Holistic and pragmatic standards processes enable interdisciplinary science

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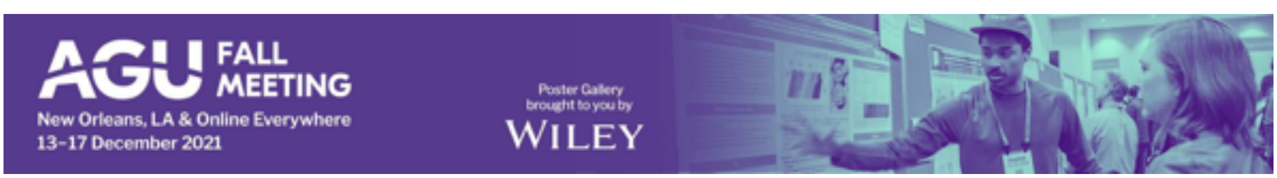


MOTIVATION AND GUIDANCE

To promote open science, NASA has developed an aggresive open science **strategy** (https://science.nasa.gov/science-red/s3fs-public/atoms/files/SDMWG_Full%20Document_v3.pdf) and **policy** (http://science.nasa.gov/researchers/science-data/science-information-policy) (Now open for **comment** (http://nspires.nasaprs.com/external/solicitations/summary.do?solId=%7B3612D133-135D-24D2-BC4C-17EFAC73F8E7%7D&path=&method=ini)) that call for the establishment of a data standards process reaching across the five diverse divisions of the Science Mission Directorate (SMD).

The key is ensuring that standards are adopted when necessary and when they meet a particular need. In this case we are explicitly driven by the need to implement the new policy *and* a new cross-SMD data discovery service (aka catalog). See IN45H-0520 - Developing the Cross-Disciplinary Information Model for NASA's Science Mission Directorate and IN23B-09 - Methods and Results of Truly Interdisciplinary Data Discovery.

A Working Group with representation across SMD has advocated a set of principles that shall guide any approval process. A principle-based approach has shown to be useful in other organizations as well.

DRAFT Principles

- Use existing standards where possible.
- There is no one (format) standard to rule them all. Disciplinary standards should be respected, but there will be some level of required commonality or crosswalking.
- Any standard must solve a problem and be actively adopted.
- Bottom up standards are preferred to top down mandates where possible.
- The details of exactly how a standard is adopted are as important as the standard itself.
- Reduce *total* effort. Incorporate necessary information and practices (e.g. metadata, identifiers, etc.) into routine scientific workflows. Make it effortless for the provider.
- The concerns of data providers must be addressed.
- Prioritize adding value over meeting requirements. Carrots are better than sticks.

Existing Processes and History

We have also reviewed existing standards processes within and outside of NASA as well as a few case studies of past standardization efforts to identify lessons learned:

- **Middle Out —** Strive to find a balance between a a lightweight and controlled process.Think glocally.

