Persistent Identifiers Best Practices

CEOS

Data Stewardship Interest Group

Doc. Ref.: CEOS/WGISS/DSIG/PIDBP

Date: December 2019

Issue: Version 1.3

Document Status Sheet

Issue	Date	Comments	Editor
0.7	December 2014	First draft issue for CEOS-Data Stewardship interest group review	Tyler Christensen
0.8	March 2015	Second draft, incorporating some comments received during the CEOS-DSIG review	Tyler Christensen
1.0	March 2015	First version for public release	Tyler Christensen
1.1	January 2016	Added recommendation and use case scenarios for near real time products.	Tyler Christensen
1.2	January 2017	Added recommendations for the landing page. Updated applicable and reference documents.	Razvan Cosac
1.3	December 2019	Added new recommendations and use cases in line with received RIDs.	Razvan Cosac, Ville Saaristo

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1 INTRODUCTION

1.1 Purpose of the document

This document aims to provide recommendations and best practices on the use of Persistent Identifiers (PIDs) to Earth Observation mission data, allowing globally unique, unambiguous, and permanent identification of a digital object.

1.2 Document Overview

This document is divided into:

Section 1: Introduction, including definitions, abbreviations, and related documents

Section 2: Background

Section 3: Objectives and Needs

Section 4: Components of a PID System

Section 5: PID Best Practice Content

Annex A: More Information on Persistent Identifiers

Annex B: Use Case Scenarios, tailored for the Earth Observation community

1.3 Acronyms

Acronym	Description
ARK	Archival Resource Key
DOI	Digital Object Identifier
EO	Earth Observation
ES	Earth Science
PID	Persistent Identifier
RA	Registration Agency
XML	eXtensible Markup Language

1.4 Definitions

Topic	Description
Registration Agency	The primary role of Registration Agencies (RAs) is to provide services to Registrants – allocating DOI name prefixes, registering DOI names and providing the necessary infrastructure to allow Registrants to declare and maintain metadata and state data (i.e. use of the DOI system). Registration Agencies also provide added-value services, such as reference linking or metadata lookup, for registrants and other customers. The following link could be useful to understand more about registration agencies: https://www.doi.org/doi_handbook/8_Registration_Agencies.html
Landing Page	When a data user clicks on a persistent identifier link, the resolver will lead to a landing page. This webpage shows all of the relevant information about a data set, and (most importantly) will have a prominent link for downloading the data. Note that the PID resolver should not point directly to the data download. The landing page will display some metadata and may also link to documentation, publications that have used the data set, citation recommendations, data use policy, etc. The landing page should be actively updated and maintained. If the URL to the page changes, it must be updated in the resolver database. The following link could be useful to understand more about landing pages: http://vso1.nascom.nasa.gov/rdap/RDAP2012_landingpages_handout.pdf

1.5 Related Documents

1.5.1 Applicable Documents

ID	Reference	Title	Issue
[AD-1]	CEOS/WGISS/DSIG/EODPG	EO Data Preservation Guidelines	1.0
[AD-2]	CEOS/WGISS/DSIG/PW	Long Term Preservation of Earth Observation Space Data: Preservation Workflow	1.0

1.5.2 Reference Documents

The following documents, though not formally part of this document, amplify or clarify its content.

ID	Reference	Title	Issue
[RD-1]	CEOS/WGISS/DSIG/GLOS	Long-Term Preservation of Earth Observation Space Data: Glossary of Acronyms and Terms	1.2

2 BACKGROUND

Internet resources tend to have a short life. Their identification and persistent location pose complex problems that affect many technological and organizational issues involving the citation, retrieval and preservation of cultural/scientific resources. This is by no means a technical problem alone: persistent digital object identification, including texts, music, video, still images, scientific documents and the like, is still a major issue that prevents the use of today's Internet as a trustworthy platform for the research and dissemination of scientific and cultural content.

The rapid increase of digital assets in recent years, especially in the context of e-science, has made this dependency even stronger, making it clear that digital identifiers are crucial in order to preserve, manage, access and re-use data sets over time. The implementation of a system for persistent identification of digital and non-digital objects is the first fundamental step to this purpose, becoming a crucial prerequisite for sustained and reliable resource discovery, citation and re-use.

The persistent identification of digital objects (e.g. articles, data sets, images, streams of data) as well as of non-digital objects (real-world entities, like e.g. authors, institutions, teams, geographic locations and so on) is a crucial issue for the whole information society. The capability to unambiguously locate and access digital resources, associate them with the related authors and other relevant entities (e.g. institutions, research groups, projects) is becoming essential to allow the citation, retrieval and preservation of cultural and intellectual resources.

