned to archive their higher-level products will have entries in PCS Checklist categories that point to the common input products archived at the partner DAAC. ASDC DAAC, for example, is the assigned DAAC to archive TES instrument products. Provenance shows inputs to the TES Level 1

[2] The word "holds" implies responsibility for managing rather than physical location of storage, which could be on-premises at the DAAC or in the Cloud.

algorithm include Aura platform products that are assigned to GES DISC DAAC. Therefore, we should have entries in the ASDC TES PCS checklist that point to Aura platform products archived at GES DISC. In another example, ORNL DAAC is assigned the responsibility to archive a collection of products from a particular investigation. The collection includes a subset of SAR products from ASF DAAC. The ORNL PCS for the investigation should have entries that point to the ASF SAR data products.

2.3 Preservation Locations and Pointers

In some cases, it is possible that not all the data or information needed to satisfy a particular specification requirement is archived by the assigned NASA DAAC. Some required artifacts may be archived by another DAAC or by a partner organization such as USGS or NOAA. NASA sponsored documentation may be archived by the NASA Scientific and Technical Information (STI) Program. The NASA STI program has provisions for handling material that is identified as having International Traffic in Arms Regulations (ITAR) restrictions, or is proprietary, copyrighted, and/or patent protected. If there are unpublished engineering documents, release notes, auxiliary data, ancillary data, or software that require access controls due to such reasons and are not accepted for archive by the NASA STI Program then the ESDIS Project will archive them in the ESDIS Project Library and control access to them. When providing these items to the DAACs, the projects should specify and include any distribution restrictions and expiration dates for those restrictions. The DAACs should coordinate with the ESDIS Project to ensure their inclusion in the ESDIS Project Library. The DAAC PCS checklist for the project should include all references (e.g., URLs) to items that are not physically archived in the DAAC as well as indicate where the items are archived, and the archival organization contact information.

2.4 Use of Persistent Identifiers

Not all preservation artifacts need a globally unique persistent identifier, such as a Digital Object Identifier (DOI). Deciding whether to register a DOI is the responsibility of the assigned DAAC. The general guidance for any given artifact is to assess whether it will need to be cited in the future. If this is the case, then registration of a DOI is recommended. It is expected that journal publications and NASA scientific technical information archived by the NASA Technical Report Service may already have DOIs, and in these cases the DAACs should reference the existing DOI in their PCS checklists (i.e., not register a new DOI for the artifact). Examples of artifacts that currently do not typically have a DOI and may need one are DMPs, Interface Control Documents (ICDs), calibration data, and calibration description documents. For any of the preserved items, persistent identifiers should be added to the checklist whenever available (e.g., DOIs for documents and datasets, ORCIDs for individuals).

2.5 Ensuring Future Usability

Generally, specifications of the artifacts in the PCS are intended to ensure future usability and potential reproducibility of the data. For this purpose and for the convenience of future researchers, it is desirable to archive the preservation artifacts along with the data as much as possible. Many of the preservation artifacts are not expected to change in the future[3]. In cases where a specification artifact is

[3] Exceptions to this are noted in section 2.12.

maintained by an organization other than the assigned DAAC, the PCS checklist should be annotated to uniquely identify the artifact, and include a pointer (e.g., URL) to the artifact, its archive location, name of the archiving organization and contact information. Periodically, the DAAC should verify that the preservation artifact is still preserved by the partner organization, and if status change is evident and plans warrant, obtain a copy of the artifact for preservation with the data. When pointing to data and documentation archived by another DAAC or another agency it is an added responsibility of the assigned DAAC to maintain links and get agreement from the partner archive to notify the DAAC if links change or artifact/data is going to be deleted/deprecated.

The preservation specification is generally designed to provide complete provenance and context information about each of the DAAC's data products. Higher level (levels 3 through 4) science data products are often derived from or created from multiple lower level (level 1 and 2) input data products or raw (level 0) instrument data observations. Such input data products and raw instrument data may be archived at different DAACs. Some discipline science products may be created by inputs from multiple instruments on the same platform or on different platforms. In other cases, discipline science products archived at multiple DAACs may all have the same input science data products or raw instrument data archived at a different DAAC. This makes implementation of the specification complex. Guidance in the respective subsections below is intended to help determine how the specification can be fulfilled, specifically when to point to a partner archive to satisfy the specification requirement.

2.6 Unavailable Artifacts

In cases where some of the content is not available for preservation, the efforts made to obtain them as well as the reasons for unavailability should be documented by the DAAC in the project checklist. In the cases where some data or documents are not archived at the DAAC due to their being proprietary, information should be included on how to contact the organization which holds such proprietary artifacts. In cases where the DAAC decided that a particular specification requirement did not need to be satisfied, the reason should be annotated in the PCS checklist for the project. The DAAC should make sure to indicate that all artifacts called for in the PCS have been considered. The DAAC should document the efforts made to obtain the artifacts even in cases where some of the content is not available for preservation. No section should be left empty in the PCS checklist.

2.7 Checklist Organization

The deliverables checklist (called for in section 3.9 of [1]) should be organized by sections and subsections (3.1 through 3.8 of [1]) and show all the content that has been preserved to meet those parts of the specifications. The checklist should be maintained in spreadsheet form by the DAAC.

Table 3 shows the column headings that should be used in the checklist spreadsheet along with descriptions. For each PCS category (indicated by the PCS subsection number and category title), a PCS checklist may list several entries, each of which should contain information in the columns as indicated below.

Table 3 Checklist spreadsheet column headings and descriptions

Column Headings	Description
Data Preservation Content Spec Reference [section number]	Identifies the intended category that the item satisfies (i.e., PCS Section Number)
PCS Category Title	Confirms the category (i.e., PCS Section Title)
Title and Description (free text)	A short description of the contents in the context of the PCS category. This applies to documents & data items; may include Document Title, Document Number, DOI, data collection name or data collection group name.
Source (free text)	The name of the organization, group, or individual that created the item; applies to both document and data items.
Creation Date	The date the item or collection was published, completed, or generated (to distinguish between versions, especially if more than one version is to be archived).
URL	The internet address of the artifact item; applies to documents and data. Note that it is possible (but not necessary) that the item's DOI will point to the URL.
Format (free Text)	The name or file extension (such as .pdf, .doc, .xls, .bin) that identifies the format of the file(s).
Archive Date	The date the item was received and archived by the DAAC; in the case of multiple files the date of when the last file was archived; in the case of partner archive the data that the DAAC verified that the item was archived.
Archive (free text)	The name of the assigned DAAC (who will archive the item) or the name of partner archive organization that the assigned DAAC will point to for the item.
Status	Three report options:1) the item has been archived at the DAAC or its location at partner archive has been verified (i.e., complete), 2) the item is available but not obtained from the source yet, or is available from partner archive but have not obtained a reference (e.g., URL) yet or 3) the item is not available despite our best efforts or partner archive is withdrawing their responsibility and DAAC will have to obtain a copy. Include the projected date when the DAAC will obtain the item from the partner archive.
Important Notes	Any communication needed about the documentation (e.g., poorly scanned, and difficult to read, but best that could be found; attempts made to find the artifact)

See Appendix B for a sample checklist. This is a simple example intended to ensure consistent application by the DAACs. In some more complex cases tailoring by the DAAC may be necessary.

The template may be updated as we gain more experience with preservation by the DAACs. The most recent template can be found on the Earthdata wiki under ESDIS EOSDIS Preservation Plans & Status (https://wiki.earthdata.nasa.gov/x/7xYECg).

2.8 Web Presentation of Preservation Materials

A derived form of the PCS checklists and the materials identified in the checklists are to be provided online by the assigned DAAC. How the checklists and materials are organized on the web is dictated by the quantity and complexity of the materials preserved and decided by the assigned DAAC. Good examples of document organization and checklist presentation include:

- NSIDC: ICESat/GLAS
- GES DISC: HIRDLS

DAACs need to provide for easy user discovery of collected preservation materials. Access-controlled items discussed in section 2.5 should still be discoverable, but users will need to request access and be approved before they can obtain them. This may require adding a specific preservation link to the DAAC website and including a URL pointing to the PCS checklist on dataset landing pages to facilitate finding preserved content items relevant to a given data product.

2.9 Preservation of Project Websites

The assigned DAAC should import important content from the project website(s) maintained during the project lifetime and preserve this vital web content along with the other preservation materials. In some cases, it may be appropriate to import, maintain, and provide to users the final version of the project website in its entirety. In other cases, only specific content is needed and can be incorporated into the DAAC website. Often, project websites provide valuable summary information or highlight key performance results or applications. In other cases, they may duplicate identical content in published papers, or document files, which do not need to be copied. In the case of airborne and field investigations, the field website/archive may still be active when preservation is underway but may disappear in the future. Institutions have no requirement to keep them. Therefore, important information on the project websites should be preserved and noted in the appropriate PCS category. The DAACs may decide upon the format of the items (e.g., convert websites to PDF) while preserving the content. A good example of an archived mission web site can be found at https://podaac-tools.jpl.nasa.gov/drive/files/allData/aquarius/docs/AquariusMissionWebsiteContent.

2.10 Complex Instrument Assemblies

For complex instrument assemblies, in which one or more discrete instruments are closely coupled, the preservation content may be grouped (e.g., each category covers content for the entire assembly). However, it is important to ensure that the content in a category fulfills information for each instrument in the assembly. Examples of such assemblies are [AIRS, AMSU, HSB] which are treated as a package and ASTER which is an assembly of three instruments.

2.11 Flow of Preservation Artifacts

Figure 1 below shows the recommended flow of preservation artifacts from the individuals/groups that provide them to the archiving organizations (DAACs, ESDIS Library, NTRS) and from there to the end users who discover artifacts through the PCS Checklist. Specifics at individual DAACs may vary, but this figure represents the overall flow conceptually.