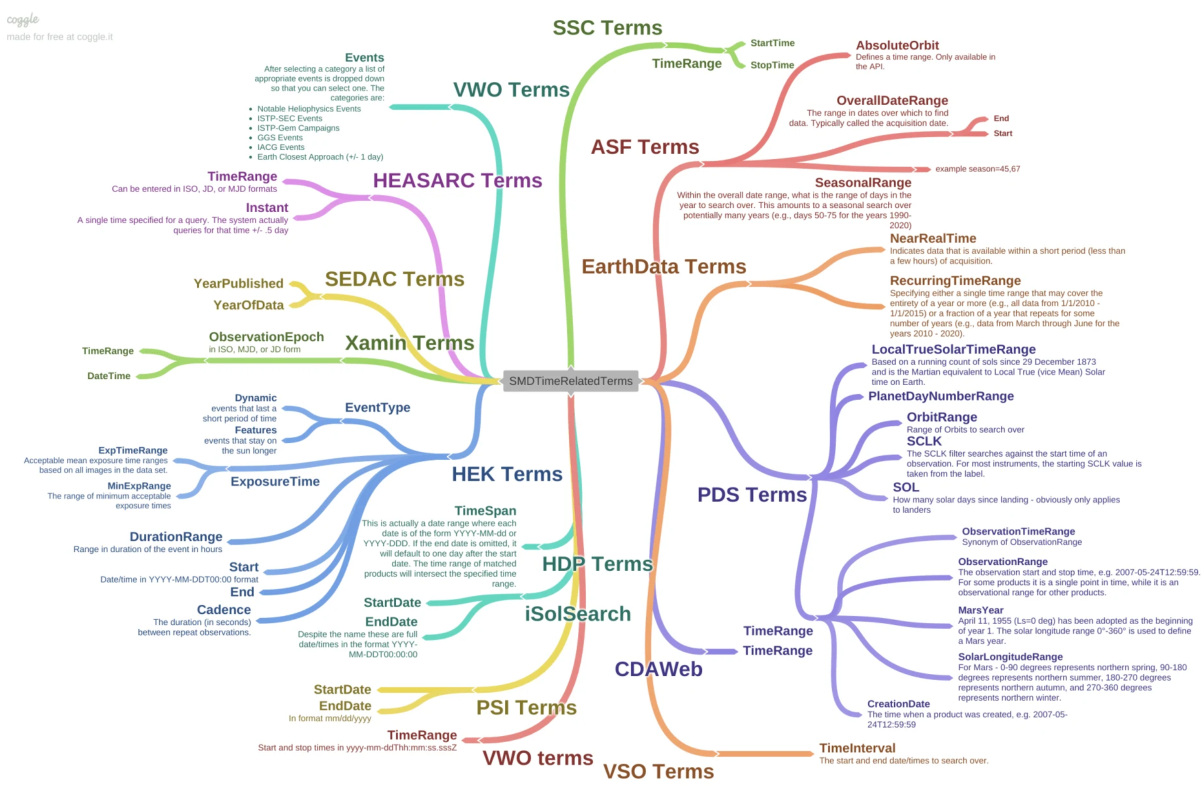
- Professional **coordination** is needed but not heavy authority. Authority or enforcement is a separate issue.
- **Participant Alignment** — Both institutional commitment and community engagement are essential but their objectives may not always align.
- **Agile Bureaucracy —** Sustained institutions are critical, but these institutions must remain agile in their methods and even in their mission or audience.
- **Care and Connection**
    - Public, transparent **maintenance** of a standard may be more important than development.
    - Transparent decision mechanisms with active community engagement is essential, even if consensus is not necesary
    - Incentives must be clear on why someone would participate
    - Define roles and authorities and recognize these may change.
- Services are harder than products (and more dynamic)
- Need to consider different levels of standards and the necessary level of consensus and rigor in adoption.

EXPLORING THE NASA DATA ECOSYSTEM

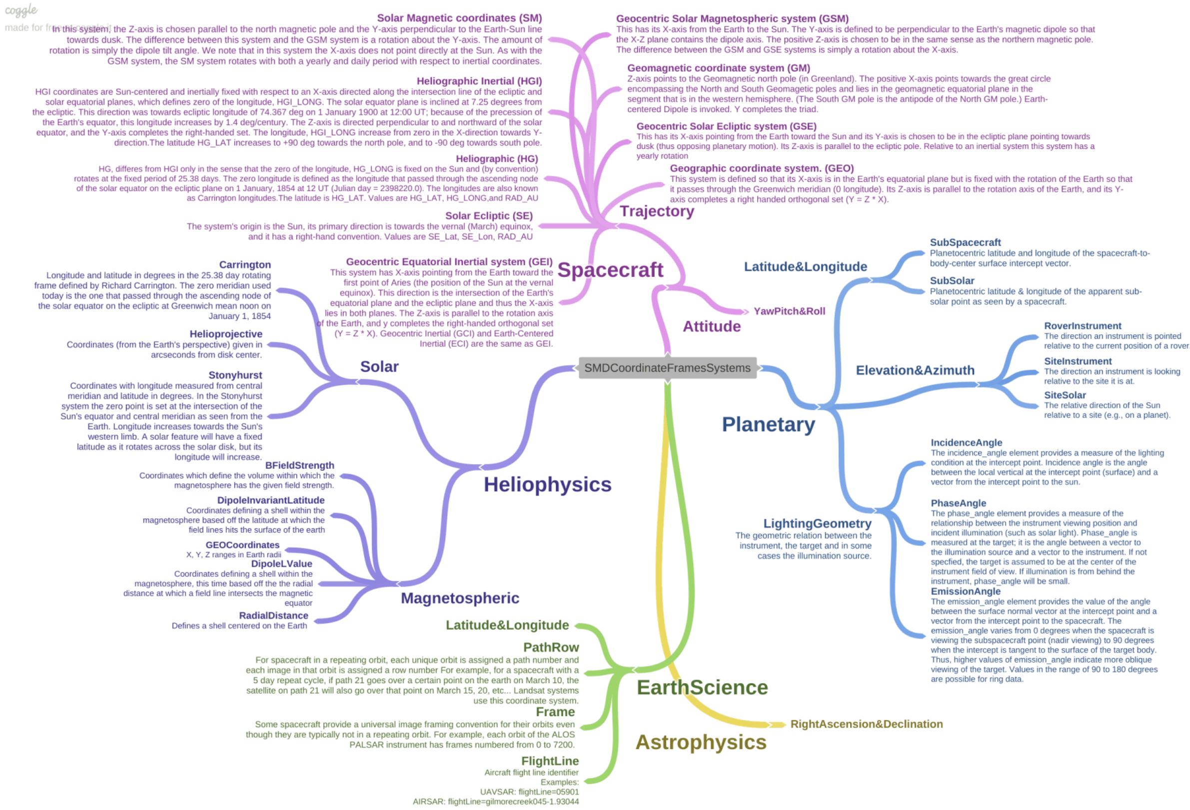
We take an ecological approach developed by Pulsifer et al. 2020 (https://drive.google.com/file/d/1UHHE0j3e7mj8xxaLwRVAMXo_u-BOreKO/view?usp=sharing) where we seek to identify information ecosystem components (e.g. data centers, missions, programs, datasets, services, protocols, users) and establish how they interact.