An identifier is a unique identification code that is applied to "something", so that the "something" can be unambiguously referenced. For example, a catalogue number is an identifier for a particular specimen, and an ISBN code is an identifier for a particular book. Persistent identifiers (PIDs) are simply maintainable identifiers that allow us to permanently refer to a digital object. Identifiers are a way of giving digital resources, such as documents, images and data records, a unique reference number.

A Persistent Identifier is an identifier that is effectively permanently assigned to an object. The only useful persistent identifiers are also persistently actionable (that is, you can "click" them); however, unlike a simple hyperlink, persistent identifiers are supposed to continue to provide access to the resource, even when it moves to other servers or even to other organizations. A digital object may be moved, removed or renamed for many reasons. A solution is to give the object a persistent identifier that will remain the same regardless of where the resource is located and how it is stored.

Long term data preservation, dissemination and access of scientific digital objects are now among the core missions of international institutions. The use of URLs can't be considered a reliable approach for addressing these issues due to the structural instability of links (ex. domains no longer available) and related resources (relocation or updating). The current use of the URL approach increases the risk of losing documents or under-using available collections. In the Spatial & Scientific Heritage domain it is essential not only to identify a resource but also to guarantee continuous access to it.

PIDs are also an increasingly global standard. Not using a reliable PID system could harm a data provider's credibility and standards-compliance. PIDs also lead to increased citation of data resources used in published studies, so that data providers can better track the impact of their data resources.

3 OBJECTIVES AND NEEDS

The growth of scientific and non-scientific digital data is resulting in an increasing number of digital objects and resources that has to be managed. This data intensive environment offers many new opportunities: the possibility of accessing a massive amount of scientific and cultural data in digital format, the increasing linkage across authors and their publications, the development of new and much more powerful metrics for assessing the impact of scientific production, etc.

However, this scenario has led to the emergence of new challenges such as digital preservation, data integration, quality assessment and provenance. These challenges become magnified in global contexts where resources are distributed across systems and standards, and the movement of data across disciplines and organizations is very intensive.

The main purpose of a persistent identifier is to help data users cite and find specific data sets. In this context the Earth Sciences and Earth Observation mission data identified objectives and needs are listed below:

Objectives & Needs

- Globally unique, unambiguous and permanent identification of a digital object for locating and accessing over time.
- Improve discoverability and accessibility.
- Enable users to retrieve objects without knowing their location.
- Enable repositories to change the location of objects internally.
- Enable repositories to share objects with other services where appropriate.
- Enable researchers to cite digital objects consistently over time, which also benefits data holders.
- Increase data visibility and use.
- Increase credibility and value of data holdings.

4 COMPONENTS OF A PID SYSTEM

The first component is, obviously, the data resource that will receive a persistent identifier. This data resource itself is expected to persist over time, as part of a long-term data preservation strategy.

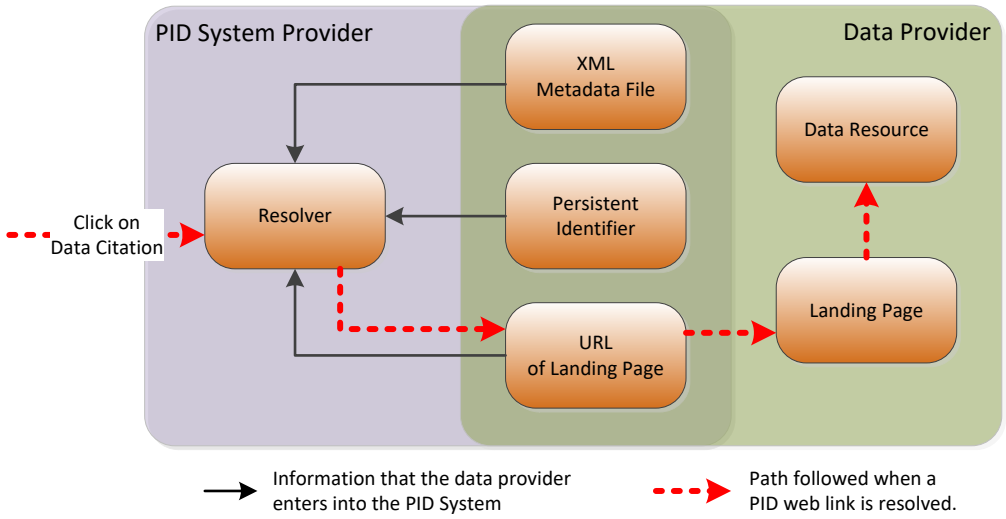
Note that in talking about the identifier, we will use the example of a DOI that is registered through a Registration Agency. Some subtle differences could be found if a different system is chosen, but the overall structure will be similar.

A data provider will get a DOI "prefix" from the Registration Agency, simply a number that uniquely identifies that providers' subset of DOIs. The data provider then generates an internally unique "suffix" for the archived data resource. A landing page must also be constructed. This is a web page with information about the data and a download link (if available), hosted by the data provider's web server. Finally, an XML metadata file must be constructed according to the Registration Agency's metadata schema.