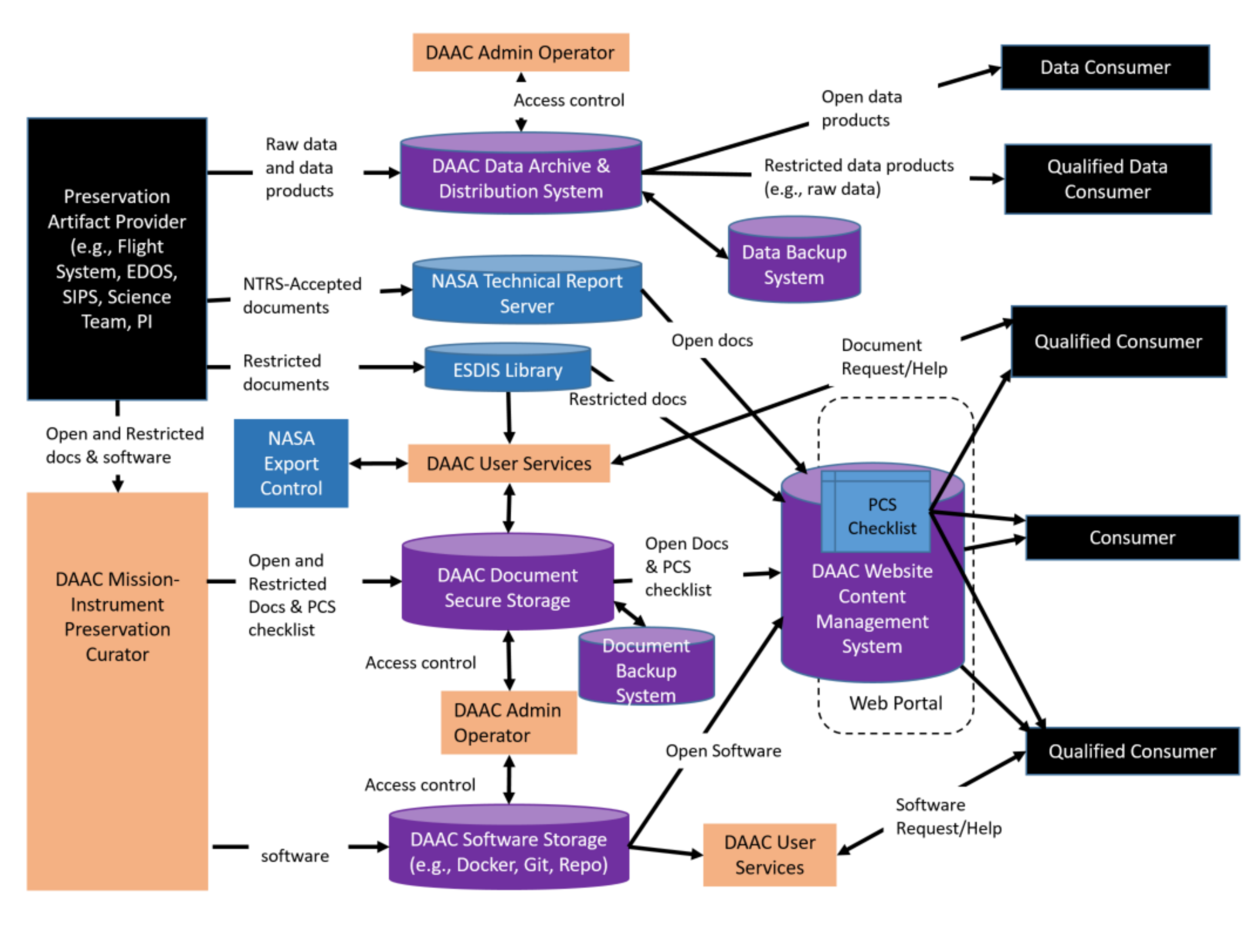

Figure 1. Recommended flow of preservation artifacts.

2.12 Long-term Care and Maintenance of Preservation Checklist and Artifacts

Subsections 2.5 through 2.11 have addressed actions to be taken during the lifetime of a project. To ensure usability well after the end of a project, the contents gathered for preservation require long-term care. Periodic review of the checklist should be conducted at least annually to ensure that all the information is up to date. There are some artifacts that could change over time, such as the ST members' names and roles (and ORCID when available), important journal publications, and calibration/validation information. Updates to gathered contents and checklist may need to be made by the assigned DAAC when any documentation gets updated, data reprocessing occurs and/or important user feedback becomes available. It would be useful to indicate, when the artifacts are entered in the checklist, which ones are likely to change in order to help focus attention on those artifacts during the periodic reviews. The assigned DAAC should occasionally verify that all the links to externally stored artifacts still work and update them as needed. If data centers other than the assigned DAAC hold some of the preservation artifacts and they plan to discontinue support for them, such items should be moved to the assigned DAAC. The assigned DAAC should communicate with partner archives to ensure that they inform the DAAC if they plan to remove any of the items they are archiving.

3 On-orbit / Satellite Missions

This section provides guidelines for preservation of items specific to large multi-organizational on-orbit/satellite missions. Different categories of items called for in the PCS are held by different organizations during a project's lifetime as illustrated in Figure 2 below. It is to be noted that during the operational phase when there is active acquisition of data and generation of derived data products there is a regular flow of data supported among the data acquisition and level 0 processing components of the Earth Science Mission Operations (ESMO) Project, the DAACs, the SIPS and Instrument Teams. In some cases, there are regular data flows between non-NASA and NASA organizations as well to support data product generation. Since such flows naturally result in data and metadata that need to be preserved, they pose less of an issue compared to other preservation content items such as pre-flight calibration, validation data, algorithm theoretical basis documents (ATBDs), etc. These other artifacts require attention at the proper times in the project life cycle so that they are gathered before the organizations and individuals responsible for them move on to other activities and hence become unavailable for consultation.

For satellite projects, there is often an assigned DAAC for each Earth science discipline-centric data product. When a lower-level data product is used as an input for the generation of a higher-level product archived at a different DAAC, then the DAAC's preservation specification for the higher-level product should reference and point to the partner DAAC as the assigned DAAC for the lower-level input product. In the case where multiple instruments are on the same platform or the same instrument is on multiple platforms one of the DAACs should be designated as the assigned DAAC for platform data and information, and the same or another DAAC should be designated as the assigned DAAC for the instrument data and information.

Below are additional best practices and guidance for satisfying specific requirements in each PCS category. The section numbers of the PCS document to which these guidelines apply are indicated in each of the following subsection titles.

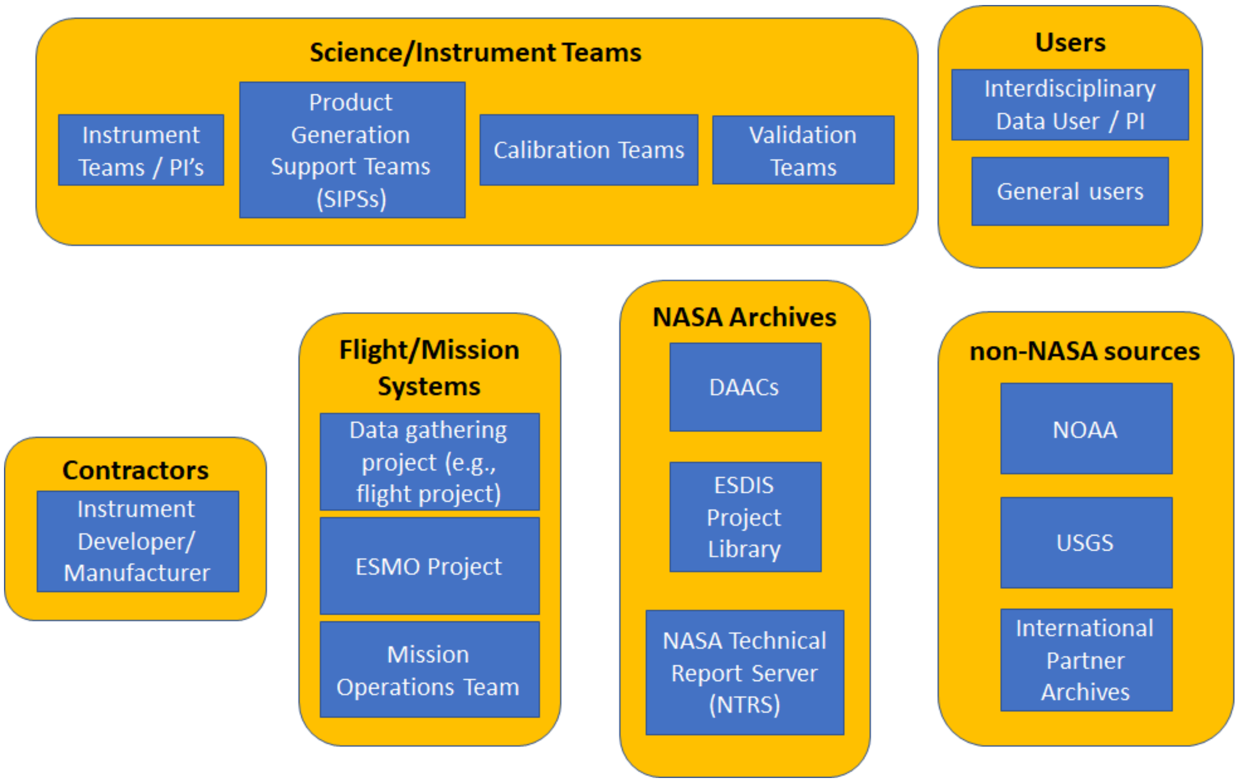

Figure 2. Organizations holding preservation contents during the life of a project. These contents must be gathered from these organizations for preservation.

