Summary Report: IGSN 2040 Project

Defining the Future of the IGSN as a Global Persistent Identifier for Material Samples

June 2021

This document summarizes findings and recommendations from the activities of the project “Defining the Future of the IGSN as a Global Persistent Identifier for Material Samples", referred to as IGSN 2040, that ran from August 2018 through March 2021. We acknowledge and thank the Alfred P. Sloan Foundation for their support.

Kerstin Lehnert, Columbia University, Lamont-Doherty Earth Observatory
Jens Klump, Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Sarah Ramdeen, Columbia University, Lamont-Doherty Earth Observatory
Lesley Wyborn, Australian National University
Laure Haak, Mighty Red Barn

Report prepared by:

Mighty Red Barn

Executive Summary

IGSN[1] (igsn.org) is a mission-driven non-profit organization whose core purpose is to enable transparent and traceable connections between samples, collections, data, publications, people and organizations through the use of an authoritative, trusted persistent identifier for samples.

The IGSN 2040 project,[2] carried out during 2018-2021 and funded by the Alfred P. Sloan[3] Foundation, was a community consultation dedicated to reviewing the core IGSN offering and developing a sustainability roadmap that establishes IGSN as a trusted research infrastructure that attracts, facilitates, and drives research discovery, innovation and advances.

The primary finding: IGSN e.V. should focus its scaling activities on community engagement, development of sample identifier practice standards, and encouraging adoption through third-party implementations and platforms. To support this strategy, IGSN e.V. is planning to establish a Samples Community and is exploring partnerships with complementary organizations, namely DataCite[4] and GBIF,[5] to provide scalable and sustained IGSN registration services, search and discoverability capabilities, and technical infrastructure.

This paper provides an overview of the history and goals of IGSN, summarizes the IGSN 2040 consultation technical findings, offers a Samples Community membership model, and outlines the proposed partnership with DataCite. It provides a transition roadmap, clarifies community governance and living will structures, and identifies key milestones and metrics for ensuring transition success and sustainability of the IGSN mission.

Implementation of the IGSN Sustainability Roadmap has already started. At its formal General Assembly on March 24, 2021, the IGSN e.V. membership voted unanimously in favor of moving forward with formal negotiations with DataCite, including formation of an oversight advisory committee. To ensure alignment, IGSN has carried out two surveys of its members. In addition, IGSN is participating in the 2021 GBIF Work Programme community consultation.

We thank the community for their support and participation in the IGSN 2040 project. We look forward with anticipation to this next phase of IGSN.

Kerstin Lehnert, Co-founder and IGSN President; Jens Klump, IGSN Vice President; Lesley Wyborn, Co-founder; and Sarah Ramdeen, IGSN Manager

[1] International GeoSample Number (IGSN) Webpage, https://igsn.org. Accessed 21 June 2021.
[2] IGSN 2040 Project Webpage. https://www.igsn.org/igsn-2040/. Accessed 21 June 2021.
[3] Lehnert K (2018) Defining the Future of the IGSN as a Global Persistent Identifier for Material Samples. Sloan Grant 8517 to Columbia University, https://sloan.org/grant-detail/8517. Accessed 21 June 2021.
[4] DataCite Webpage, https://datacite.org. Accessed 21 June 2021.
[5] Global Biodiversity Information Facility (GBIF) Webpage. Accessed 21 June 2021.

What is IGSN?

Unique sample identifiers are a key need for achieving interoperability between data systems, integrating sample descriptions with physical samples, and enabling search and discovery. In the earth sciences community, this need drove the creation of the IGSN concept - an identifier for physical samples - and, supported by a NSF grant in 2004, the development and launching of “a web-based digital registry for solid earth samples that will provide for the first time a way to uniquely name and identify samples on a global scale.” The System for Earth Sample Registration (SESAR) served as the initial geoscience sample cyberinfrastructure, and IGSN has subsequently evolved into a multiple-node global persistent identifier (PID) system adopted by a range of stakeholders, including researchers, collection curators, and data managers.

Since its inception, IGSN has been growing to meet community demand for its services (**Figure 1**). By 2021, IGSN member organizations had registered almost 10 million samples, and has been expanding to support additional research communities in archaeology, biodiversity, genomics, materials science, and planetary sciences.