We began by looking at different scales. First specific terms used by the different data centers to describe basic concepts like

Time:



and **Space:**

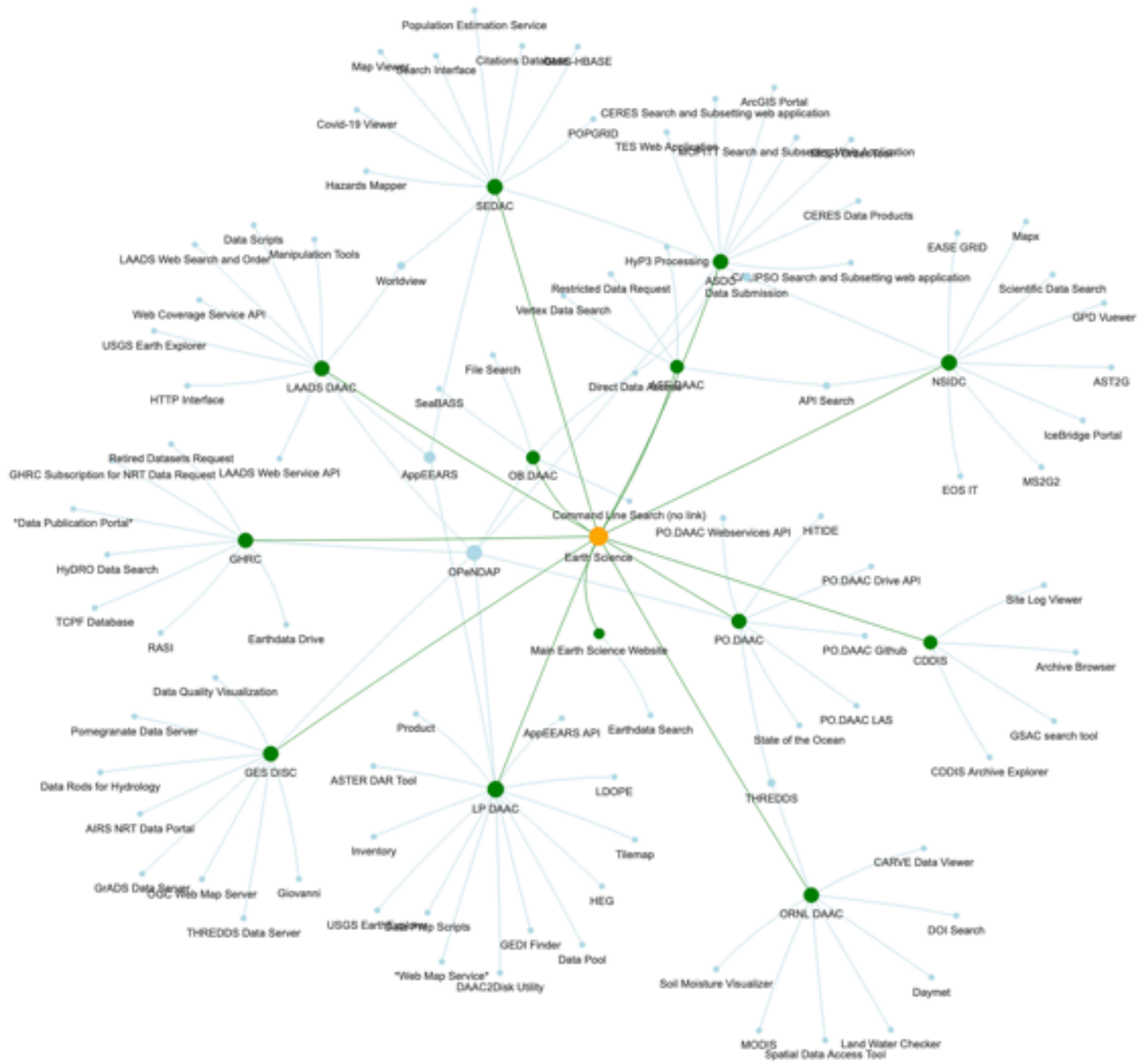


As you can see even the basics are very complicated. See IN45H-0520