To register the DOI, the XML metadata file, the URL for the landing page, and the identifier itself are submitted to the Registration Agency and from there into the DOI resolver system. When a data user clicks on a DOI citation, the resolver (https://doi.org/) can then redirect the user to the landing page. The XML metadata will be used for data discovery via online search, metadata harvesting services, data portals, and data repository catalogues.

The DOI and the data set itself should never change. However, the data provider must maintain these components as needed:

- update the landing page on its own web server
- update the DOI metadata by submitting an updated XML file to the Registration Agency (e.g. with new URL if the landing page location changes)



Information flows in a PID system. The data host provides the identifier itself, an XML metadata file, and the URL of the landing page to the PID system provider. These are then stored by the resolver system. When an interested user clicks on a PID web link, the resolver redirects them to the landing page with information on how to access the data resource itself.

5 PID BEST PRACTICE CONTENT

This document addresses the main "themes" that should be applied to guarantee a globally unique, unambiguous, and permanent identification of a digital object for locating and accessing it over time. Meeting these harmonized CEOS guidelines for PID implementation improves interoperability with other EO data providers.

Some Use Cases are provided in Annex B in order to describe the Earth Sciences and Earth Observation mission context.

5.1 General Recommendations

5.1.1.1 Choosing a PID system

[REC_01]
In choosing a PID system, the following should be considered:

- Evaluate the technical reliability, authority, and credibility of the PID system.
- Ensure that the system has financial and/or institutional support, to ensure its long-term viability.
- Make sure that it is flexible enough to represent the granularity of the collections.
- Make sure that the service uses open standards for the implementation of PIDs.
- The PIDs should be independently generated by the data provider, with no need for a centralized system.
- It is best to use an external resolver rather than an internal one that must be maintained by the data distributor.

These recommendations are specifically written so that a data provider can be 100% compliant, no matter which PID system is chosen. However, it is our opinion that DOIs are the most suitable persistent identifiers for the Earth Observation domain. DOI is a persistent identifier or handle, used to identify objects uniquely, standardized by the International Organization for Standardization (ISO 26324). DOI is the most widely used PID system globally – for publications and increasingly for data, in particular:

- Many millions of data resources now have a DOI, making it very unlikely that the system will disappear.
- Most organizations pay a small fee to register DOIs, providing funding to maintain the DOI infrastructure.
- DOI is rapidly becoming the global standard for data citation. The National Aeronautics and Space Administration (NASA), the European Organization for Nuclear Research (CERN), the Australian National Data Service, the United States Geological Survey (USGS), the European Space Agency (ESA) and other European agencies, all use DOIs for data citation. Many publications, e.g. the Public Library of Science journals, now encourage or require data citation via DOI.

5.1.1.2 PID numbering

[REC_02]
Numbering should be completely opaque. The identifier should not contain any information about the resource it identifies. Opaque IDs are easier to manage, less likely to become obsolete over time, and conform to global standards.

[REC_03]
PIDs must be universally unique, with a system to ensure each identifier is unique worldwide.

[REC_04]
No hierarchies/versioning within the actual PID numbering, since that violates the opaqueness requirement. Use the landing page instead.

[REC_05]
Consider using a checksum, such as Mod97, to check for valid PIDs.

5.1.1.3 Permanence

[REC_06]
Data providers must commit themselves to the persistence of their PIDs, maintaining and updating metadata, URLs, and landing pages as needed.

[REC_07]
The identifier should never change, neither the identifier itself nor the resource it refers to.

[REC_08]
If the already existing data content changes (e.g. reprocessing, error correction, versioning), assign a new PID. The landing page should mention the changes and provide links between the different PIDs. A new PID is not necessarily needed in the case of adding in more similar data content.

[REC_09]
If the file format of any data is changed, e.g. CDAT to GeoTIFF, assign a new PID. The landing page should mention the changes and provide links between the different PIDs.

[REC_10]
If the data are transferred to new physical storage media, it is not necessary to assign a new PID. It would be good practice to perform a validation/checksum to guarantee the integrity of the new copy and check for bitwise differences.

[REC_11]
Only assign PIDs to data sets that are disseminated and archived for long-term – not auxiliary/ancillary data, experimental products, on-demand processing, or near-real-time (NRT) products that are not archived. If these data (e.g. auxiliary/ancillary, NRT, etc.) are archived and publicly disseminated, then they may qualify for a PID.

[REC_12]
Based on user demand, in limited cases PIDs may be given to near-real-time products, but only if the data provider commits to archiving the product for at least 10 years or if a science-quality version of the near-real-time product is archived. The landing page should clearly state the limitations of the product, clarify the data provider's archiving commitment, and link to the science-quality version if available.