Figure 1. IGSN Growth and Participation

Mission

The core purpose of IGSN is to enable transparent and traceable connections between samples, collections, data, publications, people and organizations through the use of an authoritative, trusted persistent identifier for samples. In this way, IGSN can drive research discovery, innovation and advances.

The IGSN vision is a world where physical samples are valued, uniquely identified, and linked into the scholarly ecosystem on a global scale to enhance their impact and to support transparent and reproducible research across disciplines, borders, and time.

IGSN provides an open, shared, and trusted globally unique persistent identifier system for physical samples, specimens, or artifacts in support of the advancement of knowledge.

Governance

IGSN services are operated by the International Geo Sample Number Implementation Organization (IGSN e.V.), established in 2011 in partnership between SESAR and organizations in Australia and Germany as an international, non-profit membership organization to operate and govern the IGSN central registration system.

Membership in the IGSN e.V. is open to all organizations that wish to allocate IGSNs and use the Registration Agency of the IGSN e.V. in their capacity as Allocating Agents. Affiliate Membership with an advisory function is offered to organizations who do not wish to use the IGSN eV Registration Agency as an allocating agent, but who have an interest in promoting and supporting the purposes of the IGSN e.V.

IGSN e.V. members are community implementers of IGSN registration services and have catalyzed the use of persistent identifiers for samples. Among the members of the IGSN e.V. are the geological surveys of the US, UK, Australia, and Korea; large data service providers including the Australian Research Data Commons and the GFZ German Research Centre for Geosciences; as well as research organizations, national labs, and universities.

Scaling for Sustainability: IGSN 2040

The IGSN e.V. is charged with providing a sustainable infrastructure for use by and benefit to its members. To support its growth, IGSN e.V. launched the IGSN 2040 project in 2018, funded by the Alfred P. Sloan Foundation, to "*achieve a trustworthy, stable, and adaptable architecture for the IGSN as a persistent unique identifier for material samples, both technically and organizationally, that attracts, facilitates, and satisfies participation within and beyond the Geosciences, that will be a reliable component of the evolving research data ecosystem, recognized as a trusted partner by data infrastructure providers and the science community alike.*"

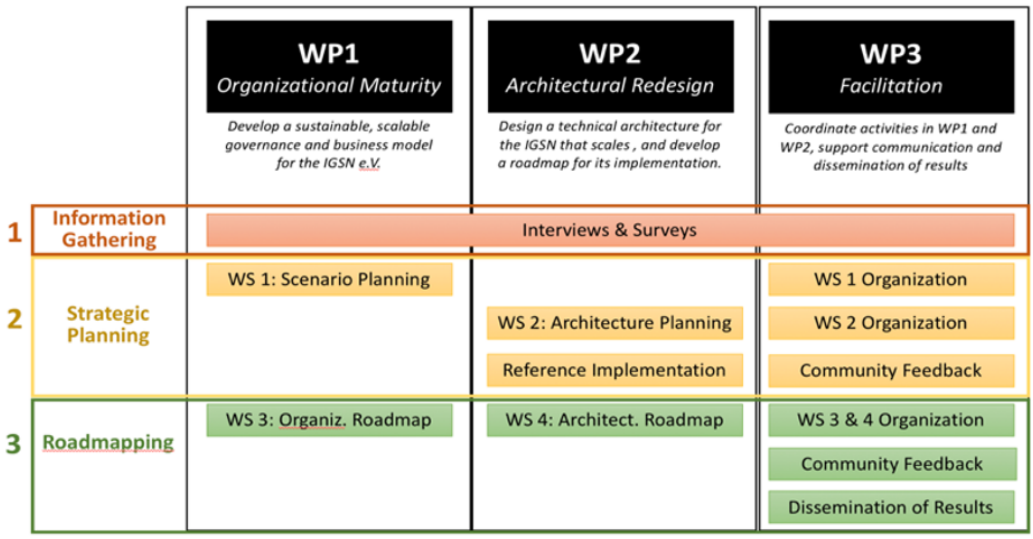

Figure 2. IGSN 2040 Work Plan.