3.1 Measuring Instrument/Platform Description - Guideline for PCS 3.1

(PCS 3.1.1 Instrument and Platform Description)

For projects with multiple instruments on a single platform such as the EOS Terra, Aqua and Aura, one of the DAACs should be designated early in the project lifecycle to serve as the assigned DAAC for platform descriptions and data. The assigned DAAC will preserve the mission and platform description, spacecraft telemetry and orbit and attitude data products. Other DAAC(s) that archive raw data and derived products from a particular instrument onboard the mission platform should still identify the description documents but provide links to them at the DAAC designated as the assigned DAAC for the mission. Similarly, in the case where discipline-specific higher-level products are archived at different DAACs, a single DAAC should be designated as the assigned DAAC for the measuring instrument raw and ancillary data products. This DAAC will need to work with the Flight Project, PI, and ST to identify and capture the instrument and platform description documentation.

The mission/platform descriptions are usually available from the Flight Project library and may include additional information from the PI in the form of requirements and specification documents. It should include content from the Flight Project or PI's website that gives overall summary description and specifications of the mission and instruments. The Platform and Instrument design and as-built material is often identified in the respective Critical Design Review (CDR) materials. Mission platforms and instruments often produce multiple types of documentation during their development. Often, document titles can be non-descript or misleading, and it becomes necessary to obtain copies for examination to see if they satisfy the requirement. It is best to preserve descriptions as close to the as-built capability as possible. The assigned DAAC should, at a minimum, identify and obtain or point to the mission CDR package and the instrument CDR package.

(PCS 3.1.2 Pre-flight/Pre-operational Instrument Calibration Data)

For pre-flight/pre-operational instrument calibration data there may be numeric instrument/sensor and platform characteristics captured, including pre-flight or pre-operational performance measurements (e.g., spectral response, instrument geometric calibration (geo-location offsets, platform location and pointing), noise characteristics, etc.). This data is often captured and included in mission and instrument description documentation and specifications, as-built data books and test results. It is important to indicate in the PCS checklist where the definitive pre-flight instrument calibration information is documented. On occasion, some mission/instrument may actually have digital data from test results that were used in on-orbit calibration product generation. In other cases, pre-flight calibration data may have been quickly outdated and replaced once the instrument was in orbit. In such cases, the entries in the PCS checklist corresponding to this section should indicate whether pre-flight calibration data was replaced by on-orbit calibration and why it is not needed for future use of the data.

3.2 Instrument and Science Data Products - Guideline for PCS 3.2

(PCS 3.2.1 Raw Data and Derived Products)

As indicated in section 3.1 above, one DAAC will be designated as the assigned DAAC for platform ancillary data, telemetry, and orbit and attitude data products. The same or another DAAC may be designated as the assigned DAAC for the raw instrument data and ancillary instrument data. If they are different DAACs, the instrument DAAC's PCS checklist should point to the platform DAAC which holds data used to perform calibration or geolocation.

Derived science data products include mission standard products as well as supplementary products generated by NASA-funded investigators associated with the mission. When there are multiple versions of derived science products archived at a DAAC the checklist should indicate which of the earlier versions remain in the archive and how these can be requested even though they may not be searchable or accessible through the DAAC data access website or the Earthdata Search client. In some cases, a trade-off may be needed between storage of higher-level data products and their re-computation from lower-level data. Either approach would satisfy preservation requirements. When feasible, it is preferable to store higher level products, at least in their final version. This would eliminate concerns about exact reproduction of the originally generated final version due to possible changes in operating environments. As indicated in the PCS [1], "If results reported in peer reviewed publications were based on earlier versions of the product, those versions or at least representative subsets of those versions should also be archived. At a minimum, the algorithm and software that generated such earlier versions should be archived. The mapping between the software versions and data versions should be preserved."

(PCS 3.2.2 Metadata)

The requirement here is for metadata that came from the PI/ST in the form of documentation and .met files that came with the data products. Metadata provided in separate files (e.g., ISO XML) should be preserved along with the product files. Metadata files and associated documentation from the PI/ST that was used by the DAACs to create CMR or DAAC metadata databases should be identified and included with the product documentation and product data. It is important to identify and archive versions of the metadata and documentation that correspond to the respective versions of the data product. The DAACs should look back at what PI/ST documentation they used to create the CMR and DAAC metadata and be sure it is included in the checklist. Metadata from the PI/ST is usually embedded within the data product files but can sometimes exist as separate files that go along with the data product files. In this case, the links between the data product files and the corresponding metadata files should be clearly noted and maintained.

3.3 Science Raw Data, Product and Algorithm Documentation - Guideline for PCS 3.3

(PCS 3.3.1 Science and Product Development Teams)

For help to potential future users, it is suggested to include the names and roles of as many science and instrument team members as possible. This section should also consider including a record of PI and ST meeting presentations and notes that report significant findings and decisions made during the course of the mission. As indicated in section 2.2 above, the information about the science and instrument team members may need to be updated over time, even in the post-mission phase, by the assigned DAAC.

(PCS 3.3.2 Product Requirements, Designs and Specifications)

NASA Projects such as the Earth Science Mission Operations (ESMO) Project are sources of artifacts for preservation of instrument and platform (e.g., spacecraft) descriptions and designs, raw and Level 0 data format and content documentation. Example artifacts include Spacecraft to Ground system ICDs and Instrument to Platform ICDs, and spacecraft and instrument telemetry handbooks which contain the bit-level format documentation of the raw science and platform data in the archive. The assigned DAAC should work with the PI/ST to identify the required artifacts and request a copy for archive by the DAAC, or in the case of designated sensitive or restricted artifacts the DAAC should request they be archived by the ESDIS Library. In the latter case, the DAAC PCS checklist should point to the artifact archived by the ESDIS Library.

(PCS 3.3.3 Processing and Algorithm Version History)

The assigned DAAC should obtain data version release notes and provide to users a document that maps each of the data product versions to the corresponding algorithm software versions. The mapping between the software versions and data versions should be preserved in the form of a table. The data version release notes should describe the changes made to the algorithm for each data product version. This information is generally available from the Science Investigator-led Processing System (SIPS) staff responsible for product generation.

In addition, DAAC announcements relating to new data product version releases should be compiled for preservation. These announcements will help future users by corroborating information found in release notes.

(PCS 3.3.4 Data Product Generation Algorithm)

The DAAC should secure a copy of the ATBD as well as any updates that explain version changes or documents that describe all the versions of products in the archive. The DAAC should already have data product user guides, which should describe the algorithm and product format and any separate metadata file formats. This documentation should cover the latest version of data products available for search and discovery as well as all previous versions archived at the DAAC. A tool is in development for creating, managing, and distributing ATBDs. This tool will be utilized by all new projects starting in 2022. Once the tool is in use, the assigned DAAC can obtain a DOI for the ATBD and include it in the PCS checklist.

(PCS 3.3.5 Product Quality)

The data quality requirement is partially satisfied by providing a list of journal publications that describe the overall data quality of the products. Other documentation that indicates data quality includes relevant test reports, data issue logs (known issues logs), and data reviews and appraisals available from the PI or instrument calibration team. Typically, the description of embedded information at the file level is documented in the product specification and user guides, including quality flags, and uncertainty fields. The PCS checklist quality section should indicate whether the quality information is embedded in the file level metadata and/or documented in the user guide or product specification, and how to access the quality information. Adding to the publication list over time to improve data quality information is an important maintenance activity. Information about validation and results of Calibration/Validation (Cal/Val) activities are important in characterizing data quality. They are covered in detail in section 3.7 of the PCS [1] and section 3.7 below.

(PCS 3.3.6 Product Applications)

Preservation of applications knowledge is also satisfied by providing a list of publications that describe various applications of the data products in operations and decision making. This list should also be maintained over time. In addition to publications, the DAAC should identify and preserve tools, applications, or workflows available from the PI/ST, as well as tools and applications developed by the DAAC, per UWG recommendations, which are actively in use by the PI/ST as examples of product applications. Also, user feedback about the data products that would be valuable to share with others should also be gathered and included.

3.4 Instrument Operation Events and Calibration - Guideline for PCS 3.4

(PCS 3.4.1 On-orbit, in-flight, in-the-field Calibration Method)

The method of calibration while in orbit may be captured in the Level 1 processing algorithm and by the instrument calibration or performance characteristics. The entries in the PCS checklist corresponding to this section should indicate when the method of calibration is documented as part of the Level 1 algorithm or when there are separate algorithms that generate lookup tables. The checklist should also indicate if the algorithm software contains embedded calibration data or requires ancillary input calibration data (e.g., spectral response, etc.)

For some instruments there may be specialized methods that involve pointing the instrument toward calibration targets (for radiometric or geolocation) and capturing and developing calibration information based on those observations. Documentation of any specialized calibration methods of this nature should be requested from the PI, ST, or designated instrument performance characterization teams (e.g., MODIS Characterization Science Team - MCST) and referenced in the PCS checklist. If a special calibration method description is included in the ATBD it should be indicated in the checklist as well.

Flight Projects provide periodic (e.g., monthly, quarterly, annual) flight status and anomaly reports summarizing platform and instrument operations events during the mission. These show the cause of significant impacts to science data coverage and quality. They also will indicate special calibration events. These reports should be requested from the Flight Project, retained as PCS artifacts, and referenced in the PCS checklist. The EOS Aura Spacecraft Status presentation prepared by the Aura Mission Director for the ESMO Project Status Reviews (PSRs) is an example for consideration. This periodic presentation provides a rolling summary of Aura spacecraft anomaly events, specific instrument anomaly events and solid-state recorder losses which result in packet loss for science data. In addition, the presentation summarizes Aura inclination adjustment, drag make-up and conjunction avoidance maneuvers as well as ground track errors, orbit maintenance, mean local time at Aura's ascending note which impact science data coverage and quality. Finally, the presentation identifies any operations errors which may have impacted science data coverage. Another example for consideration is the set of presentations by the Aura Mission Director for the periodic Mission Operations Working Group (MOWG) meetings. These presentations provide similar but somewhat higher-level rolling summaries of Aura spacecraft and instrument events, and content may be already included in the ESMO PSRs.

