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PRACTICE PAPER

Building Open Access to Research (OAR) Data Infrastructure at NIST

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As a National Metrology Institute (NMI), the USA National Institute of Standards and Technology (NIST) scientists, engineers and technology experts conduct research across a full spectrum of physical science domains. NIST is a non-regulatory agency within the U.S. Department of Commerce with a mission to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. NIST research results in the production and distribution of standard reference materials, calibration services, and datasets. These are generated from a wide range of complex laboratory instrumentation, expert analyses, and calibration processes. In response to a government open data policy, and in collaboration with the broader research community, NIST has developed a federated Open Access to Research (OAR) scientific data infrastructure aligned with FAIR (Findable, Accessible, Interoperable, Reusable) data principles. Through the OAR initiatives, NIST's Material Measurement Laboratory Office of Data and Informatics (ODI) recently released a new scientific data discovery portal and public data repository. These science-oriented applications provide dissemination and public access for data from across the broad spectrum of NIST research disciplines, including chemistry, biology, materials science (such as crystallography, nanomaterials, etc.), physics, disaster resilience, cyberinfrastructure, communications, forensics, and others. NIST's public data consist of carefully curated Standard Reference Data, legacy high valued data, and new research data publications. The repository is thus evolving both in content and features as the nature of research progresses. Implementation of the OAR infrastructure is key to NIST's role in sharing high integrity reproducible research for measurement science in a rapidly changing world.

Keywords: Data Repository; FAIR; research metadata; metrology; data portal; government

Introduction

NIST research is predominantly characterized as "long tail" in terms of the data produced, i.e., small datasets that are highly varied in topic and content (Genova & Horstman 2016). This is colloquially described as "a mile wide and an inch deep" and may be classified as big data in context of variety and veracity. Newer, more modern laboratory instrumentation such as nuclear magnetic resonance spectrometers, electron microscopes, synchrotron beamlines, and high-performance computers usher NIST into the realm of managing the velocity and volume of big data. Furthermore, new strategic initiatives in the areas of artificial intelligence (AI) require an infrastructure designed to support digital mining and transformation. Management and exchange of the underlying research domain-specific data with both internal and external communities are important considerations for the OAR architecture and implementation.

The overarching goal of OAR is to deliver a robust research data infrastructure to share the results of NIST research with the community at large. Our strategy for achieving this goal involves collaborative data science as demonstrated through usage statistics from astronomical archives' data discovery and access patterns (White et al. 2010). Organizations face many challenges striving to balance rapid advancements in technology and data driven research with internal operational costs and constraints. To meet these challenges, NIST assembled a diverse group of experts with key leaders and engaged stakeholders via cross-organizational advisors. This resulted in a joint effort to build an integrated system engineered to support data workflow processes, systems infrastructure, and public dissemination with secure publicly accessible platforms for scientific collaboration.

At the onset of the OAR project, priority was placed on developing a system that would allow us to comply with government open data policy (OMB M-13-13). This resulted in a baseline Minimum Viable Product (MVP), delivering a NIST public data listing (PDL) which enforces adherence to a new government data standard semantic model, the Project Open Data (POD) schema. The NIST PDL continues to be routinely harvested by the Department of Commerce and made available through the US data.gov web portal, which hosts records of all POD-compliant government public datasets. Following enactment of the OPEN Government Data Act (2019), updates and compliance of our OAR infrastructure will be further advanced.

However, to achieve FAIR capabilities (Wilkinson et al. 2016), the OAR infrastructure supporting a science data portal and public data repository was designed to extend the limited MVP to include standard open formats, protocols, and demonstrated best practices in data management and publication to harness the full potential for community re-use of NIST research data products. The data portal provides both discovery and data access (distribution) capabilities through a science-oriented web user interface and REST ('Representational state transfer' 2019) application programming interfaces (APIs). The repository enables interoperability for scientific disciplines such as crystallography, biology, and chemistry as shown in the organization context (**Figure 1**) by supporting programmatic access to semantically rich data structures captured through the NIST data publication process. Key to the reuse of these data is the implementation of data citation for each of the records along with provenance metadata and link to usage policy.

Architecture

The OAR architecture is in large part consistent with the consolidated Federal Enterprise Architecture (FEA, OMB 2013) reference models. FEA systems are fundamentally designed to identify common assets and shared technologies through a combination of enterprise class and open source solutions to ensure long term sustainability. In the case of OAR, FEA implementation was achieved through process models, data and logical workflows, application design and host infrastructure, architected to synergistically address stakeholder requirements. Adopting this robust architecture has demonstrated through iterative improvements in the OAR design, e.g. data review, usability features, that this model facilitates sustainability. Using agile methods, change may occur independently targeting different aspects of the FEA to streamline and modernize functionality. One realization with OAR maintenance is the risk associated with COTS enterprise solutions, i.e., budgeting funds for high license costs and rigidity in functionality, whereas the open source platforms are demonstrating benefit in the broader community context in keeping pace with evolving technologies especially in the areas of standard data semantic, syntactic, and schematic practices.