The IGSN 2040 project work plan was structured in three sections (**Figure 2**). The primary output was development of the IGSN Sustainability Roadmap.

Work Package 1. The Organizational Steering Committee (see Appendix 1 for membership) hosted an Organizational workshop[6] in July 2019 that refined a mission statement and associated driving values and requirements for IGSN e.V., and subsequently a task group worked on the IGSN business model.

Work Package 2. The Technical Steering Committee (see Appendix 1 for membership) hosted a Technical workshop[7] in May 2019 that developed the technical model for the future architecture of the IGSN Central Registry, and tested this model in a Technical Sprint[8] in May 2020 with IGSN e.V. Allocating Agents.

Work Package 3. IGSN 2040 engaged in scenario planning to collect insights and surface key themes. This process included a review of IGSN 2040 Steering Committee discussions, community leader interviews, and a survey of the Steering Committee and IGSN e.V. members.[9] Survey and interview questions explored IGSN core purpose, distinctiveness, value proposition(s), community concerns, strategic challenges, visions of success, and drivers of change. Respondents identified funding and sustainability as key goals for IGSN e.V.

In general, participants agreed that IGSN needed to expand services beyond identifier registration, and recommended investments in community engagement and support services for users, curators, and consumers. **In short: there was consensus that IGSN should support its community of users through a community of practice approach to achieve scale.**

Unique Value

The core IGSN innovation is an identifier for samples, necessary for sample discovery and research collaboration. The founders developed unique services: the IGSN itself, identifier registration services, and an extensible core metadata structure for samples communities. They promoted community awareness and adoption through community working groups, start-up grant funding, and implementation networks fostered by IGSN Allocating Agents.[10] This work drives the current distinct value proposition of IGSN e.V.: **an interoperable samples discovery ecosystem, equal parts technology and community, with dynamic feedback between the two components.**

---

[6] Lehnert K, Wyborn L, Klump J, Ramdeen S (2020) IGSN 2040 Organizational Steering Committee Workshop Report. https://doi.org/10.5281/zenodo.3724722.
[7] Klump J, Lehnert K, Wyborn L, Ramdeen S (2020) IGSN 2040 Technical Steering Committee Meeting Report. https://doi.org/10.5281/zenodo.3724683.
[8] Fils D, Klump J, Robertson J (2020) Connecting Data to The Physical World: IGSN 2040 Sprint Outcomes and Recommendations. https://doi.org/10.5281/zenodo.3905364.
[9] The surveys and interviews, performed by Susan Stickley of Stratus, were conducted in confidence to increase openness of discussion. Survey response rate was 59% (13/22).
[10] IGSN Allocating Agents Webpage. https://www.igsn.org/allocating-agents/. Accessed 21 June 2021.