(PCS 3.4.2 Calibration Data)

For some missions, on-orbit calibration events may have resulted in special products, auxiliary or ancillary datasets which may have already been archived at the DAAC for preservation. In addition, there may have been cross-instrument calibration events which resulted in special products that have been archived at the DAAC. These specialized products and metadata should be identified in this section of the PCS checklist.

For some missions Cal/Val data and metadata are held separately from the DAAC that archives the data products (e.g., MCST holds MODIS Cal/Val data). For preservation of mission calibration, the DAAC should request this data and metadata from the project for preservation at the DAAC.

Data records about instrument and platform events (e.g., maneuvers) and ground system data acquisition records that account for data gaps should be identified in this section and archived by the assigned DAAC. Examples for consideration include spreadsheets, logs and data plots that were developed for tracking spacecraft and instrument operations performance and for preparing presentations for the Mission Director's Aura spacecraft and instrument status reviews.

3.5 Science Algorithm Software - Guideline for PCS 3.5

The DAAC should ask and/or encourage the PI and ST to obtain and include an open-source license agreement with the algorithm software source code. Other licenses such as user compliance agreements may be made available to users for acceptance. The DAAC may provide the license agreement to be accepted by the user before data distribution or may provide contact information so that the user can request and agree to software usage requirements or restrictions. Software should be accompanied by complete documentation as discussed in section 3.5 of the PCS [1].

The PCS checklist should indicate whether the algorithm software package contains ancillary input data or whether all of the input requirements are identified in PCS section 3.6.

3.6 Algorithm Input Data - Guideline for PCS 3.6

The PCS checklist for this section should identify all of the algorithm input data including ancillary data streams used in geophysical retrieval algorithm calculations. If the data is located at another archive the checklist should indicate which archive and provide organizational contact information. If the input data is included in the algorithm software packages, then the checklist should add a note that the algorithm input data is included in the algorithm package. If ancillary input calibration data is included in the calibration method documentation a note should be entered in this section that indicates the information required is provided within an artifact in another category. We want to avoid duplicate entries in the PCS checklist to minimize confusion. For example, if ancillary data is included in the calibration method documentation for section 3.4.1, then a note should be entered in section 3.6 to point to the appropriate artifact with the input data in section 3.4.1.

3.7 Science Data Product Validation - Guideline for PCS 3.7

Preservation of information about data product validation is usually satisfied by including a list of journal publications and reports (e.g., Product Assessment Reports), suggested by the PI or ST, that describe results of validation investigations or comparisons of derived parameters to independent observations. The ATBD listed in section 3.3. of the PCS Checklist many have science data product validation information. If this is the case, then there should be a note entry in section 3.7 of the checklist that points to the ATBD in section 3.3. A good example of science data product validation is the Aquarius Salinity Validation Analysis report produced by the mission Cal/Val team (e.g., http://dx.doi.org/10.5067/DOCUM-AQR02).

In addition, data from validation efforts may be identified by the PI/ST and archived by the DAAC. Validation data should be identified in this section of the PCS checklist along with documentation on data format and validation methods (i.e., documentation on algorithm or process for generating the validation data).

DAACs should periodically revisit data citations and research results, to determine whether to change or revise validation information.

3.8 Science Data Access and Analysis Tools - Guideline for PCS 3.8

Preservation of science data access and analysis tools is satisfied by reaching out to the PI, ST, and SIPS to ask for software tools they have built and used in the course of data quality monitoring, calibration, compliance checking and visualization (e.g., data readers, image creation, metadata and/or geophysical measurement monitoring, trending, and summaries). This is especially important for tools used with raw data, ancillary data, auxiliary data, calibration data and lower-level data products in the archive (for higher-level data products the DAAC will likely already have these tools, which will also need to be preserved). The DAAC should decide whether any of the additional tools would be useful and important for future data users, and if so, acquire a copy of the source code, build requirements, and release notes, and ask the PI, ST, or SIPS authors for permission to distribute or for obtaining an open-source license.

4 Airborne and Field Investigations

4.1 Overview of Airborne and Field Sub-category

The primary goal of preservation with respect to airborne and field investigations is to identify and retain the information, data and software needed to make the investigation data products useful to future researchers. This subsection identifies the types of documents that may apply to the various PCS sections for investigations. Each DAAC is advised to consult with the Airborne Data Management Group (ADMG, see https://earthdata.nasa.gov/esds/impact/admg) and ESDIS to determine the most appropriate compliance level for a specific investigation based on the investigation's type presented in Section 1.1.

Since airborne and field investigations are more heterogeneous than satellite missions, they can be quite complex. The details from many instruments on multiple airborne and ground platforms as well as additional support data - such as that from satellites and models - require time-consuming effort to gather and organize in a manner that clearly presents the items to data users. Limited investigation funding as well as limited DAAC- and scientist-time restricts the degree to which required preservation materials can be obtained and made available.

The following table identifies potential documents that may contain the needed information for each preservation specification element. The documents listed should be considered as vital to secure by the time of investigation completion. If any of the listed documents are not available, then the content of those documents must be identified and gathered from other sources where possible by the DAAC. The documents listed in Table 4 should be collected for currently active and future investigations. Preservation activities for historical investigations present significant challenges as many of the documents may not exist or cannot be located. Therefore, historical data products are not typically expected to comply with the PCS requirements.

4.2 Applicable Airborne and Field Investigation Documents

The following table shows the airborne and field investigation documents that apply to the various sections of the PCS.

Table 4. Applicable Airborne and Field Investigation Documents by PCS Section

Content Specification Section	**Possible Document(s) with needed information content and additional guidance**
3.1.1 Instrument and Platform Description	Instrument and platform information is most often summarized in the investigation DMP. The Platforms can be covered first with information about what instruments were contained onboard. Each instrument should then be covered with sufficient detail to meet the specification and compliance level. Other documents with additional information include: Permanent land station histories and detailed field station documents containing station location (latitude/longitude), station common name, instruments installed, photos of the station location if available, and operation status. In the case of human data collection, documents identifying collection protocols are also important to retain. Instrument-specific publications may contain additional information that meets the requirement. Information about the platform an instrument is operated on is required for airborne data. Should an instrument operate on multiple platforms during the investigation, the information as to when the switch from one platform to another occurred should be noted and retained as required information.
3.1.2 Pre-flight/ Pre-operational Instrument	N/A. Most often there is no pre-deployment calibration data such as that for satellite instruments. If a particular airborne or field

Content Specification Section	Possible Document(s) with needed information content and additional guidance
Calibration Data	instrument does require pre- and post-flight or pre- and post-deployment calibration, the DAAC should gather the information from the instrument team and preserve it.
3.2.1 Raw Data and Derived Products	All investigation data products are to be delivered to the assigned DAAC and preserved, including Level 0 and Level 1 data that may not be often requested by users. There is also the need to preserve platform information and data products. Examples of platform data include navigation, air temperature, atmospheric pressure, video camera data. Platform information includes details of the aircraft, ship, automobile, or field site and can include still images of a field site, the tail number of the aircraft, or images of the flight tracks plotted in the deployment region. Derived data products may, on occasion, be auto-generated on demand by the user via a DAAC investigation-specific tool. In this case, the tool description and software should be preserved.
3.2.2 Metadata	Data products from airborne and field investigations are often produced by separate instrument PIs participating in the investigation. The data product metadata is often contained within the data files. However, if the data are stored in plain text or binary files, the DAAC should work with the PIs or the investigation data manager to develop an additional metadata document to be stored with the data or to translate the data product to a self-describing file format. It is required for data discovery that the investigation short name be added to the collection and file metadata. Though not listed in the PCS, the field station instrument operation status, which may be provided as a figure or table showing instrument operation during each deployment, is an important item to preserve. The operation status can allow future users to distinguish between missing data due to instrument performance or

Content Specification Section	Possible Document(s) with needed information content and additional guidance
	missing data due to failure to capture and retain the needed files.
3.3.1 Product Team	The investigation team is identified, with roles, in the Investigation DMP and the IIP. Since the DMP is a living document, any changes in the investigation team should be noted.
3.3.2 Product Requirements and Designs	It is uncommon to have design requirements for individual instruments in an investigation. If available, the information will be located in the DMP and the IIP. Preservation of these documents should meet the specification.
3.3.3 Processing and Algorithm Version History	For each instrument in which raw data are processed to create data products, the algorithm information and processing methodology description must be retained. This may be presented in the DMP and references therein, or can be found in individual instrument ATBDs or journal publications.
3.3.4 Data Product Generation Algorithms	For each instrument in which data are processed to create data products, the algorithm information (ATBDs) and processing methodology description must be retained. This is commonly presented in the DMP and references therein, or in specific journal articles describing the instrument.
3.3.5 Product Quality	The DMP should contain data quality information for each instrument. Publication citations for the instruments flown in an investigation should be included in the DMP as many instruments used have participated in previous investigations. The DAAC must add post-investigation publication references when available at a later time that address instrument and data product quality for that specific investigation.
3.3.6 Product Application	The DAAC should collect publications made during the project or in the post-investigation years that address the use and application of the investigation data products. Also, user feedback about the data