We are also beginning to catalog all the many services provided by the myriad NASA data centers.

Dynamic version (https://nasa-smd-networks.s3.amazonaws.com/all_services_all_daacs_all_divs_network_1127.html) of this network (takes time to load).

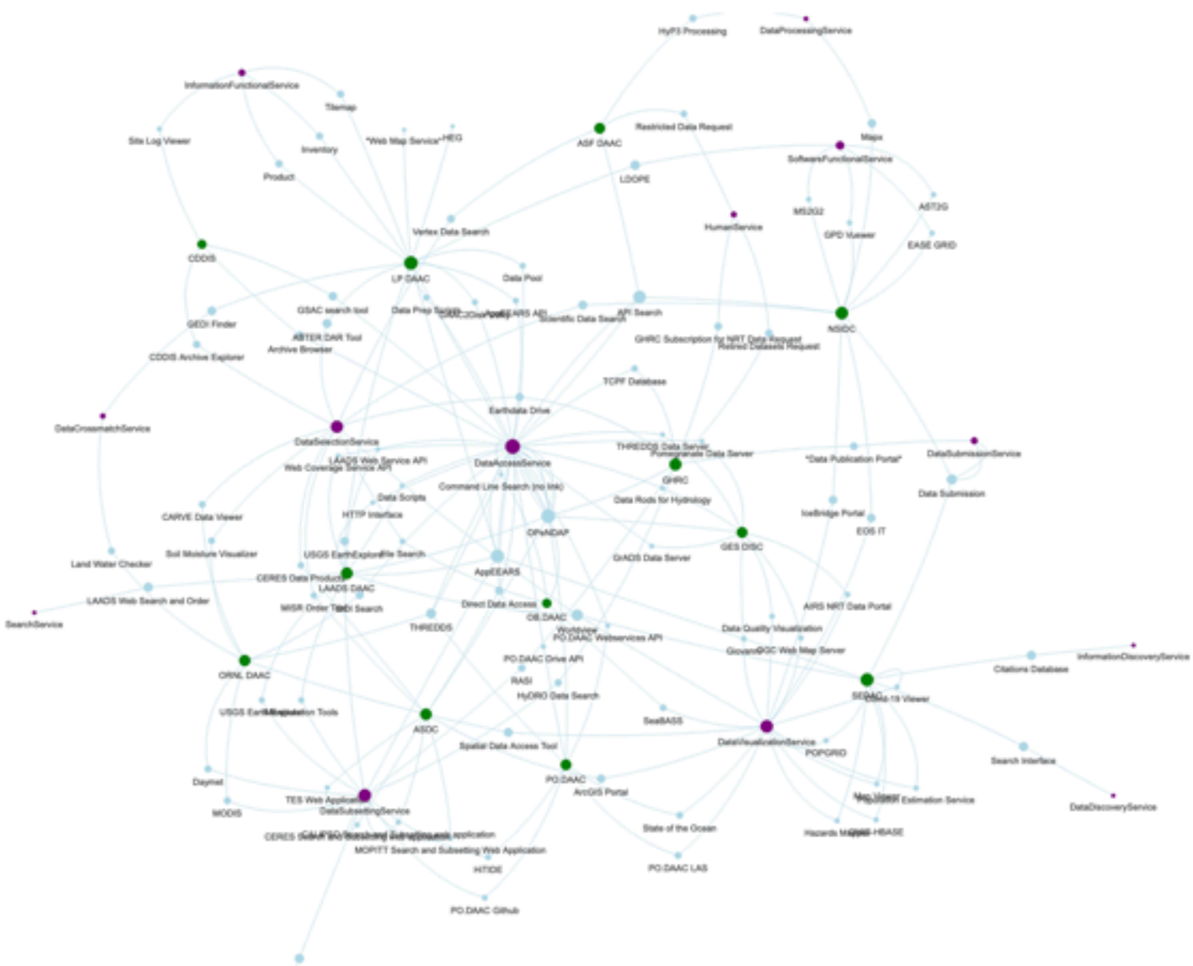
Here's a closer view at the Earth Science Division