[REC_13]
If a data set is transferred to a new institution, keep the same PID. In this case, a new landing page should be generated, and the URL and the resolver's metadata file should be updated. If the new host does not use PIDs, a tombstone landing page must still be maintained, either by the previous host or the new institution, giving information about the new data owner.

[REC_14]
The PID must remain resolvable. This means updating the landing page URL in the resolver if the location changes. If a data set must be deleted, a tombstone page must be maintained (e.g. explain why the data were removed, link to a new version, contact information for questions, etc.).

5.1.1.4 Resolving

[REC_15]

A PID must be actionable, meaning that the identifier will lead the user to information about the resource. This is also called resolution of an identifier.

[REC_16]
The PID should resolve to a landing page, not a direct link to data download. The page should be hosted by the data holder and updated as needed.

[REC_17]
The landing page should contain provenance, quality, and access constraints, but doesn't have to show the entire metadata record. The goal is a readable summary of the data set so a potential user can see if it meets their needs. Information on how to access the data should also be included, with an online download link if available.

[REC_18]
Use the landing page to link data sets that are related (e.g. reprocessing, versioning, subsets, and supersets). These relationships can also be reflected in the resolver's metadata fields.

5.1.1.5 Granularity

[REC_19]
As a general rule, assign PIDs to data collections (e.g. a consistent time-series) rather than an individual scene. This can be flexible, depending on how users will want to cite the data.

[REC_20]
Data from the same source but at a different processing level (e.g. L1B vs. L2) should receive separate PIDs.

[REC_21]
Assign a single PID for a whole time-series, even if new data are still being added. It is more convenient to cite a subset of a larger data source, rather than many PIDs to make up a single time series. Note that no retrospective changes will be made to historical data records that are already in the archive.

[REC_22]
Use one PID for a multi-satellite time-series, as long as the series is internally consistent.

5.1.1.6 Documentation

[REC_23]
An institution that uses PIDs should have an official, written PID policy.

[REC_24]
Make sure that the uses of PIDs are part of the written policy of the institution.

- Be clear, and make public, in which environments the PIDs are unique and how they resolve to an available resource.
- Clarify what is meant by 'persistent', whether there are any limitations, and how this will be implemented.

[REC_25]
Provide citation guidelines that use the PID, including how to cite a subset in space and time.

[REC_26]
Documents related to a data set should be linked on the landing page, not as subset PIDs.

[REC_27]
Comply with the latest metadata standards from your PID provider, and update as needed.

5.1.1.7 Interoperability

[REC_28]
The same data set should have the same PID, even for duplicates in different archives or disseminated by two different data centres. If an archive hosts a copy of a static data set that already has a PID, then keep the original PID. A single landing page may have several different links for data access and download.

[REC_29]

In case of inter-agency data records, a PID (e.g. based on DOI) can be associated with a list of all contributing collections and their respective PIDs (e.g. DOIs, ARK). No translator is needed in case different PID systems are used by different providers. The DOI system explicitly recognises other schemes and is designed to assist identifier interoperability.

5.1.1.8 Landing Page recommendations

When a data user clicks on a persistent identifier link, the resolver will lead to a landing page. This webpage shows all of the relevant information about a data set, and, most importantly, will have a prominent link for downloading the data. The landing page will display some metadata, and may also link to associated documentation, citation recommendations, data use policy, etc. In the case that a new PID is created because of e.g. reprocessing, the landing pages will also retain data set provenance and links between these two PIDs. The data provider must take the commitment to actively update and maintain the landing page for an indefinite amount of time.

[REC_30]

It is recommended that landing pages use structured metadata (e.g. schema.org, DCAT, CSVW, and other community standards) in order to facilitating discovery and use.

A landing page should contain the following information:

- Data set long name.
- A description of the data set (Note: a data set can also represent a time series or a collection). This section can also contain information on the provenance and quality of the data. Otherwise, a separate section could be created for the quality information.
- A link for accessing and obtaining the data, together with any information regarding access constraints, such as data access policy. This could be represented either by a direct link to the data, or in case authentication is required, it could be a link to the log-in/registration page, after which the user would be redirected to the requested data. A landing page may have several different links for data access and download.
- General characteristics of the data set, such as:
    - mission/satellite/project name
    - instrument/sensor name
    - data format
    - data type
    - measured parameters
    - temporal coverage
    - spatial coverage
    - resolution
    - processing version
    - access/use restrictions
    - keywords
- Links to other related data sets

- Links to the documentation associated to the data set
- The data set DOI
- Data citation information (i.e. how to cite the data set)
- Contact information

5.2 PID Policy - Example

This section can be customized by local institutions to reflect their own PID policy decisions. The result could be used as an official persistent identifiers policy statement. An example of a policy statement for the use of persistent identifiers is given below. This has to be adapted to suit the needs of the individual organization.