Content Specification Section	**Possible Document(s) with needed information content and additional guidance**
	products that would be valuable to share with others should also be gathered and included.
3.4.1 Calibration Method	The Investigation DMP will contain a description of the methodology or the instrument PI should provide a publication reference that contains the calibration methodology information, as appropriate.
3.4.2 Calibration Data	If an airborne instrument does require calibration, the DAAC should gather the data from the team and preserve it. Data logging aircraft operation is vital to onboard instrument data use. Therefore, flight logs, forward-looking camera images and videos, aircraft instrument operation logs, science logs, and aircraft data (flight speed, altitude, pressure, external temperature, etc) should be preserved and included in the PCS checklist.
3.5 Science Algorithm Software	Any software utilized to create investigation data products must be provided to the DAAC under open data and open source policies. (https://earthdata.nasa.gov/collaborate/open-data-services-and-software)
3.6 Science Data Product Algorithm Inputs	Ancillary data used in creating a data product should be stored with the data product unless it is available from another permanent archive facility.
3.7 Science Data Product Validation	DAACs should collect references of individual instrument or data product publications and the primary investigation overview publication, if there is one. Publications such as these may discuss intercomparisons of values from multiple instruments made during the investigation.
3.8 Science Data Access and Analysis Tools	If the data products are in a self-describing format, no special tools or software are needed. It is highly important that if the data product is not in a standard, self-describing format the needed software or tool for accessing and using the data must be preserved

Content Specification Section	Possible Document(s) with needed information content and additional guidance
	with any relevant documentation. Also, if any special software is developed for utilizing or visualizing investigation data, that should be preserved as well if it is not located at the DAAC.
3.9 Deliverables Checklist	A checklist must be publicly available at the assigned DAAC for the entire investigation, but may be organized as separate checklists for individual instruments or platforms, as needed.

4.3 Airborne and Field Investigation Items to Preserve

The following table shows the required items to be preserved from airborne and field investigations, along with the rationale for preservation, the sections in the PCS that apply to those items and a few examples of documents that contain such items.

Table 5. Required Airborne and Field Investigation Items to Preserve

Required Item to Preserve	Why does this document need preservation	Applicable PCS elements	Document Example
Data Management Plan (DMP)	Describes data handling in detail from instrument or human observation to data product delivery to DAAC. Follows the DMP Template for Data Producers	3.3.1 - 3.3.5 3.4.1	Most DMPs are currently not publicly available. To comply with the new OSS requirements, they must now be made public at the DAAC. One older example of a DMP created using an older DMP template is the HS3 DMP
Investigation Implementation	Describes the investigation details required for approval to carry out the	3.3.1 and 3.3.2	ABoVE

Required Item to Preserve	Why does this document need preservation	Applicable PCS elements	Document Example
Plan (IIP)	investigation. The IIP may not necessarily be public, but contains valuable content that the DAAC may need to extract and preserve.		Implementation Plan
Investigation Reports	Allows a user to determine what events happened during a flight (flight report) or what important science of the day occurred (science report) or the weather forecast for the day (weather report). May include other relevant reports produced during investigation operation.	3.4.2	OLYMPEX Investigation Reports published as a Data Product
Investigation Catalog	Such a catalog contains all flights/trips conducted by a mission, along with fundamental metadata of the flights/trips (e.g., date, location, weather condition, purpose of the flight/trip, notes, etc.) and links to both brief and detailed flight/scientific reports associated with each flight/trip. Such a catalog provides a high-level overview and useful contextual information for understanding the airborne/field mission in the future.	3.4.2	Investigation Catalog for ACT-America
Field station names and locations	Many investigations have multiple field locations. A table, list or document containing the site reference name, latitude/longitude location, and instruments at that location should be obtained from the team if the information exists. This table can also link to relevant data products when	3.4.2	OLYMPEX Ground Station Locations

Required Item to Preserve	Why does this document need preservation	Applicable PCS elements	Document Example
	presented by the DAAC to users.		
Individual instrument operations log or timeline	Often, an investigation has some type of summary table or timeline for field instrument operation. Projects are highly encouraged to create this for preservation. The table may contain instrument, site names and locations, date placed and removed, operation status by date, and notes on operation issues	3.4.2	Example field station operations log
Aircraft Videos	NASA aircraft often have a forward, mid, and/or rear-facing video cameras used to record images of the atmospheric environment during flight. Future examination of these movies can help scientists understand the conditions the aircraft flew in at the time instrument measurements were obtained.	3.4.2	Aircraft videos are archived by one DAAC as a facility instrument. The collection contains all videos from all NASA aircraft. It is recommended that the investigation DAAC point to the videos for the investigation at the DAAC holding all videos. If a non-NASA aircraft was flown, air video for that aircraft should be archived as a data product with the rest of the investigation data.

4.4 Presentation of Preservation Materials

Due to the complexity of airborne and field investigations, there is a large quantity of information needing preservation. Organization of all the material can be quite difficult. The goal should be to find a way to present the information as clearly as possible. DAACs can choose whatever manner provides the best clarity for a given investigation. Examples of organization are: 1. by instrument (and resulting data products); 2. by platform (and the instrument data and derived products associated with that platform), or 3. by data product type (such as grouping the various aerosol data products, meteorological products, and support data products). Other styles of organization may also be suitable depending on the type of project.

For the most part, organizing by instrument seems to work best for smaller investigations. One example of the preservation material for an airborne and field investigation is that for the Hurricane and Severe Storm Sentinel (HS3) investigation, one of the first Earth Venture Suborbital missions. This investigation was small, consisting of only 2 aircraft of the same type with 3 different instruments on each aircraft. The preservation items are available at the Global Hydrology Resource Center (GHRC) DAAC. In this simple example, GHRC chose to organize the checklist information as a separate table for each instrument.

This approach would likely be rather difficult for much larger investigations with many more instruments. An example of a larger oceanographic field investigation is the Salinity Processes in the Upper Ocean Regional Study (SPURS). The SPURS data and information are at the Physical Oceanography DAAC. Much useful content is located on the server. But the content is not presented to the users in a manner that identifies which documents provide the information for which of the preservation specifications.

4.5 Unique Cases

There are a variety of special cases that may have information that is difficult to obtain or may require special handling and organization. In each unique case listed below, variances in adherence to the PCS requirements listed in Table 1 may be necessary.

Non-public Low-Level Data: Raw, or Level 0 (L0) data products may exist for some airborne or field instruments, which are used to develop higher level data products. At times, these L0 data products may not be available to the public for data access or may be available on request only. The assigned DAAC will need to note the existence of such data at the DAAC, the status of the L0 data (available on request or not available), and what data products the non-public data are used for. It is important for the DAAC to ensure that the low-level data retained are self-describing, or that software/code needed to read the data is stored with the data to satisfy future reprocessing needs.

Extremely Large Investigations: While most field investigations are typically much smaller than satellite programs as far as data volume, multi-organization investigations that occur sporadically over many years and involve more than 25 instruments can be quite cumbersome to organize and present. In addition, the time needed to collect the preservation content artifacts for a large collection of instruments may be unsupportable given the limited funding of investigations. This may mean that only the most necessary items are collected and provided in the checklist. However, the assigned DAAC should note in the PCS checklist any helpful information that is known and indicate that an artifact was not located and collected. With large multi-organization investigations, NASA may contribute in a specific way that does not provide full data services to the investigation data products, in which case, the DAAC is not required to meet the content specification or may need to gather and send appropriate information and documents to a non-NASA organization for preservation.

Data at Multiple DAACs: There are cases in which data products from an investigation are archived at two or more DAACs. Coordination for airborne and field instrument data at multiple DAACs requires cooperation of all personnel involved at the DAACs and coordination of preservation content gathering and organization. Depending on the size, complexity, and value of the investigation data, a DAAC may be assigned, or each DAAC would simply be advised to gather the content artifacts to store with the relevant data at the DAAC. If there is any question about which DAAC is responsible for organizing specific preservation contents, the DAACs involved should consult with the ESDIS Project. .

Facility Instruments: There are frequently-flown instruments that contribute valuable data to multiple focus areas. These are referred to as “facility instruments” (FI, such as AVIRIS-NG) or “major airborne instruments” (MAI, such as AJAX). The primary difference between these two categories of instruments relates to the funding mechanism and the request system for including the instrument in an investigation. For both FIs and MAIs, all data acquired by the instrument is stored together at one DAAC, called the *instrument* DAAC. In contrast, a DAAC that archives data products for an investigation is called the *investigation* DAAC*.* An *investigation* DAAC should identify the instrument data pertaining to the investigation and link to the data at the *instrument* DAAC. It is advisable that the *instrument* DAAC work with each *investigation* DAAC to provide links for instrument preservation content artifacts and a PCS checklist for the instrument that the *investigation* DAAC can utilize in its *investigation* PCS checklist. Thus, the *investigation* DAAC maintains the *investigation* PCS checklist that contains links to the relevant instrument data and preservation content held at the *instrument* DAAC. Any flight logs for a given investigation are to be preserved at the *investigation* DAAC. The instrument DAAC may wish to archive flight logs for flights that occur which are not associated with a specific investigation. Instrument logs should be preserved at the *instrument* DAAC.

5 Data Producing Activities

5.1 Overview of Data Producing Sub-category

Creation of data products is another category that has unique implementation guidance. A current example is the Making Earth System Data Records for Use in Research Environments (MEaSUREs) Program, which has funded several data producing activities. Some of these data producing activities create merged products using data from multiple instruments over time. Thus, the materials needing to be preserved extend beyond the specifics of the merged product created, but also include details of every component included in the merged product. If the components leading to a merged product have been well documented and preserved elsewhere, the preservation of content for the data producing activity can consist of identifying and preserving pointers to any existing component documentation and data. In cases where the component information is not preserved, best efforts should be made to provide sufficient information about the components to ensure future users' understanding of the merged product.