Dynamic version (https://nasa-smd-networks.s3.amazonaws.com/all_services_all_daacs_EarthScience_network_1127.html) of this network.

We have also begun to classify the many types of services.

Here is a look at service types in the Earth Science Division showing some level of shared services and areas warranting further exploration:

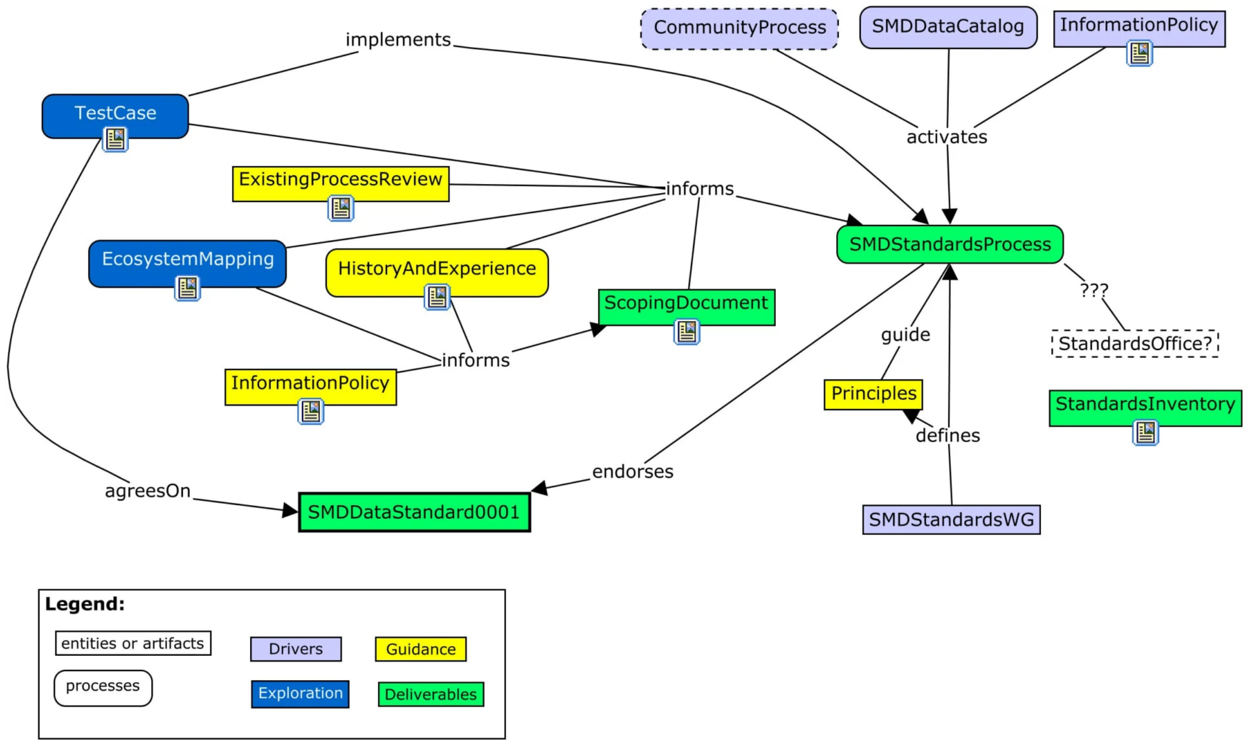


Dynamic version (https://nasa-smd-networks.s3.amazonaws.com/all_services_all_daacs_EarthScience_serviceTypes_network_1127.html) of this network.