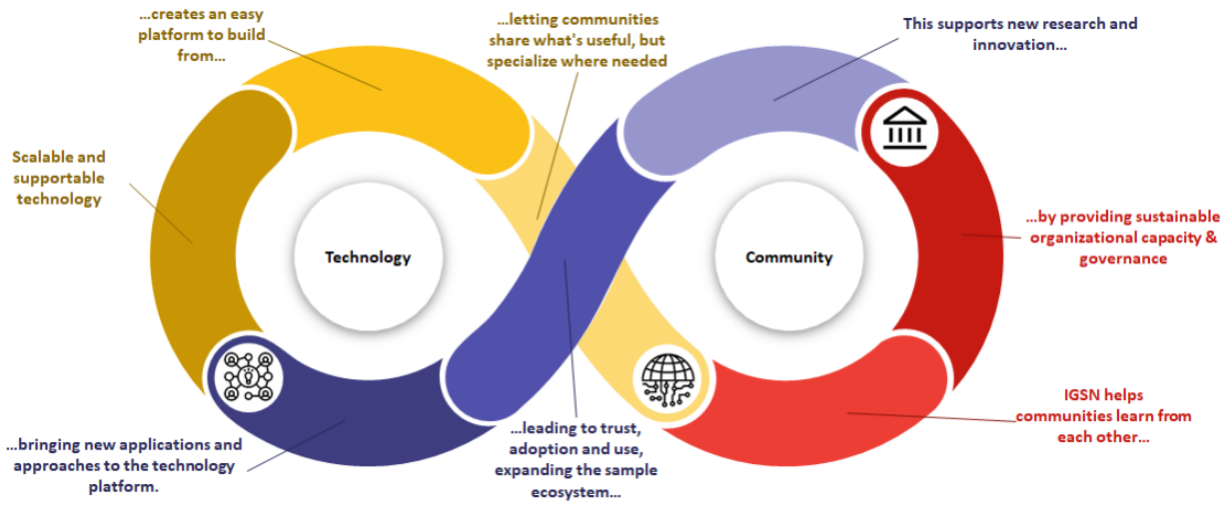

Figure 3. IGSN Distinct Value Proposition

Scaling Options

IGSN 2040 participants discussed several scaling options, considering how much control IGSN e.V. would maintain over its services vs. how much cost it would incur. One one end of the scale, IGSN e.V. could become fully integrated into another organization and the IGSN brand and governance cease to exist. On the other end was IGSN e.V. scaling to become a fully independent organization, responsible for supporting all operations and costs.

IGSN 2040 recommended a middle route as the best path forward: partnering with a complementary organization. In this scenario, IGSN e.V. maintains its brand identity and reduces its latency to scale by leveraging the operational capacity of an existing organization.

IGSN 2040 participants determined that a partner must share IGSN values and non-profit organizational structure, have an aligned mission, and engage a similar set of stakeholders to a shared benefit (**Figure 4**).

After reviewing comparator organizations, IGSN e.V. has been exploring operational partnership options with DataCite and sample discovery services with the Global Biodiversity Information Facility (GBIF). There are exciting opportunities with both organizations.

Shared values. A trusted international non-profit organization with mutual operational values.

Shared mission. Connecting resources to people and organizations to make them discoverable, reusable and traceable.

Shared benefit. Building innovative technology and communities of practice that enable open research.

Figure 4. Comparator Qualities

GBIF: New Communities and “Last Mile” Services

GBIF offers a data services and discovery platform that can easily integrate IGSNs and clearly demonstrate benefits of their use through existing ingest, metadata cleaning, data sharing, and citation tracking facilities. IGSN brings expertise in sample identification, management, and field collection and digitization workflows, particularly in the geosciences. GBIF uses DataCite services to issue DOIs for datasets deposited on the GBIF platform, but at present does not require external identifiers for samples.

There are mutual benefits for GBIF and IGSN in a collaboration framed around practices and technology for sample discovery; sample citation; and the linking of samples, publications, and data. Conversations are continuing with the goal to identify pilot projects.

As part of their 2021 Work Programme, GBIF is currently running a community consultation in which IGSN is participating.

DataCite: Technical Infrastructure

DataCite provides scalable and sustainable DOI registration services in over 40 countries, to data centers, libraries, government agencies, research universities and more. DataCite has already supported registration of over 1.2 million Physical Object identifiers by their members.

The IGSN system architecture evolved in close alignment with DataCite, and similarity between the two systems lays the foundation for a close technical partnership and relatively low implementation cost. IGSN e.V can utilize existing DataCite services including APIs, draft identifiers; agent metadata catalogs; IGSN resolution using the globally-distributed doi.org network; IGSN handle aliasing to DataCite DOIs; and IGSN handle data migration.

IGSN e.V. brings to the partnership a future-facing technical model, expertise supporting large-volume identifier registrations, and deep roots in sample communities. IGSN e.V. and DataCite have a common purpose, and a close relationship in the future can provide mutual benefit to their shared vision of connecting research and identifying knowledge. In addition, DataCite has, over the years, supported scaling of various identifier communities through governance, sustainability, insurance, and technical implementation facets.

IGSN e.V. can leverage DataCite ID registration services while maintaining their identity and brand, freeing resources for important community advocacy efforts. We are proposing to form a mutually beneficial partnership, as described below.