5.2 Applicable Documents

The following table provides suggested information location and additional guidance for this category of data products. The primary documents containing information needed to meet the specifications are the DMP and the data product guide which may have various names depending on the DAAC. Names for a data product guide can include "User's Guide", "Read Me" or "Read-Me".

Table 6. Applicable Data Producing Activity Documents by PCS Section

Content Specification Section	**Possible Document(s) with needed information content and additional guidance**
3.1.1 Instrument and Platform Description	DMP should include information about the instruments and platforms that are used for the data producing activity. Typically, since the data producing activity uses data from well documented instruments and platforms, citations/references to the corresponding documentation will suffice.
3.1.2 Pre-flight/ Pre-operational Instrument Calibration Data	Generally not applicable. However, if calibration data have been used in the activity, such data should be delivered to the DAAC for preservation.
3.2.1 Raw Data and Derived Products	The derived products resulting from the data producing activity should be delivered to the assigned DAAC and preserved.
3.2.2 Metadata	The DAAC and the PI of the data producing activity should determine content and organization of metadata before product generation is started. Metadata should be embedded in the data product files themselves. There may be a need for separate metadata files that go along with the data product files. In that case, data product files and the corresponding metadata files should reference one another and both file types must be preserved.

Content Specification Section	Possible Document(s) with needed information content and additional guidance
3.3.1 Product Team	The DMP should include details about the product team.
3.3.2 Product Requirements and Designs	Funded data producing projects should develop a detailed DMP that contains sufficient information to meet 3.3.2, in which case the DMP is all that is needed. If the DMP does not describe the design and product requirements, then the appropriate sections of the proposal and cooperative agreements should be extracted and preserved.
3.3.3 Processing and Algorithm Version History	Each data product version delivered to the DAAC should be accompanied by a description of the rationale for creating the version and how it differs from the previous version(s). A data product guide developed by the DAAC, and project investigators may provide this information.
3.3.4 Data Product Generation Algorithms	The DMP contains the algorithm descriptions with more detailed information in associated ATBDs. There may also be peer-reviewed articles that contain algorithm description and validation. The algorithm descriptions preserved must match those used to generate the data product.
3.3.5 Product Quality	The data product guide should contain product quality checks, flags and other quality information, including citations of publications covering quality assessment procedures and results. It is important to recognize that some quality information may be determined after preservation materials have been gathered. When such quality information becomes available, the DAAC should include it in an update to the data product guide and note it in the PCS checklist.
3.3.6 Product Application	The DAAC should collect articles, published during the activity or in the years after the activity is completed, that address use of the activity's data products.

Content Specification Section	**Possible Document(s) with needed information content and additional guidance**
3.4.1 Calibration Method	The data product guide may provide this information, including citations of publications containing calibration method description.
3.4.2 Calibration Data	Any data used for calibration (e.g., cross-calibration of data from multiple instruments or the same instrument on different platforms) should be delivered to the DAAC for preservation.
3.5 Science Algorithm Software	Whatever software is utilized in creating the project's data products must be provided to the DAAC under the open data and open source policies (https://earthdata.nasa.gov/collaborate/open-data-services-and-software)
3.6 Science Data Product Algorithm Inputs	Data producing activities utilize existing data products to develop a new data product. The component input data links should be included in the metadata of the new data product. Ancillary data used in creating a data product should be stored with the data product unless it is available from another permanent archive facility.
3.7 Science Data Product Validation	DAACs should list references to publications that cover the data product validation. The DAAC should maintain and add to the list over time.
3.8 Science Data Access and Analysis Tools	Many of the higher-level (Level 1 and above) data products archived by the assigned DAAC are in standard HDF format (a self-describing format), and standard tools (i.e., software libraries) for reading the archived data are expected to be available and maintained by The HDF Group to ensure long-term access. Similarly, other standard formats (e.g., netCDF, GeoTIFF) have access tools and documentation available and maintained for the long-term by programs and organizations external to NASA. We expect these programs to continue to support the tools necessary for access to archived data products. Currently they do not need to

Content Specification Section	Possible Document(s) with needed information content and additional guidance
	be identified here or preserved by the DAACs. However, data access tools that were developed as specific examples for the archived data products (e.g., readers, visualization, and analysis tools) should be identified in this category and preserved by the assigned DAAC. It is highly important that if the data product is not in a standard, self-describing format, the needed software, or tool for using the data must be preserved. Also, if any special software is developed for utilizing or visualizing project data, that should be preserved as well.
3.9 Deliverables Checklist	A checklist must be publicly available at the assigned DAAC for each data producing activity whose data products are assigned to the DAAC. In the cases where an activity generates multiple products, the DAAC may decide to maintain a single checklist or more than one checklist as required to best identify the preservation content for each data product.

6 Commercial Smallsat Data Acquisition Program

The Commercial Smallsat Data Acquisition (CSDA) Program purchases small portions of data from select commercial vendors and reviews such data for value to NASA research objectives. If the data products pass review, a greater quantity of data is purchased through a special CSDA agreement with the commercial vendor. These data products may have limited documentation and may not meet all PCS requirements. Some of the PCS items may be proprietary for the vendors and need to be considered so that the agreements with the vendors are adhered to. At the very least, the CSDA program should be able to supply information for PCS items: 3.1.1, 3.2.2, 3.3.5, 3.3.6, and 3.9. Each vendor agreement is different and may permit more or less PCS items to be collected. The best information for the commercial products will be the data product user guide and any commercial vendor information. Linkages to the commercial vendor websites with more information should be made clear to all CSDA Program data users. It is recommended that agreements with the vendors include details of how (and which items) the vendors will comply with in the PCS document.

7 Citizen Science for Earth Science Program

The Citizen Science Data Working Group, in support of the NASA's ESDS Program, has developed a white paper [5] that covers data archiving and preservation aspects of Citizen Science data in addition to several other topics. Section 3.5 of [6] provides guidelines for data preservation and examples of preservation artifacts for citizen science projects. A future version of the current document (i.e., the PCS Implementation Guidance) will address more details on how to apply the PCS to Citizen Science data, based on experience with currently funded projects under the Citizen Science for Earth Science Program (CSESP).

8 References

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[2] NASA, "Earth Science Data Systems Level of Service Model," 22 April 2020. [Online]. Available: https://earthdata.nasa.gov/collaborate/new-missions/level-of-service. [Accessed 10 August 2021].

[3] H. Ramapriyan, G. Peng, D. Moroni and C.-L. Shie, "Ensuring and Improving Information Quality for Earth Science Data and Products," *D-Lib Magazine,* vol. 23, no. July/August 2017 Number7/8, 2017.

[4] NASA, "Scientific Information policy for the Science Mission Directorate," 4 August 2021. [Online]. Available: https://science.nasa.gov/science-red/s3fs-public/atoms/files/Scientific%20Information%20policy%20SPD-41.pdf. [Accessed 14 January 2022].

[5] NASA, "Citizen Science Projects - NASA ESDS Citizen Science Data Working Group White Paper," 24 April 2020. [Online]. Available: https://science.nasa.gov/citizenscience. [Accessed 10 August 2021].

[6] H. K. Ramapriyan, "Data Management Standards and Best Practices for NASA-sponsored Citizen Science Investigations," 29 January 2018. [Online]. Available: https://wiki.earthdata.nasa.gov/download/attachments/131662879/DM%20Stds%20and%20Best%20Practices%20for%20NASA%20CSESP-20180129.docx?api=v2. [Accessed 10 August 2021].

9 AUTHORS' ADDRESSES

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Appendix A. Abbreviations and Acronyms

ADMG	Airborne Data Management Group
ATBD	Algorithm Theoretical Basis Document
Cal	Calibration
CCSDS	Consultative Committee for Space Data Systems
CDR	Critical Design Review
CSDA	Commercial Smallsat Data Acquisition (Program)
CSESP	Citizen Science for Earth Science Program
DAAC	Distributed Active Archive Center
DMP	Data Management Plan
DOI	Digital Object Identifier
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
ESA	European Space Agency
ESDIS	Earth Science Data and Information System (Project)
ESDS	Earth Science Data Systems (Program)
ESMO	Earth Science Mission Operations (Project)
FI	Facility Instrument
GES DISC	Goddard Earth Science Data and Information Services Center
GHRC	Global Hydrology Resource Center
ICD	Interface Control Document
IIP	Investigation Implementation Plan
ITAR	International Traffic in Arms Regulations
MAI	Major Airborne Instrument
MEaSUREs	Making Earth System Data Records for Use in Research Environments
MOWG	Mission Operations Working Group
NOAA	National Oceanographic and Atmospheric Administration
NSIDC	National Snow and Ice Data Center
NTRS	NASA Technical Reports Server
PCS	Preservation Content Specification
PI	Principal Investigator
PSR	Project Status Review
SIPS	Science Investigator-led Processing System
ST	Science Team
STI	Scientific and Technical Information (Program)
USGS	United States Geological Survey
UWG	User Working Group
Val	Validation

APPENDIX B. PCS CHECKLIST SAMPLE

The following table shows a sample PCS checklist, which can be used as a template for checklists for other instruments and data products. Also, a template has been provided at ESDIS EOSDIS Preservation Plans & Status (https://wiki.earthdata.nasa.gov/x/7xYECg), and will be kept updated if changes are needed.