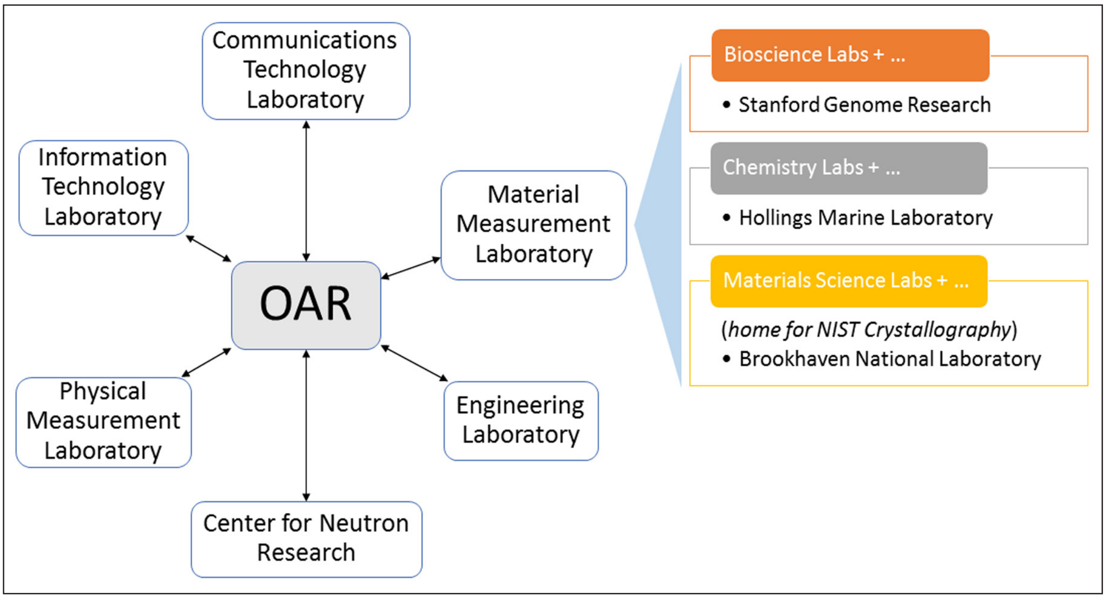

Communications Technology Laboratory
Information Technology Laboratory
Material Measurement Laboratory
OAR
Physical Measurement Laboratory
Engineering Laboratory
Center for Neutron Research
Bioscience Labs + ...
• Stanford Genome Research
Chemistry Labs + ...
• Hollings Marine Laboratory
Materials Science Labs + ...
(home for NIST Crystallography)
• Brookhaven National Laboratory

Figure 1: NIST OAR organizational context. NIST laboratory sites are in USA Gaithersburg, Maryland and Boulder, CO in addition to partner remote site locations as listed in the figure.