At its formal General Assembly on March 24, 2021, the IGSN e.V. membership voted unanimously in favor of moving forward with formal negotiations with DataCite.[11]

[11] M Buys and J Lehnert (2021) Bringing together communities: IGSN and DataCite. DataCite Blog. https://doi.org/10.5438/thhf-kx17

Technical Architecture

The objective of the IGSN e.V. is to implement and promote standard methods for identifying, citing, and locating physical samples with confidence by operating an international IGSN registration service. IGSN technical architecture has the primary objective to support the mission and business processes of the IGSN community.

IGSN Identifier Syntax and Resolution

Unlike many other persistent identifiers, an IGSN is not only used by machines but also needs to be handled by humans collecting samples in the field. The labelling of sample containers prescribes a limit to the number of characters that fit on a label. Also, IGSNs in lists and tables will often need editing by humans. Long character strings increase the risk of mistypings.

IGSN uses the Handle system to create unique sample identifiers. Each identifier includes 3 syntax components: the IGSN leader string, the organizational namespace code, and the sample ID. More information on IGSN syntax is available on the IGSN github pages.[12]

An IGSN can be resolved by entering the string, 'http://igsn.org/', followed by the IGSN, in a web browser. Use of IGSNs ensures that regardless of how the webs service changes over time (i.e. the metadata profile page URL changes) you can still resolve to the correct webpage for a sample metadata profile.

Evolving System Design

The original IGSN system architecture has its origin in the DataCite system architecture from which many elements have been re-used, including the DataCite Metadata Store. A high-level overview of the IGSN system architecture is shown in **Figure 5**.

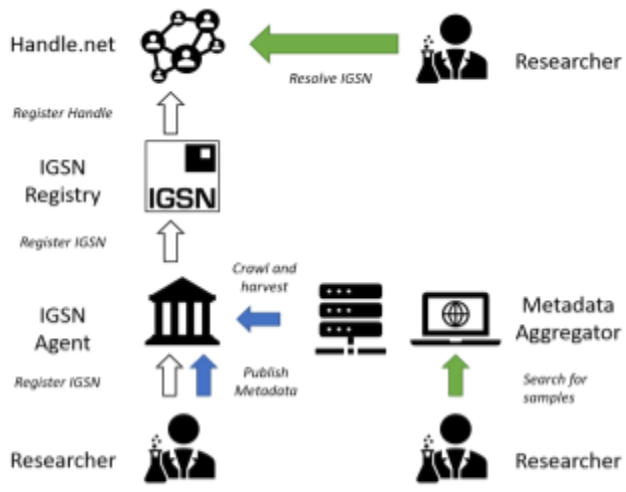

Figure 5. IGSN Technical Architecture.

The IGSN 2040 project recommended evolving the syndication of metadata from OAI-PMH to JSON-LD to encode sample metadata in landing pages, and to leverage schema.org to extract structured metadata from web resources. The demonstrated capability of these technologies to scale to very large numbers makes them suitable for IGSN. Another key element of the new architecture is the publication of metadata through community-governed metadata profiles and support of multiple metadata

[12] Syntax guidelines - IGSN. Github. https://igsn.github.io/syntax/ Accessed 21 June 2021.

profiles to enable use of the service by many disciplinary groups. This proposed architecture was tested in a series of technical sprints during the IGSN 2040 project.[13,14] More work with communities of practice will be needed to define an extended samples metadata profile in a way that makes samples for any designated community[15] not only findable and accessible, but also provides enough contextual information for users to decide on the fitness for reuse of a sample or data derived from it.

In addition to evolution of the core technology, a key finding of the IGSN 2040 project was the need to expand IGSN services beyond identifier registration and resolution. The uniqueness of IGSN is in its management of sample metadata and communities of practice. In this view, IGSN becomes the catalyst for samples communities to create a strong, open science ecosystem rooted in use of samples and associated data toward new scientific discovery and research.

The IGSN Sustainability Roadmap

The future vision for IGSN includes building a Samples Community, partnering with DataCite on technical infrastructure, and exploring common approaches to implementation of community best practices with GBIF. The Sustainability Roadmap provides a work plan and timeline for the transition and identifies key milestones and metrics for ensuring transition success and sustainability of the IGSN mission.