Statement of Persistence: [DataOwner] commits to assigning permanent identifiers to the data sets that are released to the public. The data, identifiers, metadata, and landing pages will be maintained indefinitely. Tombstone pages will be provided for any data that are no longer available for any reason.

PID system: [DataOwner] chooses to use the DOI system for identifiers, conforming to the Registration Agency standards for metadata and landing pages. Identifiers will be opaque strings of random letters and numbers, ending with a two-digit checksum calculated according to a Mod97 algorithm. These identifiers are globally unique within the DOI system. Metadata conforming to the Registration Agency metadata schema will be made freely available for data discovery.

Resolving our PIDs: Because [DataOwner] uses DOI, all identifiers are resolvable online through the DOI web interface (e.g. http://doi.org/10.4225/25/5487CC0D4F40B). The URL will always redirect to a landing page that shows the current location of the original data set, even if it has moved. The landing page will also provide data set details and information on any access restrictions.

Citing our Data: Scientists who use [DataOwner] data in their research are asked to use the persistent identifier when citing the data source in their publications. (Example: Cooper, L.; Lamont-Doherty Earth Observing Laboratory (LDEO); (2009): HLY-08-01 POES Satellite Images (Version 1.0); UCAR/NCAR - Earth Observing Laboratory. http://doi.org/10.5065/D6G73BQC)

Granularity: [DataOwner] identifiers are assigned at the collection level, e.g. to the entire time series of a data parameter. If a researcher uses a subset of the data in their research, the citation should include the subset boundaries so that others who wish to repeat the research can extract the same subset. (Example: Fiedler, E.K.; McLaren, A.; Merchant, C.J.; Donlon, C. (2014): ESA Sea Surface Temperature Climate Change Initiative (ESA SST CCI): GHRSST Multi-Product ensemble (GMPE). NERC Earth Observation Data Centre, 24th February 2015. Time subset: 1991-09-01 to 2004-01-01. http://doi.org/10.5285/7BAF7407-2F15-406C-8F09-CB9DC10392AA.)

Contact Information: If there are any questions about these identifiers or to report a broken link, please contact [email address and phone].

ANNEX A – More Information on Persistent Identifiers

Persistent Identifiers (PIDs) are simply maintainable identifiers that allow us to refer to a digital object. An identifier is a unique identification code that is applied to "something", so that the "something" can be unambiguously referenced. Identifiers are a way of giving digital resources, such as documents, images and data records, a unique reference number. A Persistent Identifier is an identifier that is effectively permanently assigned to an object.

The only useful persistent identifiers are also persistently actionable (that is, you can "click" them); however, unlike a simple hyperlink, persistent identifiers are supposed to continue to provide access to the resource, even when it moves to other servers or even to other organizations. A digital object may be moved, removed or renamed for many reasons.

A solution is to associate a persistent identifier (PID) with a digital resource that will remain the same regardless of where the resource is located.

Notions:

1. Persistent Identifiers must be globally unique
2. Persistent Identifiers must exist indefinitely

These are the main steps to be performed in order to implement a PID system:

1. Selection of resources that need a PID;
2. Resource name assignment and register creation;
3. Resolution of a PID with the associated URL;
4. Maintenance of the register that associates PID-URL and guarantee of continuous access to the resources.

Persistent Identifier system requirements

The PID system requirements are:

- Global uniqueness: We consider the identifier a label that is associated with an object in a certain context. "Context" is intended as both the kind of standard used for the name syntax and the identification of the authority (sub-namespace) that assigns this label.
- Persistence: refers to the permanent lifetime of an identifier. It is not possible to reassign the PID to other resources or to delete it. That is, the PID will be globally unique forever.
- Resolvability: refers to the possibility of retrieving a resource once it is published.
- Reliability: the PID infrastructure must always be active (service redundancy, back-up deposit services, etc.) and the register updated (through automatic systems).
- Authority: is who assigns, manages and resolves the identifiers.
- Flexibility: An identifier system will be more effective if it is able to accommodate the special requirements of different types of material or collections.
- Interoperability: this aspect is fundamental for guaranteeing the possibility of disseminating and accessing science digital objects.

Persistent Identifier scheme

It will be useful here to identify three elements relevant to the data set that you want to expose using Persistent Identifiers:

1. Authority: This generally correlates to the institute or organization which has responsibility for the data set (also known as the information resource). Important considerations when choosing an authority include:
    a. Stability – organizations that endure little change to their name and the names of their dependencies are a better choice for long term authority names.
    b. Longevity – organizations that have more community support are more likely to persist into the future.