This is very early exploration. Ideally it would continue as part of an ongoing SMD standards process. Already we can begin to see areas where standardization could improve data discovery and interoperability, whether it be simple things like consistent Earth date and time descriptions or more sophisticated technologies like the broad use of OpenDAP across the Earth Science Division.

INTRODUCTION: METHODOLOGY AND SCOPE

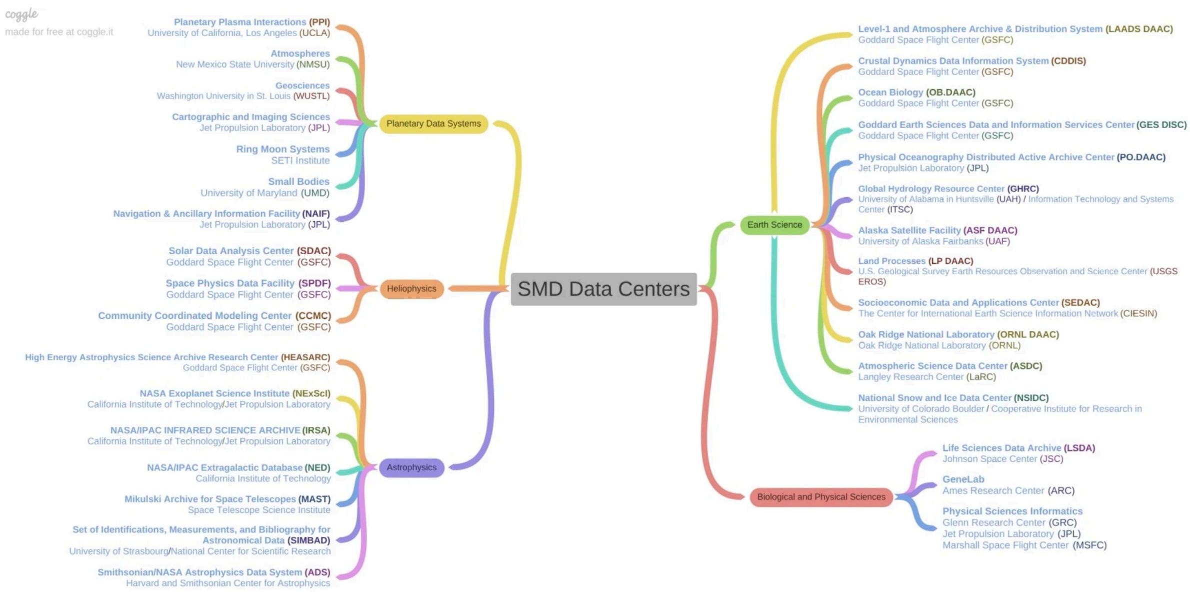
Developing, maintaining, and implementing standards is a complex, ongoing socio-technical process. Correspondingly, developing an effective standards process requires a holistic, interconnected view.



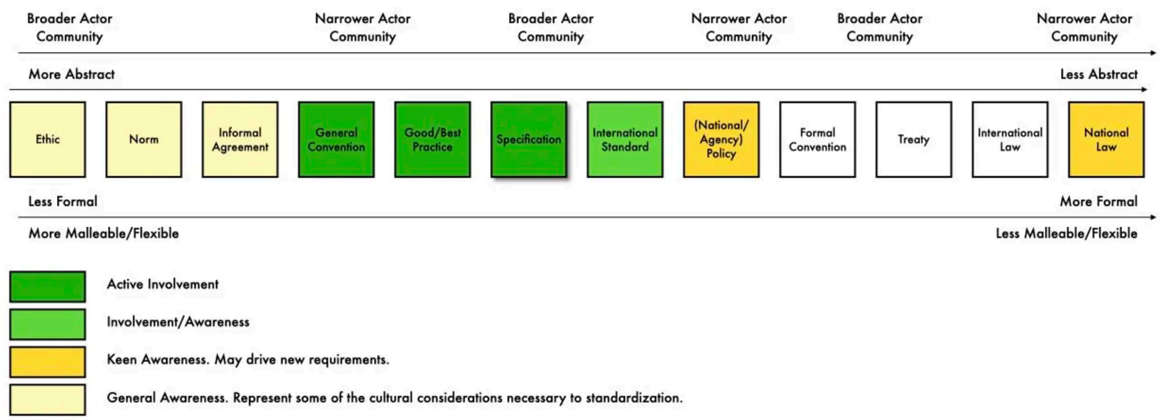
This figure presents a conceptual view of how we use multiple processes and artifacts to develop a standards process for NASA's Science Mission Directorate (SMD). The figure with links to detailed resources is available here (https://cmapscloud.ihmc.us/viewer/cmap/1XJW5M8G6-26PTXYJ-8L3).