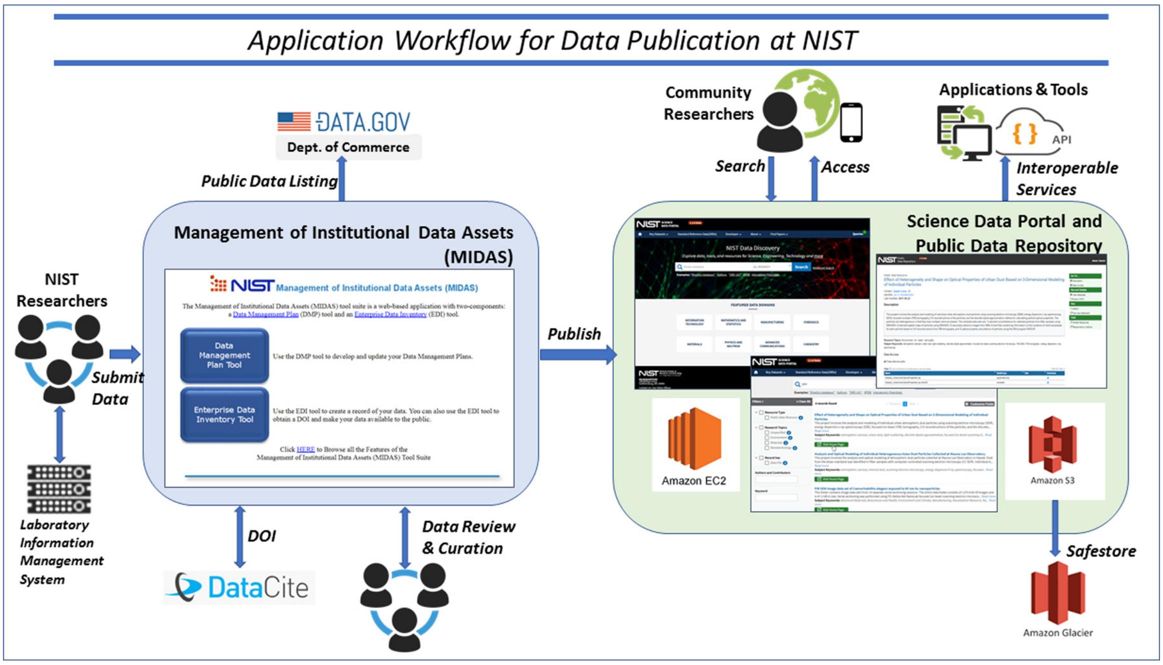
Figure 2 illustrates the high-level OAR application workflow for data publication. NIST researchers upload data products (files and metadata), which are generated from their Laboratory Information Management Systems (LIMS), to the OAR infrastructure via the NIST Management of Institutional Data Assets (MIDAS) tool. MIDAS also manages the data review process, and reporting/accountability for determining compliance with policies. Persistent identifiers are automatically assigned through a direct service interface to DataCite. Following approval from the review and curation processes, data are automatically preserved through a publishing service to the Public Data Repository (PDR) in a standard BagIt format (Plante et al. 2019). The public repository datasets may subsequently be discovered through the Scientific Data Portal (SDP) on the NIST website (https://data.nist.gov). NIST has implemented the government-recommended cloud strategy (https://cloud.cio.gov/strategy/) as part of the OAR infrastructure, such that the OAR preserved datasets are hosted in a NIST Amazon Web Service (AWS) public enclave using the AWS Simple Cloud Storage Service (S3), and data are additionally copied to AWS Glacier storage as a long term "safestore". The AWS Elastic Compute Cloud (EC2) server platform is used to host the repository and science data portal applications.

OAR Implementation

The OAR project design was initiated in 2015 and completed a basic MVP release in 2017. The initial development phase involved a handful of dedicated staff which focused on production of the MVP and high priority features defined from inputs of the key stakeholders. As the system matured to include the described features in this article, additional shared staff resources have contributed to advance the capabilities for preservation, discovery and distribution services. Using an agile methodology, requirements are refactored into the system evolution based on testing and feedback collected from NIST science staff, organizational decision makers and external users.

The OAR data portal and public data repository were implemented with a use case driven design approach. At the conceptual level, a data taxonomy was established as a guideline for preservation, review, and discoverability requirements for NIST data (**Figure 3**). This coarse hierarchy, mapped into common use cases for research data, serves to orient users how the OAR systems support the research lifecycle.

The OAR data publication workflow is composed of modular system components which include many best practices of data management systems such as review, curation, cataloging, indexing, preservation, discovery, filtering, and access. The data portal and public data repository applications are designed and developed using open source software as documented in public NIST OAR Github repositories (https://github.com/usnistgov/oar-sdp & https://github.com/usnistgov/oar-pdr). As shown in **Figure 4**, the Science Data Portal (SDP) web user interface is customized to provide discovery and access to the NIST research domain datasets.


Application Workflow for Data Publication at NIST
DATA.GOV
Dept. of Commerce
Public Data Listing
Community Researchers
Search
Access
Applications & Tools
API
Interoperable Services
NIST Researchers
Submit Data
Laboratory Information Management System
Management of Institutional Data Assets (MIDAS)
NIST Management of Institutional Data Assets (MIDAS)
Data Management Plan Tool
Enterprise Data Inventory Tool
Publish
Science Data Portal and Public Data Repository
Amazon EC2
Amazon S3
Safestore
Amazon Glacier
DOI
DataCite
Data Review & Curation