- The **Samples Community** provides continuity and structure for IGSN e.V. members to collaborate on sample metadata descriptions and search and discovery parameters. A dedicated community manager will host working groups, events, and a knowledge base, through which communities of practice centered on sample identification will be fostered, with the ultimate goal of creating a central portal to enable sample discovery.
- The proposed **partnership with DataCite** will provide ongoing IGSN registration services, technical support, and back-office membership services.

These services will be offered through a mixed model of direct and consortia membership. This model affords economies of scale through centralized help desk and engagement services, with the consortia structure supporting localized diversity by region, sample type, or discipline. In addition, it enables participation in governance for all member organizations. This vision aligns with the findings of the IGSN 2040 project, as well as with IGSN e.V. members, who are willing to

[13] Jones, M., Richard, S. M., Vieglais, D., Shepherd, A., Duerr, R. E., Fils, D., & McGibbney, L. J. (2021). Science-on-Schema.org (Version 1.2.0). Zenodo. https://doi.org/10.5281/zenodo.4477164

[14] Fils, D., Klump, J., & Robertson, J. (2020, June). Connecting Data to The Physical World: IGSN 2040 Sprint Outcomes and Recommendations. Technical Report. https://doi.org/10.5281/zenodo.3905364

[15] A designated community is an identified group of potential Consumers who should be able to understand a particular set of information. The Designated Community may be composed of multiple user communities. A Designated Community is defined by the Archive and this definition may change over time. Open Archival Information Systems (OAIS, CCSDS, 2012 page 1–11).

help support this next phase for IGSN, so long as metadata governance and development of a samples search and discovery portal are prioritized.[16]

The proposed plan includes provisions that seek to maintain the IGSN brand and nurture use of PIDs by samples communities. In addition to creation of the IGSN Samples Community and continuance of IGSN e.V. as noted above, these include shared work on core metadata specifications and continued IGSN e.V. community ownership of sample metadata extensions. While IGSN registrations will transition to DOI infrastructure, sample PIDs will retain the IGSN name. Existing IGSNs will be aliased to the DOI infrastructure in a transition that will appear seamless to users.

Membership and Usage Fees

We propose the IGSN Samples Community be supported by a flat membership fee to support community management services and adoption of the current DataCite tiered fee structure to support IGSN registration services.

The membership and fee model are based on the assumption that research organizations, repositories, and platform providers are members who bear the fees that could be partly defrayed by data sharing allowances on research grants. IGSNs, help desk services, and communications resources will always be made available to individual researchers for no cost.

Governance

IGSN e.V. will continue as an entity and provide community governance and oversight for the development of the proposed IGSN Samples Community as well as for the proposed partnership with DataCite e.V. Samples Community members will participate in IGSN e.V. governance. Those community members that opt for direct membership in DataCite would be eligible to participate in DataCite governance

To oversee the partnership process and ensure alignment with IGSN values and goals, the IGSN e.V. will form an Advisory Council, which will meet at least quarterly to review progress and report to the IGSN e.V. on an annual basis. The IGSN e.V. will be responsible for determining whether to continue the partnership (see Insurance section, below).

Success Metrics

Important for the investments into IGSN's future is a clear vision of what success will look like. For IGSN, mission success is a world in which physical samples are valued, uniquely identified and linked into the research ecosystem on a global scale to enhance their impact and to support reproducible research. The journey started over 15 years ago with the launch of the IGSN registration service. It proceeds now through the transition to a new organizational structure.

[16] In developing its sustainability model, IGSN e.V. leadership worked closely with its members to explore options. Supporting these conversations were two member surveys, carried out in March and May 2021, respectively.

There are four major milestones in the transition to partnership (**Figure 6,** *top*). Formation of an IGSN Samples Community is a component of the community work needed for the partnership to succeed. A dedicated community manager will be critical. The goal is to fully support this position through IGSN e.V. services fees; as we ramp up IGSN Samples Community membership, we will seek interim funding from in-kind member contributions and a start-up grant.

DataCite will provide the technical support for migrating existing IGSN handles (via aliasing) to DOI infrastructure. They will work with IGSN e.V. members to stand up IGSN-DOI registration services. And, with the goal of ensuring citability of samples, DataCite is committed to working with IGSN to review alignment of core metadata and support samples collection workflows. The proposed start-up grant would support initial work to integrate IGSN technology into the DataCite technology stack. Future work led by the IGSN Samples Community will support community development and adoption of field-based sample registration tools.