Scope

All of the archives in the five divisions of the NASA Science Misison Directorate



But focussed on data-related conventions, leading practices, and specifications.



Definitions

Ethic: a system or set of moral principles; (in weaker sense) a set of social or personal values. Examples: Open science, reproducibility.

Norm: a recurrent pattern of social behaviour that is accepted in or expected of a group. Examples: citation, public presentation of research

Informal Agreement: an arrangement made between two or more parties and agreed by mutual consent. Examples: PID registration, federated search systems

General Convention: a rule or practice based upon general consent, or accepted and upheld by society at large. Examples: commonly accepted vocabularies, routine data transfer protocols, general business practices

Best/Leading Practice: defined procedures that are accepted or prescribed as being correct or currently most effective. Examples: Data management plan guidelines, SOPs, community accepted methods

Specification: an established norm or requirement for a repeatable technical task. It is usually a formal document that establishes uniform engineering or technical criteria, methods, processes, and practice. Examples: metadata profiles, defined semantics, code libraries

International Standard: an internationally recognized [through a formal organization] exemplar or definition of correctness, consistency, or some definite degree of any quality. Examples: ISO19115, definition of a meter, standard water (or whatever substance), OAIS

Formal Convention: an agreement between different countries that is legally binding to the contracting States. Examples: UN Convention on the Law of the Sea,

Treaty: a contract between two or more states, relating to peace, truce, alliance, commerce, or other international relation. Examples: NATO agreement

National/Agency policy -- a principle or course of action advocated and adopted by a government or agency. Examples: NASA information policy, OSTP rule.

International Law (legal instrument) (the body or branch of law concerned with dealings between nations; a law of this kind).

National Law a binding rule or body of rules prescribed by the government of a sovereign state that holds force throughout the regions and territories within the government's dominion. Example: Evidence act.

TRYING OUT THE PROCESS — A TEST CASE

Identifiers for Data Citation

While exploring the broad landscape we also examine a "simple" test case for the process.

The SMD information policy states:

1. SMD-funded data collections shall be citable using a persistent identifier, and SMD should encourage that data users to cite the sources of the information used to conduct peer-reviewed, published research.

2. SMD-funded data shall be indexed as part of the NASA catalog of data.

This raises the questions of which identifier? How? What is to be identified/citable?

Data citation is an increasingly common practice and is a requirement of AGU journals. DOIs are broadly used across NASA to facilitate data citation at least at a high level of aggregation (i.e., the collection level). Nonethelss, citation is still an emerging practice and different disciplines use DOIs in different ways.

Early work suggests:

- The primary object of reference varies across disciplines. For example, in Astronomy the paper often contains the data. Some disciplines are also developing data journals.