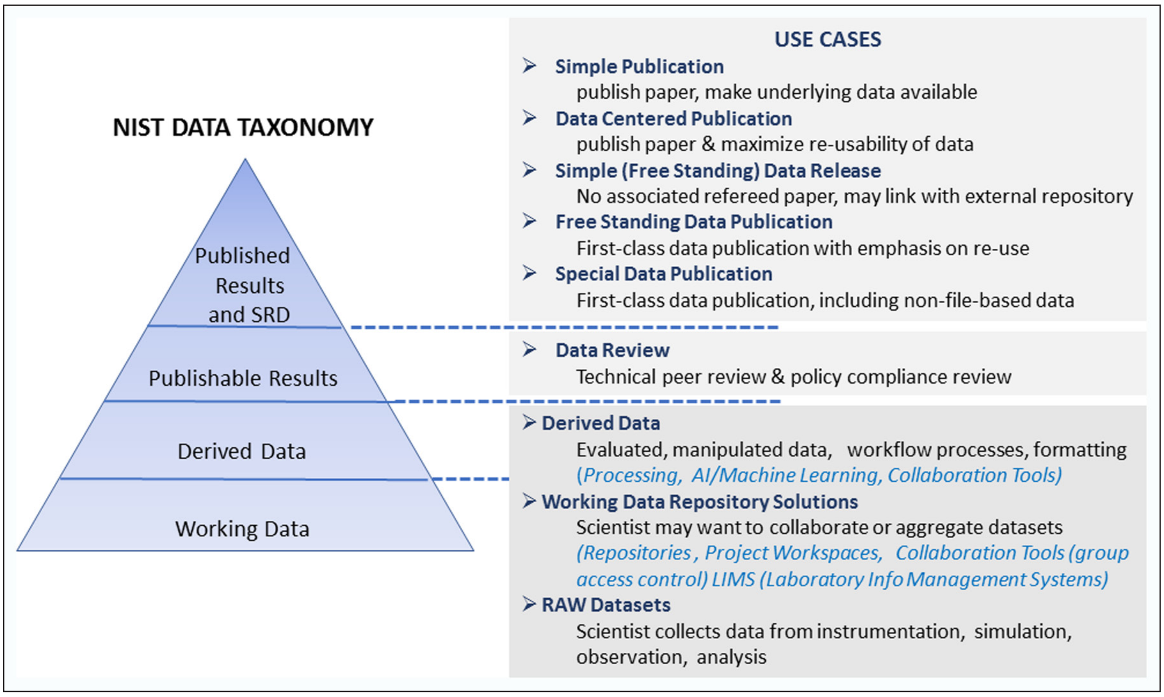
The Management of Institutional Data Assets (MIDAS) tool suite is a web-based application with two-components: a Data Management Plan (DMP) tool and an Enterprise Data Inventory (EDI) tool.

Use the DMP tool to develop and update your Data Management Plans.

Use the EDI tool to create a record of your data. You can also use the EDI tool to obtain a DOI and make your data available to the public.

Click HERE to Browse all the Features of the Management of Institutional Data Assets (MIDAS) Tool Suite

Figure 2: NIST data publication workflow showing external resource interfaces.