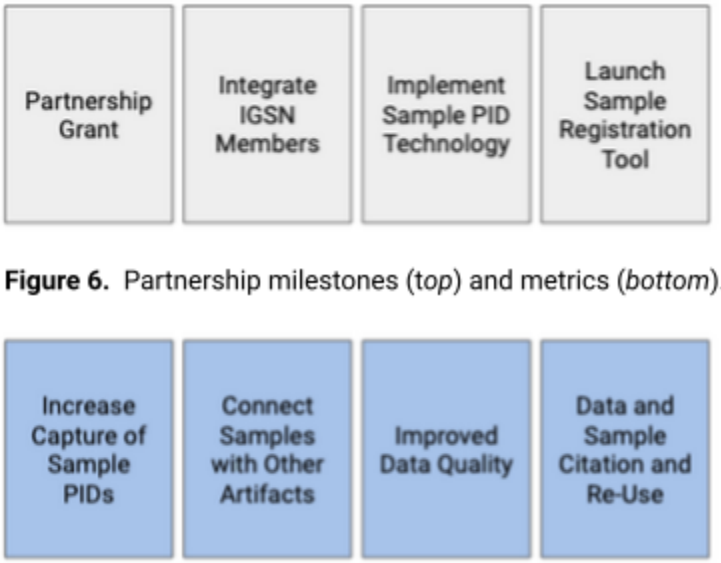

Figure 6. Partnership milestones (*top*) and metrics (*bottom*).

Completion of these milestones is associated with key outcomes: increased capture of PIDs for samples, integration of samples in the PID graph, and improved metadata quality driving sample citation and re-use (**Figure 6**, *bottom*). These metrics can be captured through basic queries of DataCite metadata:

- **Sample PIDs:** Total count of sample PIDs and organizations issuing sample PIDs, and change over time (monthly stats)
- **Connections:** Links between sample PIDs and other research contributions (Event Data)
- **Data Quality:** Richness of sample metadata, prevalence of fields described, extensions utilized, and change over time (monthly stats)
- **Citation:** Samples acknowledged in datasets, papers, and other research activities (Event Data)

Insurance

The sustainability plan is itself an example of an open infrastructure insurance plan: how to sustain and evolve IGSN e.V. services and continue to drive the adoption of sample PIDs catalyzed by IGSN founders. By sharing this draft plan for discussion, the goal is to ensure process transparency and engender trust in the plan developed.

Living Will

The sustainability plan is a living will. It proposes a plan for ensuring sustainability of IGSN registration services by partnering with DataCite. It describes how IGSN e.V. will shift its focus to community outreach services to promote adoption and effective practices, and additional partnerships with organizations such as GBIF and projects such as iSamples to build out search and discovery services. And, it shows how IGSN e.V. retain community governance throughout the transition and new service structure, through continuance of IGSN e.V. and formation of an IGSN Samples Community; creation of an IGSN Advisory Council; specification of milestones and metrics for overseeing the services transition; and the option for IGSN e.V. members to also become DataCite e.V. members and participate in its governance. The partnership with DataCite will be overseen by the DataCite Board and IGSN Advisory Committee, with a specified term, modification process, and a renewal/termination process that takes into account DataCite's investment in new staff to support IGSN service provision.

These provisions augment the existing bylaws and practices of IGSN, including use of open source software, open and available data and APIs, and patent non-assertion -- all best practices of open scholarly infrastructures.

Wind Down

If both organizations decide to exit the partnership, DataCite and IGSN e.V. will cooperate on an orderly transition that ensures IGSN continues as an open, community-supported initiative. The following steps will be taken:

- **Code and metadata.** Any independent IGSN code repositories and data dumps will be made available on GitHub under a MIT license and under CC0 license respectively
- **Transition.** IGSN e.V. will select a new organization or group of organizations to take ownership of the initiative, if such interest exists. DataCite e.V. will support the transition for a period of up to 6 months beyond the termination date of the agreement, although would not assume any fiscal responsibility beyond such date.
- **Funds.** DataCite e.V. and IGSN e.V. will approve disbursement of remaining membership funds (mid-fiscal year) and/or project funds where possible.
- **Staff resources.** IGSN e.V. will be responsible for onboarding any dedicated IGSN staff resources should there not be an opportunity for the staff to continue with DataCite e.V.
- **Handle server.** DataCite e.V. will support the transfer of DOIs in collaboration with CNRI.