2. Context: This correlates to the data set (which might be a database or a clearly identified subset of a database). Considerations when choosing a context name include:
    a. Contexts must be unique within an authority.
    b. What subset of the information resource can be independently curated? If you are applying Persistent Identifiers to a large, heterogeneous data set (perhaps actively curated in some areas, and fairly static in others) or to a data set which has been derived from multiple sources, consider splitting the data set into subsets. Also consider what might happen to information resources if the authority were to wind down, split or merge with another organization.
3. Object: This correlates to the specific resource (possibly a database row). Object names (identifiers) must be unique within a context.

DOI: Digital Object Identifier

DOIs are a managed identifier system, maintained and controlled by the DOI Foundation. The DOI Foundation manages a commercial infrastructure for the assignment and use of DOI identifiers. DOI is the most widely used Persistent Identifier system globally – for publications and increasingly for data. More than 3 million data resources now have a DOI, and more than 100 million DOIs have been assigned over all resource types. Hence, it is unlikely that the DOI system will disappear. DOIs may be free for research institutions, but other organizations pay. Therefore, there is funding available in the DOI foundation, which helps maintain the DOI resolver and associated infrastructure. NASA, NOAA, NERC, and then Australian National Data Service also use DOI for harmonization in EO/ES DOI is therefore a good choice. With DOI, the EO data become visible and discoverable beyond EO portals, e.g. in generic search engines. This wide visibility outside the EO community is a major advantage of using DOIs.

- DOI example: 10.1000/186
- DOI must be bought at a cost per identifier from the DOI Foundation.
- Registration, support, persistence control and policy making is provided by the DOI Foundation, ensuring a robust system for maintaining the identifiers.
- DOI is resolved through the online DOI resolver by appending the DOI to the URL http://doi.org/ (e.g. http://doi.org/10.1000/186)
- Authority, context and object identifier components are obscured with the use of DOIs (which can be seen as a positive aspect if opacity is deemed important).
- The primary focus of the DOI system is on the management of entities of interest as intellectual property, but this does not preclude issuing a DOI name to any entity of interest to a user community.
- All DOI names must be registered in a DOI system directory. Registrants are responsible for the maintenance of current data relating to DOI names that they have registered.
- The DOI system will not accept duplicate DOI names on registration; no two DOI names from different registrants can ever share the same prefix; no two identical strings can be assigned within one prefix.
- DOI registration through registration agencies, or local members of these agencies, may be free or have a reduced cost for public research institutions.
- Resource may change, be updated, be renamed, be moved, or be removed (assignment of new DOI or update of DOI metadata to reflect changes or point to updated resource)

ANNEX B – Use Case Scenarios

The scenarios below address a number of situations that may occur in Earth Observation (EO) and which may affect the way persistent identifiers are applied to EO by data managers. The main purpose of a persistent identifier is to help data users cite and find specific data sets. The recommendations below are provided based on this main objective.

B.1 Data User

1. Citing data sets

   a. A user downloads a data set, does some science, publishes the result, and cites the data source using a PID.
   Recommendation: The PID should resolve to a landing page that provides access to the exact same data. The PID may link to the data set series from which the data set was taken. Citation guidelines should provide information on how to cite the individual data set used.

   b. A scientist uses and wants to cite two years' worth of data from a 20-year time series.
   Question: Should "chunks" of a longer time series get their own PID?
   Recommendation: The whole data set series (collection) gets one PID. The data provider should give guidelines on how to cite the data (e.g. use the PID but specify the time and area so that others can retrieve the same subset).

2. Accessing cited data sets

   a. A scientist reads a published article, sees a data citation, and wants to access the same data set used in the original research.
   Recommendation: The PID should resolve to a landing page that provides access to the exact same data.

   b. A scientist reads a published article, sees a data citation, and wants to access the same data set used in the original research. The data set is not available any more.
   Recommendation: The PID should resolve to a "tombstone" landing page that explains why the data are gone, provides a contact for more information, and – if possible – refers to an alternative / similar data set which is accessible.

   c. A scientist reads an article from 15 years ago with a data citation. The cited data set is still archived and accessible, but it has been replaced with a new one reprocessed and /or computed using an improved algorithm.
   Recommendation: The landing page should mention the changes and provide links between the different PIDs of the data sets.

   d. A scientist reads an article from 15 years ago with a data citation. The original data set is no longer archived, because it has been replaced with a new product that uses an improved algorithm.
   Recommendation: The landing page should explain why the data are gone and links to the improved product.