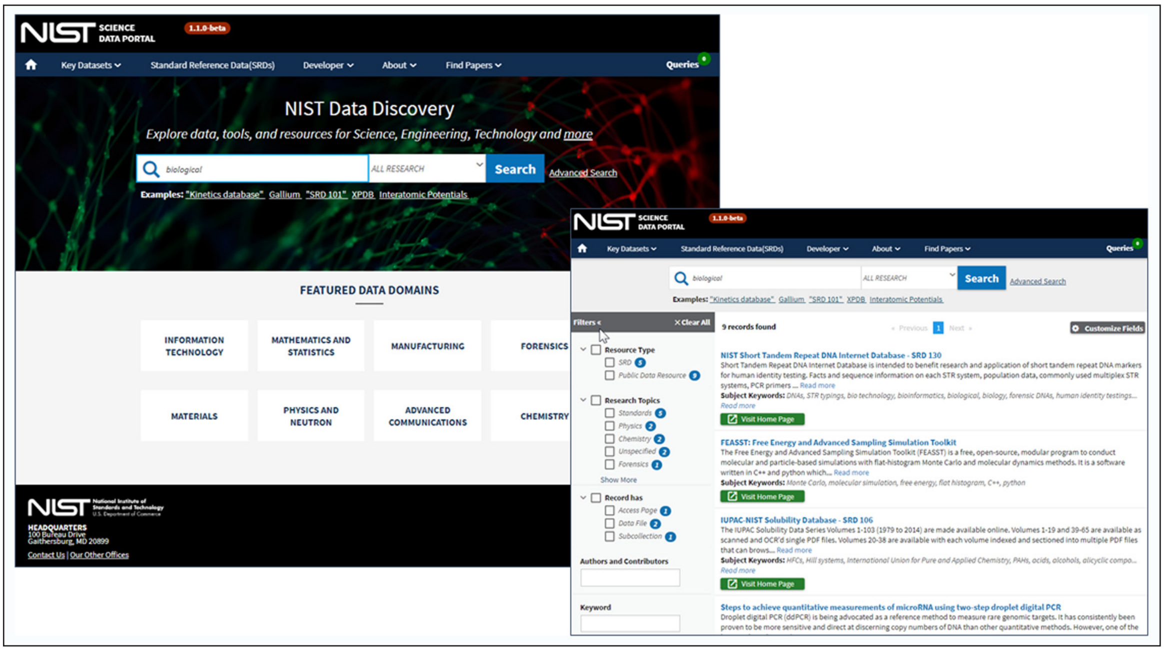
USE CASES

- Simple Publication
  publish paper, make underlying data available
- Data Centered Publication
  publish paper & maximize re-usability of data
- Simple (Free Standing) Data Release
  No associated refereed paper, may link with external repository
- Free Standing Data Publication
  First-class data publication with emphasis on re-use
- Special Data Publication
  First-class data publication, including non-file-based data

- Data Review
  Technical peer review & policy compliance review

- Derived Data
  Evaluated, manipulated data, workflow processes, formatting *(Processing, AI/Machine Learning, Collaboration Tools)*
- Working Data Repository Solutions
  Scientist may want to collaborate or aggregate datasets *(Repositories, Project Workspaces, Collaboration Tools (group access control) LIMS (Laboratory Info Management Systems)*
- RAW Datasets
  Scientist collects data from instrumentation, simulation, observation, analysis

Figure 3: NIST data taxonomy pyramid for preservation, review, and discoverability requirements.



NIST Data Discovery

Explore data, tools, and resources for Science, Engineering, Technology and more

Examples: "Kinetics database" Gallium "SRD 101" XPDB Interatomic Potentials

HEADQUARTERS
100 Bureau Drive
Gaithersburg, MD 20899

9 records found

NIST Short Tandem Repeat DNA Internet Database - SRD 130
Short Tandem Repeat DNA Internet Database is intended to benefit research and application of short tandem repeat DNA markers for human identity testing. Facts and sequence information on each STR system, population data, commonly used multiplex STR systems, PCR primers .... Read more
Subject Keywords: *DNAs, STR typings, bio technology, bioinformatics, biological, biology, forensic DNAs, human identity testings... Read more*

FEASST: Free Energy and Advanced Sampling Simulation Toolkit
The Free Energy and Advanced Sampling Simulation Toolkit (FEASST) is a free, open-source, modular program to conduct molecular and particle-based simulations with flat-histogram Monte Carlo and molecular dynamics methods. It is a software written in C++ and python which... Read more
Subject Keywords: *Monte Carlo, molecular simulation, free energy, flat histogram, C++, python*

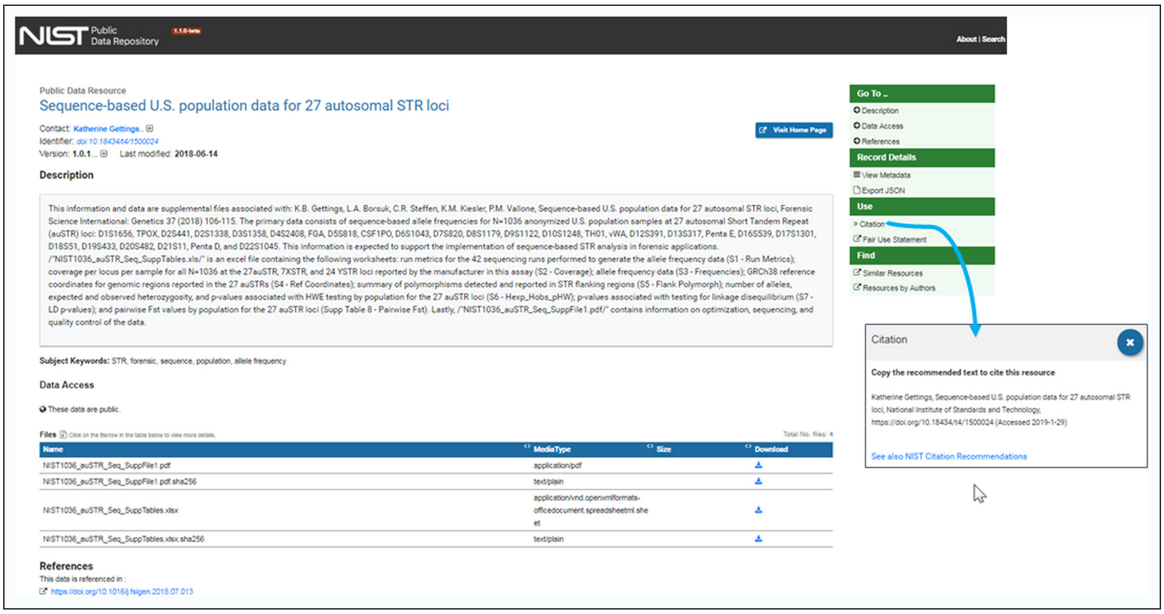
IUPAC-NIST Solubility Database - SRD 106
The IUPAC Solubility Data Series Volumes 1-103 (1979 to 2014) are made available online. Volumes 1-19 and 39-65 are available as scanned and OCR'd single PDF files. Volumes 20-38 are available with each volume indexed and sectioned into multiple PDF files that can brows... Read more
Subject Keywords: *HFCs, Hill systems, International Union for Pure and Applied Chemistry, PAHs, acids, alcohols, alicyclic compo... Read more*