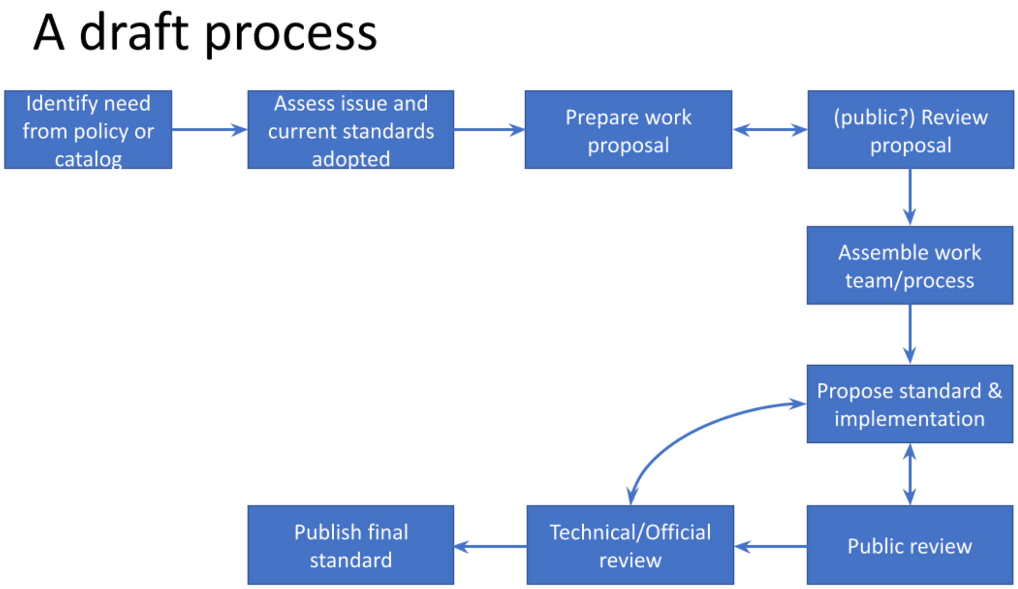
- Credit practices vary widely across disciplines

- It is essential to separate concerns and keep the scope of the standards effort tightly focussed

- Here we focus on a specific recommendation of which identifier(s) to use for data citation and a general process for assigning and maintaining the ID. We only provide general guidance on the nature of the "object" to be identified. We avoid credit and other more general aspects of citation.

THE WAY FORWARD

We have drafted an initial process and clarified roles and authorities. Scoping the process to explicitly deal with standards to implement the information policy and data catalog provided clearer lines of authority and responsibility.



This simplistic figure belies the **immense complexity** of NASA's scientific enterprise. **Scaling** of the process will be a formidable challenge. Continuing to define and explore the NASA data ecosystem can help us prioritize.

New communities of data professionals across NASA will need to emerge and foster cross disciplinary communication and collaboration. i.e the core functions of informatics. Much of these needs to be conducted informally but it will also require formal coordination, perhaps through an SMD standards office.

Data centers are understandably cautious of new requirements. Budgets will need to accomodate approriate **transitioning of legacy systems and ongoing maintenance.**

Standardization needs to be viewed as an ongoing operational activity in data curation and stewardship.

"Standardization is dynamic, not static; it means not to stand still but to move forward together."

1920's motto for the Engineering Standards Committe (precursor to ANSI)

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ABSTRACT

Open, interdisciplinary science inevitably relies heavily on standards. Standards are those often unseen agreements that we take for granted when systems and processes are working fine. Yet standards work is perpetual, laborious, and sometimes contentious, especially for standards to work across diverse disciplines. Standards development, maintenance, and implementation is a complex, ongoing socio-technical process.

NASA has developed a progressively open science policy and strategy that calls for the establishment of a data standards process reaching across the five diverse divisions of the Science Mission Directorate. This is a delicate exercise. We, therefore, seek to apply a holistic yet pragmatic approach to developing and maintaining a standards process.

We adopt an ecological philosophy that focuses on the interactions within the data ecosystem and how standards facilitate those interactions. We couple high-level analysis with on the ground experimentation.

We began by 1) mapping information ecosystem components (e.g. data centers, missions, services, protocols, users), 2) establishing how the components interact (e.g. sharing (meta)data, funding, personnel exchange), and 3) modelling system dynamics (e.g. creation of products from multiple data centers, redundant processes, shared services). The goal is to apply understanding of the ecosystem to real world applications (e.g. planning a new mission, implementing new policy requirements, improving process efficiency, etc.). We have also conducted studies of historical standardization efforts, documenting lessons learned and cautionary tales.

We then contrast this more abstract work with real examples. We reviewed and assessed multiple existing standards development processes both within and external to NASA. We now work to implement an initial test process which can be further optimized. We seek to define a consistent approach for assigning persistent identifiers for research objects, especially for the purposes of citation. The experience from this relatively ‘simple’ test case adds a pragmatic perspective on how researchers and engineers actually work.

This presentation will review the details of this methodology and our initial findings.