Implementation of the Roadmap

The implementation of the roadmap will be a stepwise process, and we anticipate it to last throughout 2021. A major priority is obtaining start-up funds to implement the Sustainability Roadmap.

As of June 2021, IGSN e.V. leadership is working with IGSN e.V. members to refine the fees structure, and with DataCite to define an operational agreement. The agreement will be reviewed by the DataCite Board and the IGSN e.V. Members, with the expectation of finalizing it by the end of 2021. The IGSN Advisory Council is expected to launch in July, 2021. Further, IGSN is participating in the GBIF consultation through 2021, exploring opportunities for collaboration on sample discovery.

Acknowledgements

We would like to thank the Alfred P. Sloan Foundation for provisioning the funds that supported this project. We are deeply grateful to the IGSN 2040 Steering Committee members (**Appendix 1**) for their enormous and instrumental contributions to the process of defining the technical and organizational requirements for the future IGSN and designing its future architecture and business model. IGSN e.V. Members are thanked for their contributions to surveys, the technical sprint and continued support of discussions and providing feedback. Susan Stickley (Stratos Inc.) and Laure Haak (Mighty Red Barn) facilitated the strategic planning and road mapping process and were essential to bring the project to a successful completion.

Appendix 1. IGSN 2040 Steering Committee Members

Name	Committee[17]	Organization	Country
Kerstin Lehnert	PI	Columbia University	US
Jens Klump	PI	CSIRO	Australia
Lesley Wyborn	PI	Australian National University	Australia
Sarah Ramdeen	Coordination	Columbia University	US
Patricia Cruse	OSC	DataCite	US
Erin Robinson	OSC	ESIP	US
Yasuhiro Murayama	OSC	National Institute of Information and Communications Technology	Japan
Adrian Burton	OSC/SC	Australian Research Data Commons	Australia
Helen Glaves	OSC/SC	British Geological Survey	UK
Laure Haak	OSC/SC	Mighty Red Barn; formerly ORCiD	US
Dimitri Koureas	OSC/SC	Naturalis/DiSSCo	Netherlands
Lindsay Powers	OSC/SC	US Geological Survey	US
Shawn Ross	OSC/SC	Macquarie University	Australia
Wim Hugo	TSC	SAEON	South Africa
Xiaogang Ma	TSC	University of Idaho	US
Donald Hobern	TSC	International Barcode of Life; previously GBIF	Australia
Simon Cox	TSC/SC	CSIRO	Australia
Anusuriya Devaraju	TSC/SC	TERN; previously Pangaea	Germany
Martin Fenner	TSC/SC	DataCite	Germany
Doug Fils	TSC/SC	Consortium for Ocean Leadership	US
Jess Robertson	TSC/SC	Ministry of Business, Innovation & Employment; previously CSIRO	New Zealand
Natasha Simons	TSC/SC	Australian Research Data Commons	Australia
Ramona Walls	TSC/SC	University of Arizona	US
Dirk Fleischer	TSC/SC	University of Kiel	Germany
Kirsten Elger	TSC/SC	GeoForschungszentrum Potsdam	Germany
Joan Damerow	SC	Lawrence Berkeley National Laboratory, Dept of Environment	US
Sarah Kansa	SC	Alexandria Archive Institute/Open Context	US
Sean Toczko	SC	JAMSTEC	Japan
Maria Gould	SC	California Digital Library	US
Takayuki Tomiyama	SC	JAMSTEC	Japan
Brandon Serna	SC	US Geological Survey	US

PI: Principal Investigator | OSC: Organizational Steering Committee | TSC: Technical Steering Committee | SC: Merged Steering Committee

[17] Following the recommendations from the 2019 Organizational Steering Committee meeting, the OSC and the TSC committees were merged.