Steps to achieve quantitative measurements of microRNA using two-step droplet digital PCR
Droplet digital PCR (ddPCR) is being advocated as a reference method to measure rare genomic targets. It has consistently been proven to be more sensitive and direct at discerning copy numbers of DNA than other quantitative methods. However, one of the

Figure 4: 'Search' and 'Search Results' screenshots from the NIST OAR Science Data Portal homepage (https://data.nist.gov).

The SDP homepage provides a search capability and menu links to NIST key datasets (including Standard Reference Data), developer information for software and APIs, and NIST manuscript publications.

Search results are displayed with faceted filtering including categories for science research discipline, author, and record subcomponents. By selecting a record from the result list, a user is seamlessly navigated to a dynamically generated Public Data Repository (PDR) web "landing page" (**Figure 5**), a user-friendly presentation of the record metadata. The landing page URL is a RESTful endpoint and may serve as the resolved publication endpoint for the data DOI. The PDR landing page also includes a data access section for view and linked access to the data files' distribution URLs. **Figure 5** shows a Citation link, in the landing page's right menu bar, to a preformatted citation for each resource that can be copied for reference to the data publication.



Public Data Resource

Sequence-based U.S. population data for 27 autosomal STR loci

Contact: Katherine Gettings..

Identifier: doi:10.18434/t4/1500024

Version: 1.0.1... Last modified: 2018-06-14

Description

This information and data are supplemental files associated with: K.B. Gettings, L.A. Borsuk, C.R. Steffen, K.M. Kiesler, P.M. Vallone, Sequence-based U.S. population data for 27 autosomal STR loci, Forensic Science International: Genetics 37 (2018) 106-115. The primary data consists of sequence-based allele frequencies for N=1036 anonymized U.S. population samples at 27 autosomal Short Tandem Repeat (auSTR) loci: D1S1656, TPOX, D2S441, D2S1338, D3S1358, D4S2408, FGA, D5S818, CSF1PO, D6S1043, D7S820, D8S1179, D9S1122, D10S1248, TH01, vWA, D12S391, D13S317, Penta E, D16S539, D17S1301, D18S51, D19S433, D20S482, D21S11, Penta D, and D22S1045. This information is expected to support the implementation of sequence-based STR analysis in forensic applications. /"NIST1036_auSTR_Seq_SuppTables.xls/" is an excel file containing the following worksheets: run metrics for the 42 sequencing runs performed to generate the allele frequency data (S1 - Run Metrics); coverage per locus per sample for all N=1036 at the 27auSTR, 7XSTR, and 24 YSTR loci reported by the manufacturer in this assay (S2 - Coverage); allele frequency data (S3 - Frequencies); GRCh38 reference coordinates for genomic regions reported in the 27 auSTRs (S4 - Ref Coordinates); summary of polymorphisms detected and reported in STR flanking regions (S5 - Flank Polymorph); number of alleles, expected and observed heterozygosity, and p-values associated with HWE testing by population for the 27 auSTR loci (S6 - Hexp_Hobs_pHW); p-values associated with testing for linkage disequilibrium (S7 - LD p-values); and pairwise Fst values by population for the 27 auSTR loci (Supp Table 8 - Pairwise Fst). Lastly, /"NIST1036_auSTR_Seq_SuppFile1.pdf/" contains information on optimization, sequencing, and quality control of the data.

Subject Keywords: STR, forensic, sequence, population, allele frequency

Data Access

These data are public.