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
3.1	***Measuring Instrument Description***								
3.1.1	Instrument and Platform Description								
	Aura Platform	Aura Spacecraft Delta Critical Design Review Data Package, Vol 2, 3, 5, 6, 7, 8, 9, TOC, Presentation. Doc Number 12443, 12444, 12447, 12448, 12449, 12450, 12451, 12452, 12453	GSFC EOS CHEM	9/12/2000		PDF	TBS	ESDIS Library	
	Aura Platform	Aura Spacecraft Delta Critical Design Review Data Package, Vol 4. Doc Number 12446	GSFC EOS CHEM	9/14/2000		PDF	TBS	ESDIS Library	
	Aura Platform	Aura Spacecraft Software Delta Critical Design Review Data Package, Vol 5. Doc Number 12446	GSFC EOS CHEM	11/1/2000		PDF	TBS	ESDIS Library	
	Aura Platform	Aura Project Master Command and Telemetry Database Overview, Doc Number 12460	GSFC EOS CHEM	9/15/2000		PDF	TBS	ESDIS Library	
	Aura Platform	Aura Spacecraft Critical Design Review	GSFC EOS CHEM			PDF	TBS	ESDIS Library	

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
	Aura Platform	EOS Chemistry Presentation includes configuration deployed, Isometric View, Instrument Layout, Instrument Field of View, Doc Number 14111	GSFC EOS CHEM	4/30/2003		PDF	TBS	ESDIS Library	
	Aura Platform	EOS Aura Mission Operations Working Group Presentation	GSFC EOS CHEM	9/14/2000		PDF	TBS	ESDIS Library	
	Aura Platform	Unique Instrument Interface Document (UIID) for the Tropospheric Emissions Spectrometer, Doc Number 424-28-26-02	GSFC EOS CHEM	4/1/1998		PDF	TBS	ESDIS Library	
	TES Instrument	TES Mission OPS Requirements Document (D-17848)	JPL						
		TES Flight Rules and Operational Constraints, V0.7 (D-17894)	JPL						
	TES Instrument	Interface Control Document for the Tropospheric Emission Spectrometer (D-26478)	TRW	6/30/1998		PDF	TBS	ESDIS Library	
	TES Instrument	Tropospheric Emission Spectrometer Scientific Objectives & Approach, Goals & Requirements (D-11294)	JPL	4/14/1999		PDF	TBS	ASDC	
		TES Mission Plan (D-28402)	JPL	04/10/04				JPL	
		TES Mission Planning Requirements (D-29096)	JPL	06/16/04				JPL	
	TES Instrument	Tropospheric Emission Spectrometer Critical Design Review Vol1 (D-17861)	JPL	6/29/1999		PDF	TBS	JPL	
	TES Instrument	Operations Concept for the TES Mission Operations, Doc Number 01-2116	JPL			PDF	TBS	NTRS	
	TES Instrument	Infrared Detector Assemblies for the Tropospheric Emission Spectrometer, Doc Number 00-0495	JPL			PDF	TBS	NTRS	
	TES Instrument	Optics Error Budget Review	JPL	1/12/2000		PDF	TBS	NTRS	

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
3.1.2	Pre-flight/Pre-Operational Calibration Data								
		TES pre-flight calibration "TES Project Overview" presentation, Doc Number 03-2759	JPL			PDF	8/24/2013	NTRS	
		INSTRUMENT Cal and Val (Ver) Test Plans V1.0	JPL	12/04/01		PDF	TBS	ASDC	
		TES Instrument Calibration Report, Vol 1 (D-26533)	JPL	9/26/2003		PDF	TBS	ASDC	
3.2	***Instrument and Science Data Products (Data)***								
3.2.1	Raw Data and Derived Products								
	Level 0	TES Level 0 standard data files, APID 1680-1689, 1698, 1701-1706	GSFC ESMO			CCSDS PDS		ASDC	
	Level 0	TES Level 0 expedited data files, APID 1664-1671, 1676-1687	GSFC ESMO			CCSDS EDS		ASDC	
	Level 1	TES Level 1 product files, R15	JPL SIPS		https://asdc.larc.nasa.gov/project/TES	HDF5		ASDC	
	Level 2	TES Level 2 product files, R15	JPL SIPS		https://asdc.larc.nasa.gov/project/TES	HDFEOS 5		ASDC	
	Level 3	TES Level 3 product files, R15	JPL SIPS		https://asdc.larc.nasa.gov/project/TES	HDFEOS 5		ASDC	

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
3.2.2	Data Product Metadata								
		A file for each TES Level 1-3 data product file	JPL SIPS		https://asdc.larc.nasa.gov/project/TES	XML		ASDC	
3.3	***Science Raw Data and Derived Product Documentation***								
3.3.1	Instrument and Science Team								
		Team members are identified in "TES Processing Plan (Early Post-Launch Processing)" (D-27905)	JPL	09/08/04		PDF		ASDC	
3.3.2	Data Product Requirements and Designs								
	Level 0	TES Level 0 data format, "EOS Common Spacecraft Program ICD between the EOS Aura Spacecraft and the EOS Ground System", Revision C.1, Doc Number 428-ICD-007	GSFC ESMO	10/22/2001		PDF	TBS	ESDIS Library	
	Level 0	TES Level 0 data formats, "Interface Control Document between EOS Data and Operations System (EDOS) and the EOS Ground System Elements Revision 7, Doc Number 428-ICD-EDOS/EGS	GSFC ESMO	10/1/2019		PDF	TBS	ESDIS Library	
	Level 0	TES Level 0 data formats: TES Command & Telemetry Handbook Version 2	JPL	1/10/2000		PDF	TBS	ESDIS Library	

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
		ICD between ECS and SIPS, Volume 10, TES Data Flows, Doc Number 423-41-57-10, Revision D	GSFC ESDIS	1/1/2017		PDF	TBS	ESDIS Library	
		TES Level 1A, 1B, 2 and 3 Algorithms Scientific Goals and Rqts, D-17864	JPL	7/20/1999		PDF		ASDC	
		TES Level 3 Algorithms, Requirements and Products, D-26534	JPL	4/20/2005		PDF		ASDC	
		TES Data Product Specification V6.0 R6.4 (D-22993)	JPL	12/10/04	https://asdc.larc.nasa.gov/documents/tes/readme/TES_DPS_V6.0.pdf	PDF	10/1/2020	ASDC	
		TES Data Product Specification V7.0 R7.0 (D-22993)	JPL	3/17/2005	https://asdc.larc.nasa.gov/documents/tes/readme/TES_DPS_V7.0.pdf	PDF	10/1/2020	ASDC	
		TES Data Product Specification V8.0 R8.0 (D-22993)	JPL	9/7/2005	https://asdc.larc.nasa.gov/documents/tes/readme/TES_DPS_V8.0.pdf	PDF	10/1/2020	ASDC	
		TES Data Product Specification V9.0 R9.0 (D-22993)	JPL	12/13/2005	https://asdc.larc.nasa.gov/documents/tes/readme/TES_DPS_V9.0.pdf	PDF	10/1/2020	ASDC	
		TES Data Product Specification V9.1 R9.3 (D-22993)	JPL	5/24/2006	https://asdc.larc.nasa.gov/documents/tes/readme/TES_DPS_V9.1.pdf	PDF	10/1/2020	ASDC	

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
		TES Data Product Specification V10.11 R10.0 (D-22993)	JPL	2/21/2007	https://asdc.larc.nasa.gov/documents/tes/readme/TES_DPS_V10.11.pdf	PDF	10/1/2020	ASDC	
		TES Data Product Specification V10.13 R10.0 (D-22993)	JPL	4/26/2007	https://asdc.larc.nasa.gov/documents/tes/readme/TES_DPS_V10.13.pdf	PDF	10/1/2020	ASDC	
		TES Data Product Specification V11.8 R11.1 (D-22993)	JPL	6/5/2008	https://asdc.larc.nasa.gov/documents/tes/readme/TES_DPS_V11.8.pdf	PDF	10/1/2020	ASDC	
		TES Data Product Specification V11.9 R11.3 (D-22993)	JPL	5/26/2009	https://asdc.larc.nasa.gov/documents/tes/readme/TES_DPS_V11.9.pdf	PDF	10/1/2020	ASDC	
		TES Data Product Specification V12.0 R12.0 (D-22993)	JPL	11/30/2010	https://asdc.larc.nasa.gov/documents/tes/readme/TES_DPS_V12.0.pdf	PDF	10/1/2020	ASDC	
		TES Data Product Specification V13.0 R13.0 (D-22993)	JPL	06/19/13	https://asdc.larc.nasa.gov/documents/tes/readme/TES_DPS_V13.0.pdf	PDF	10/1/2020	ASDC	
		TES Data Product Specification V14.0 R14.0 (D-22993)	JPL	08/03/15	https://asdc.larc.nasa.gov/documents/tes/readme/TES_DPS_V14.0.pdf	PDF	10/1/2020	ASDC	

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
		TES Data Product Specification V15 (D-22993)	JPL	3/18/2019	https://asdc.larc.nasa.gov/documents/tes/readme/TES_DPS_R15.pdf	PDF	10/1/2020	ASDC	
	Level 2	TESDataUsersGuideV7 (D-38042)	JPL	9/27/2018	https://eosweb.larc.nasa.gov/project/tes/guide/TESDataUsersGuideV7_0_Sep_27_2018_FV-2.pdf	PDF	10/1/2020	ASDC	
	Level 2	TES Data Users Guide V8 (D-3042)	JPL	3/27/2020	https://asdc.larc.nasa.gov/documents/tes/guide/TESDataUsersGuideV8_0_March_27_2020_FV-8_rh.pdf	PDF	10/1/2020	ASDC	
	Level 3	TES Level 3 Data Plot Users Guide V1 (D-41884)	JPL	12/17/2007	https://asdc.larc.nasa.gov/documents/tes/guide/TES_L3_Data_Users_Guide.pdf	PDF	10/1/2020	ASDC	
3.3.3	Processing and Algorithm Version History								
		TES Processing Plan (early Post-Launch Processing) (D-27905)	JPL		-	PDF		ASDC	
		TES GDS Science Data Management Plan V4.0 (D-15521)	JPL	8/8/2016	-	PDF		ASDC	
		TES Level 1B Versioning	JPL		https://asdc.larc.nasa.gov/docum	PDF	10/1/2020	ASDC	