B.2 Data Archive

1. Adding data to a data set series (collection)

   a. A data archive wants to assign a PID, either to a new data set or to an existing archived data set.
   Recommendation: Develop a consistent workflow for assigning PIDs, and for evaluating whether a data set should receive a PID. Follow best practices, and commit to maintaining the data for the long term.

   b. The data set series in the archive is dynamic. New data sets or products are being added daily as the mission or project continues.
   Recommendation: The entire data set series should receive one PID. Citation guidelines should be provided to help the data users define which time span of data they used, so that future studies could repeat the research exactly.

   c. The static or dynamic data set series in the archive is found to be incomplete. The missing data sets are being recovered from external sources and added to the data set.
   Question: Does the PID remain the same?
   Recommendation: The data set series should keep the same PID, as long as the data source and processing algorithms are the same. A version history in the metadata should be used to clear up any confusion.

   d. A data set series includes data from the same sensor, carried on many different satellites (example: AVHRR on the NOAA POES satellites). The current satellite is replaced by a new operational satellite to continue the measurement.
   Question: Does the time series keep the same PID?
   Recommendation: Yes, the data set series keeps the same PID if the content of the existing data series has not changed. Details on inter-calibration and processing coefficients should be in the metadata.

2. Deleting a data set series (collections)

   a. A data set series is deleted from the archive.
   Recommendation: The PID should resolve to a "tombstone" landing page that explains why the data are gone.

   b. A level-1b product is not permanently archived. Instead, the product is generated on-demand when a user requests the data. It is then deleted. As a result of the processor, operating system, and hardware used, it cannot be guaranteed that a reprocessing will produce the exact same product down to the individual precise pixel value.
   Question: Should this kind of on-demand product get a PID?
   Recommendation: No, do not give an on-demand product a PID. Collections or products for which no permanent archiving is planned do not receive a PID. Consider assigning a PID to the lower level data from which the product is generated. Citation guidelines should specify how to cite the product. The relevant information (e.g. processor version) should be available in the (temporary) product's metadata.

c. Some level-2 products within a data set series are found to be faulty. They are replaced with corrected versions, generated with the same processors as the rest of the data series. The faulty products are deleted.
Question: Should the collection receive a PID, even though its content will change? Should it receive a new PID when the faulty products have been deleted?
Recommendation: The data set series keeps the same PID. The PID should resolve to a landing page that explains which data sets out of the series were replaced and why.

d. Several duplicate products, with slightly different calibration values, are found within a data set series. After careful testing of both versions, the faulty ones are deleted from the data set series.
Question: Does the PID remain the same? Should the data set series receive a new PID when the faulty products have been deleted? What if the faulty products have been used and cited?
Recommendation: The data set series should keep the same PID, as long as the data source and processing algorithms are the same. A version history in the data set series metadata and an explanation on the landing page should be used to clear up any confusion.

e. A project invents an improved algorithm for an atmospheric trace gas product, reprocesses the entire data set series, and releases the result for web download. This happens every few years. The data centre is not planning on keeping more than the current and two previous versions of the data set. The older versions are deleted from the archive.
Question: Does each new processing get a new PID? How to deal with PIDs for deleted versions?
Recommendation: Each reprocessed data set series receives a new PID. Ensure that the older versions are kept as long as possible, but definitely use a "tombstone" landing page which refers to the updated versions for any old versions that have been deleted.

3. Moving a data set series (collections)

a. A data set series, which has a PID assigned to it, cannot be archived any longer by the data centre. A purge alert is issued. Another data centre offers to take over the data set, permanently archive it, and make it accessible to users.
Question: Does the data set receive a new PID?
Recommendation: No, PIDs should be data-centre agnostic, i.e. not reflect the data centre in its name or number. The relocated data set series keeps the same PID but the PID metadata are updated to reflect the new location. A new landing page should be created and maintained by the new host. If the new host does not use PIDs and cannot maintain the metadata and landing page, a "tombstone" landing page must be created by one of the institutions, with information on the new data host. All PID management details should be specified in the purge alert agreement between the two institutions, e.g. who should update the PID metadata, commitment of persistence by the new host, is a tombstone page required, etc.

4. Distributed data set series (collections)

a. Several copies of a data set series are archived in different data centres and delivered to users separately. For ESA, this could even be different national institutes that use different

PID systems.
Question: Does each copy have its own PID?
Recommendation: If the data sets are completely identical, they should have the same PID. Collaborating data centres should coordinate their PID systems as much as possible. It is also possible to use a central ID resolving catalogue, such as the OKKAM Entity Name System (http://www.api.okkam.org/).

b. The European NOAA AVHRR 1km data set series consists of partially overlapping data sets hosted by multiple data centres across Europe.
Question: Should these data set series each have their own PID?
Recommendation: The data sets are not identical. They were downlinked separately and processed on local systems, possibly using different algorithms and calibrations. Therefore, these data set series should each have their own unique PID.