Files Click on the file/row in the table below to view more details. Total No. files: 4

Name	MediaType	Size	Download
NIST1036_auSTR_Seq_SuppFile1.pdf	application/pdf		⬇
NIST1036_auSTR_Seq_SuppFile1.pdf.sha256	text/plain		⬇
NIST1036_auSTR_Seq_SuppTables.xlsx	application/vnd.openxmlformats-officedocument.spreadsheetml.sheet		⬇
NIST1036_auSTR_Seq_SuppTables.xlsx.sha256	text/plain		⬇

References

This data is referenced in :

https://doi.org/10.1016/j.fsigen.2018.07.013

Citation

Copy the recommended text to cite this resource

Katherine Gettings, Sequence-based U.S. population data for 27 autosomal STR loci, National Institute of Standards and Technology, https://doi.org/10.18434/t4/1500024 (Accessed 2019-1-29)

See also NIST Citation Recommendations

Figure 5: NIST Public Data Repository single record "landing page", showing a citation available through linked navigation. The RESTful URL example is shown (https://data.nist.gov/od/id/6998B81EF78777B2E05324570681D4DC1911).

License and access rights are included in the record metadata and more broadly described in another link to the Fair Use Statement, also shown in **Figure 5** just below the Citation. Since these data are public, there are no licensing restrictions.

Domain Interoperability

The NIST Public Data Repository was designed to enable data interoperability as much as possible in order to maximize the usability of NIST data. To be usable, the data needs to tell its story in the language of not only the community it was intended for but also that of related communities that might apply it to cross-disciplinary research. This is particularly challenging for NIST data, given the broad spectrum of research domains that we serve. Nevertheless, we strove for a design that allows us to easily support common practices for interoperability, including (1) the export of metadata in multiple community formats and schemas, (2) support for community protocols for metadata harvesting, and (3) support for Google-like harvesting by embedding scrape-able metadata directly into dataset landing pages. Obviously, how we manage and share metadata is central to that interoperability.

We designed our repository's internal metadata schema and format with an eye for interoperability—in particular, to make it easy to convert to different standard formats and support new formats and protocols over time. We refer to the schema as the NIST Extensible Resource Data Model (NERDm). NERDm metadata is formatted as JSON-LD (Sporny et al. 2014); this allows us to link every term in our schema to a concept in a documented community vocabulary or ontology. NERDm most closely resembles the POD schema which was designed for describing data resources provided by the US Government and which, naturally, we need to support. (POD itself is based heavily on the DCAT ontology (Maali & Erickson 2014)). Beside supporting the usual DCAT/Dublin Core concepts, the NERDm schema provides explicit places to include a variety of persistent identifiers, including DOIs, ORCIDs, and long-term URLs. The NERDm schema itself is defined using JSON schema (JSON Schema 2018); links to the schema documents as well as detailed documentation are available from our NERDm information page (https://data.nist.gov/od/dm/nerdm).

As its name suggests, extensibility is a key feature of NERDm and central in our strategy for enabling interoperability. There are three mechanisms for creating extensions of the core schema to support domain-specific metadata:

1. *Extensions that leverage linked data semantics.* NERDm supports a mechanism for plugging in schema extensions. This allows us to create extensions that support specific research domains. A metadata document formatted in JSON-LD includes a *context*—a built-in link to a kind of data dictionary—which relates metadata tags used in the document to predefined concepts. We use this

mechanism to create extensions that can point to domain-specific ontologies. This allows generic linked-data clients to integrate metadata from different sources that refer to the same domain-specific concepts.

2. *Hooks for including domain-specific vocabulary terms.* The NERDm schema in various places includes a metadata tag named *topic*. It is a place to include descriptive keywords drawn from existing but arbitrary domain-specific vocabularies. Built into the *topic* element is an identifier for the vocabulary it was drawn from. Thus domain-specific vocabulary terms can be attached to individual files, data interfaces, or data collections as a whole.
3. *Leveraging external metadata types with JSON schema.* The NERDm extension framework allows us to make use of data types defined with JSON schema external to and independent of the NERDm schema. Using an enhanced JSON schema notation (Plante 2017), we can, in a NERDm metadata document, point to the location of the JSON schema that it conforms to. This allows us to embed directly terms from other JSON schema-based schemas (e.g. https://biocaddie.org/) directly into our metadata documents.

These techniques can be helpful to users and clients that might use our NERDm-formatted metadata directly; however, users are expected to be drawn more to the common formats of their own communities. The extension techniques are important to us internally because they make offering on-the-fly conversion to these formats easier; because the schema was assembled (and is being extended) from existing community concepts at the outset, we are not faced with an expensive "cross-walking" exercise to determine how to do the conversion. By supporting existing vocabularies and data types as directly as possible, it becomes easy to include metadata from multiple communities simultaneously, even if they cover the same, though variously nuanced, concepts.