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
					ents/tes/readme/level_1b_std.pdf				
		TES Level 2 Versioning Level 2 Standard and Special Observation Products	JPL		https://asdc.larc.nasa.gov/documents/tes/readme/level_2_std.pdf	PDF	10/1/2020	ASDC	
		TES Level 3 Versioning Level 3 Global Survey Products	JPL		TBS	PDF	10/1/2020	ASDC	
		Product availability report	ASDC		https://l0dup05.larc.nasa.gov/cgi-bin/DUE/tes_L1B.cgi	html		ASDC	
3.3.4	Data Product Generation Algorithms								
		TES Level 1A, 1B, 2 and 3 Algorithms Scientific Goals and Requirements, D-17864	JPL			PDF		ASDC	
	Level 1	TES Level 1 Algorithms: Interferogram Processing, Geolocation, Radiometric, and Spectral Calibration, Doc ID 20070034777	JPL	5/5/2006		PDF	8/24/2013	NTRS	
	Level 1	TES Level 1B Algorithm Theoretical Basis Document V1.1, Doc Number D-16479	JPL	9/30/1999	https://eospso.gsfc.nasa.gov/sites/default/files/atbd/ATBD-TES-01.pdf	PDF		TBS	
	Level 2	TES Level 2 Algorithm Theoretical Basis Document, V1.15, Doc Number D-16474	JPL	12/7/2010	https://eospso.nasa.gov/sites/default/files/atbd/TES.ATBD_.L2.V1.15.pdf	PDF		TBS	

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
	Level 3	TES Level 3 Algorithms, Requirements and Products, D-26534	JPL			PDF		ASDC	
3.3.5	Data Product Quality								
		Aura-TES L1B Products Beta Release Quality Description	JPL		https://asdc.larc.nasa.gov/documents/tes/quality_summaries/L1B_products_beta.pdf	PDF	10/1/2020	ASDC	
		Aura-TES L1B Products: Version 2 Quality Description	JPL		https://asdc.larc.nasa.gov/documents/tes/quality_summaries/L1B_products_v002.pdf	PDF	10/1/2020	ASDC	
		Aura-TES L2 Products Beta Release Quality Description	JPL		https://asdc.larc.nasa.gov/documents/tes/quality_summaries/L2_products_beta.pdf	PDF	10/1/2020	ASDC	
		Aura-TES L2 Products: Version 2 Quality Description	JPL		https://asdc.larc.nasa.gov/documents/tes/quality_summaries/L2_products_v002.pdf	PDF	10/1/2020	ASDC	
		Aura-TES L2 Products Version 3 Quality Description	JPL		https://asdc.larc.nasa.gov/documents/tes/quality_summaries/L2_p	PDF	10/1/2020	ASDC	

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
					roducts_v003.pdf				
		Aura-TES L2 Products Version 4 Quality Description	JPL		https://asdc.larc.nasa.gov/documents/tes/quality_summaries/L2_products_v004.pdf	PDF	10/1/2020	ASDC	
		Aura-TES L2 Products Version 5 Quality Description	JPL		https://asdc.larc.nasa.gov/documents/tes/quality_summaries/L2_products_v005.pdf	PDF	10/1/2020	ASDC	
		Aura-TES L2 Products Version 6 Data Quality Description	JPL		https://asdc.larc.nasa.gov/documents/tes/quality_summaries/L2_products_V006.pdf	PDF	10/1/2020	ASDC	
		Aura-TES L2 Products Version 7 Data Quality Description	JPL		https://asdc.larc.nasa.gov/documents/tes/quality_summaries/L2_products_V007.pdf	PDF	10/1/2020	ASDC	
		Aura-TES L2 Products Version 8 Data Quality Description	JPL		https://asdc.larc.nasa.gov/documents/tes/quality_summaries/L2_Products_Data_Quality_V008.pdf	PDF	10/1/2020	ASDC	
		Aura-TES L3 Products Quality Description	JPL		https://asdc.larc.nasa.gov/documents/tes/quality_	PDF	10/1/2020	ASDC	

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
					summaries/L3_products.pdf				
		TES Data Quality Version 6, R13.1	JPL	06/30/14				JPL	restricted
3.3.6	Data Product Application								
		TES Webpage Content - snapshot	JPL					ASDC	
		TES publications List	JPL					ASDC	
3.4	***Project Data Events and Calibration***								
3.4.1	On-Orbit, in-flight, in-the-field Calibration Methods, Instrument & Platform Operations Event History								
		TES Instrument Calibration Reports, Vol 1, Doc Number D-26533	JPL	09/26/03		PDF		JPL	
		TES Calibration Modifications 2010	JPL		https://asdc.larc.nasa.gov/documents/tes/quality_summaries/calibration_modifications_2010.pdf	PDF	10/1/2020	ASDC	
3.4.2	Calibration Data								
		TES On-Orbit Filter Wheel Anomalies, Doc Number DFM #1513	JPL			PDF		JPL	restricted

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
		TES On-orbit Radiometric Calibration Target Search Results, Doc Number DFM #1511	JPL			PDF		JPL	restricted
3.5	***Science Data Product Software***								
		TES Release 11 Software Package TES_R11_SW.tar.gz	JPL			tar	10/1/2020	ASDC	
		TES Release 12 Software Package TES_R12_SW.tar.gz	JPL			tar	10/1/2020	ASDC	
		TES Release 13 Software Package TES_R13_SW.tar.gz	JPL			tar	10/1/2020	ASDC	
		TES Release 14 Software Package TES_R14_SW.tar.gz	JPL			tar	10/1/2020	ASDC	
		TES Release 15 Software Package TES_R15_SW.tar.gz	JPL			tar	10/1/2020	ASDC	
3.6	***Science Data Product Algorithm Data Inputs***								
		Level 1 Algorithm Inputs, AUREPHMN Definitive Ephemeris, AURATTN Refined Attitude Data	GES DISC			binary		GES DISC	
		Level 1 Algorithm Inputs, LeapSecT, UTCPoleT	GES DISC			binary		GES DISC	
		D5TES1 Subset of DAS Op 2d meteorological state (GMAO)	GES DISC			HDF EOS		GES DISC	

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
		D5TES1 Subset of DAS Op 2d meteorological state (GMAO) metadata (.met files)	GES DISC			XML		GES DISC	
		D5TES2 Subset of DAS Op 3d meteorological state (GMAO)	GES DISC			HDF EOS		GES DISC	
		D5TES2 Subset of DAS Op 3d meteorological state (GMAO) metadata (.met files)	GES DISC			XML		GES DISC	
		Additional algorithm inputs are identified in TES Data Product Specifications	JPL					ASDC	
3.7	***Science Data Product Validation***								
		TES Validation Report V1.00 (Version F02_01 data)	JPL	8/15/2005	https://asdhttps://asdc.larc.nasa.gov/documents/tes/readme/TESValidationReport_v1_0.pdf	PDF	10/1/2020	ASDC	
		TES Validation Report V2.0 (Version F03_03 data)		1/4/2007	https://asdc.larc.nasa.gov/documents/tes/readme/TESValidationReport_v2_0.pdf	PDF	10/1/2020	ASDC	
		TES Validation Report V3.0 (Version F04_04 data)		11/5/2007	https://asdc.larc.nasa.gov/documents/tes/readme/TES_Validation_Report_v30.pdf	PDF	10/1/2020	ASDC	
		TES Validation Report V4.0 (Version F05_05, F05_06, F05_07 data)		11/23/2011	https://asdc.larc.nasa.gov/documents/tes/readme/	PDF	10/1/2020	ASDC	

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
					TES_Validation_Report_v40.pdf				
		TES Validation Report V5.0 (Version F06_08, F06_09 data)		4/8/2012	https://asdc.larc.nasa.gov/documents/tes/readme/TES_Validation_Report_v50.pdf	PDF	10/1/2020	ASDC	
		TES Validation Report V6.0 (Version F07_10 data)		6/20/2014	https://asdc.larc.nasa.gov/documents/tes/readme/TES_Validation_Report_v6.pdf	PDF	10/1/2020	ASDC	
		TES Validation Report V7.0 (Version F08_11 data)		5/30/2018	https://asdc.larc.nasa.gov/documents/tes/readme/TES_Validation_Report_v7_Final.pdf	PDF	10/1/2020	ASDC	
		TES Validation Report V8.0 (Version F08_12 data)		12/31/2019	https://asdc.larc.nasa.gov/documents/tes/readme/TES_Validation_Report_v8_Final.pdf	PDF	10/1/2020	ASDC	
		Validation of Tropospheric Emission Spectrometer measurements of the total, stratospheric and tropospheric column abundance of Ozone, https://doi.org/10.1029/2007JD008801	JPL	5/7/2008	https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2007JD008801	PDF		Wiley Library	
3.8	***Science Data Analysis Tools***								

PCS SECTION	PCS Category	Artifact Title & Description	Source Organization	Artifact Creation Date	URL	Artifact Format	Archive Date	Archive Organization	Status
		Basic IDL Tools for extraction information from TES L1B HDF product files	ASDC		https://asdc.larc.nasa.gov/documents/tes/readme/README_L1BReadSoftwareV3.txt	TXT		ASDC	
		TES Level 1B Version 3 Read Software Package	ASDC		https://asdc.larc.nasa.gov/documents/tes/read_software/TES_L1BReadSoftwareV3.tar	TAR		ASDC	
		TES - Get Data: Tools (TES subsetter)	ASDC		https://asdc.larc.nasa.gov/tools-and-services	html		ASDC	
3.9	***Deliverables Checklist***								
		[This document]; List of documents & data for preservation	ASDC	10/1/2020		excel		ASDC	