5. Identifying additional information (PDSC – documentation, software)

a. A data set has documentation associated with it. Some documentation is held by another organization.
Question: Do these get PIDs also? Is there a way to link PIDs with each other, or are these "subsets" of the data set PID?
Recommendation: The documents should not be subsets of the data set series or of its PID. If the documentation is permanently archived and disseminated, it may qualify for its own PID. A link to the documentation associated with a data set series, or its PID, can be established via the landing page no matter where the documentation is being held.

b. The archive contains auxiliary data that are used in calculating higher-level products. Some of these came from third parties and are probably archived there as well.
Question: Should these auxiliary data get a PID?
Recommendation: No, auxiliary data sets that are not meant to be released to the public do not receive PIDs. An internal ID is enough.

6. PID Granularity

a. A data centre in general holds individual data sets in collections, i.e. within data set series. PIDs usually are assigned at the level of the data set series. Additionally, individual data sets or products, such as global mosaics, are added to the archive. These products will be used in publications and scientists will want to cite them.
Question: Does the data centre deviate from its policy of assigning PIDs only to data set series and assign PIDs also to individual products for specific cases such as this?
Recommendation: For specific cases, and given sufficient importance is assigned to the product, the data centre should deviate from its general policy of assigning PIDs only to data set series and assign PIDs also to individual products if required.

b. Within a satellite series, there may be variations in the sensors (e.g. AVHRR/2 had 5 spectral bands (NOAA7-14), whereas AVHRR/3 has 6 (NOAA15-19). Moreover there are also slight differences in the range of the spectral bands between NOAA 6, 8, 10 and NOAA 7, 9, 11, 12, and 14.
Question: Should the time series from different versions of a sensor get different PIDs?
Recommendation: This is a question of how collections are organized. If data from the

different sensor versions end up in the same data collection, they would get one PID. Each archive may have different ideas about grouping, and each archive must decide what grouping makes sense for their own data collections. Users should be carefully advised on how to cite the data, indicating the sensor(s) and/or satellites and/or processor that have been used. Larger and more heterogeneous collections have to be more carefully cited. It is good practice to keep the collections as homogeneous as possible, so the user can cite with just a PID (and maybe a time/area subset, if applicable). If the archive owner chooses something different, very detailed citation guidelines must be provided to the user.

c. A dataset has been assigned a PID and it is also included in the metadata of the products of dataset. Later on, a new collection is being created that also uses this dataset as a part of it, but in this first dataset there is already a PID assigned.
Question: How to handle PID insertion when the dataset already has a PID?
Recommendation: It is recommended to only keep the first PID inside the dataset as it is. The landing page of the new collection should clarify the existence of an earlier PID for this dataset and why the new collection PID cannot be found in the dataset.

B.3 Data Producer

1. Non-permanent products

a. The ground segment for a new satellite is planning the release of novel remote sensing data products. The products are currently in an experimental phase, released only to a few known project partners, but they will soon be released to the public. One of the project partners analyses the experimental product, publishes his results, and wants to cite the product used.
Question: Should experimental products with limited release get a PID?
Recommendation: No, preliminary or experimental products do not receive a PID. A PID is assigned when the data set series is released in its final form.

b. For archiving efficiency, preliminary and final products are being held in one archive data set series. Within the collection they can be distinguished via a flag in the product metadata. The experimental products may at some point be deleted from the collection when they are no longer needed.
Question: Should the collection receive a PID, even though its content will change? Should it receive a new PID when the experimental products have been deleted? What if the experimental products have been used and cited in publications?
Recommendation: The data set series receives and keeps its PID. The PID should resolve to a landing page that explains which data sets out of the series were deleted and why (similar to scenario 2c and 2d).

c. A near-real-time (NRT) product is released to the public. These products are not archived, but only available for a couple of weeks—the emphasis is on releasing a product with as little turnaround time as possible. No archived version of the product is available.
Question: Should the NRT product receive a PID?
Recommendation: As a general rule, PIDs should not be assigned to a data set series that is not intended for long-term archiving. However, there may be cases where many scientific studies are based on the NRT product and the users are asking for a way to cite their data source. The data provider should then consider committing to archiving the NRT data files.

If the data provider can safely archive the data for at least 10 years, following general scientific best practices, then a PID may be assigned to the NRT product. One PID should then be assigned to the entire data series, even if the processor version changes mid-stream. The landing page should clearly state the limitations of the NRT product and the archive commitment by the data provider.

d. A near-real-time product is released to the public. An archived version of the same product is also available, processed after the fact with more quality control and perhaps slightly different data processing.
Question: Does the NRT product need a PID? Is that PID different from the archived time series product?
Recommendation: The recommendation is still to not assign a PID to a data set series that is not intended for long-term archiving. However, there may be a compelling reason to give a PID to the NRT product; for instance, it is being used in published studies and the authors want to cite their data source. In this case, the PID given to the NRT product should be different from the archived product's PID. The NRT product's landing page must clearly state the product's limitations and that it is not archived, and provide a link to the landing page of the archived version.