Conclusions

The implementation of the OAR scientific data infrastructure allows NIST scientists and professionals the means to share research data using standards and best practices adopted in the scientific community. This will help foster both national and international scientific collaborations, such as the Research Data Alliance and CODATA organizations along with industry and academic partnership. NIST's leadership in metrology and standards will be more broadly distributed through the FAIR OAR infrastructure. We envision new data metrology methods will manifest for uncertainty and quality assessments aligning OAR with NIST objectives across discipline areas.

The initial release of the science data portal and public data repository has demonstrated value across NIST's laboratories through reuse of open source solutions in congruence with securely managed government systems. Scientific staff have contributed positive feedback to these system capabilities which we attribute to striking a balance between what is required and personal benefit in giving credit and visibility to their research outputs. While there remains a learning curve for what it means to create high quality reusable data, we are seeing a steady increase in take-up from preliminary metrics. Data curation challenges are expected as these systems mature and NIST science data grows in capacity with modern instrumentation and theoretical computations output. We anticipate the OAR FAIR solution will facilitate the use of AI and machine learning applications and help solve many complexities in mining data rich resources. Natural language processing, semantic models, and algorithms will be simpler to build and execute across linked-data space. OAR is designed with a long-term vision to provide a rich infrastructure where creative data driven capabilities will foster new science. We must therefore collectively ensure our FAIR systems provide robust, reliable, and accurate data to maintain scientific integrity and safeguard our expertise.

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The authors would like to express their appreciation to the many NIST collaborators involved in development of the OAR infrastructure, in particular the NIST Information Services Office (ISO), the NIST Office of Information Systems Management (OISM NIST), the Associate Director for Laboratory Programs (ADLP), and especially Prometheus Computing LLC for sharing expertise in technology and software engineering. They also appreciate comments from reviewers and acknowledge the organizing committee of "SciDataCon 2018" for arranging this special issue of the *CODATA Data Science Journal*, following SciDataCon, held in Gabarone, Botswana in November 2018.

Competing Interests

The authors have no competing interests to declare.

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Gretchen Greene is project manager for the Open Access to Research and lead for development of the Data Dissemination and Public Access systems.

Raymond Plante is the technical lead for the design and development of the NIST Public Data Repository.

Robert Hanisch is Director of the Office of Data and Informatics and a project science advisor for the Open Access to Research at NIST.

References

Genova, F and **Horstmann, W.** 2016. *Long Tail of Data – e-IRG Task Force Report*. Available at URL http://e-irg.eu/documents/10920/238968/LongTailOfData2016.pdf [Accessed 29 Jan 2019].

Maali, F and **Erickson, J.** 2014. *Data Catalog Vocabulary (DCAT), W3C Recommendation*. Available at URL https://www.w3c.org/TR/vocab-dcat/ [Accessed 29 Jan 2019].

Office of Management and Budget. 2013. *Federal Enterprise Architecture Framework version 2*. Available at URL https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/egov_docs/fea_v2.pdf [Accessed 29 Jan 2019].

Office of Management and Budget. 2013. *M-13-13 Memorandum for the Heads of Executive Departments and Agencies*. Available at URL https://project-open-data.cio.gov/policy-memo/ [Accessed 20 April 2019].

OPEN Government Data Act. 2019. *Foundations for Evidence-Based Policymaking Act of 2017 Title II*. Available at URL https://www.congress.gov/bill/115th-congress/house-bill/4174/text#toc-H8E449F-BAEFA34E45A6F1F20EFB13ED95 [Accessed 29 Jan 2019].

Plante, R. 2017. *EjsonSchema*. Available at URL https://github.com/usnistgov/ejsonschema [Accessed 20 Jan 2019].

Plante, R, Greene, G and **Hanisch, R.** 2019. The BagIt Packaging Standard for Interoperability and Preservation. In: *ADASS XXVIII ASP*, San Francisco, CA, in press.

'Representational state transfer'. 2019. *Wikipedia*. Available at URL: https://en.wikipedia.org/w/index.php?title=Representational_state_transfer&oldid=893532373 [Accessed 30 Apr 2019].

Sporny, M, Longley, D, Kellogg, G, Lanthaler, M and **Linstrom, N.** 2014. *JSON-LD 1.0: a JSON-based Serialization for Linked Data, W3C Recommendation*. Available at URL https://www.w3.org/TR/json-ld/ [Accessed 29 Jan 2019].

White, R, et al. 2010. The High Impact of Astronomical Data Archives. In: *Astro2010: The Astronomy and Astrophysics Decadal Survey, Position Papers, no. 64.*

Wilkinson, M, et al. 2016. The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data*, 3: 160018. DOI: https://doi.org/10.1038/sdata.2016.18

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