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***Feature***

# *When Launching a Collaboration, Keep It Agile*

By the Stakeholder Alignment Collaborative

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# When Launching a Collaboration, Keep It Agile

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Illustration by Stephanie Wunderlich

*Tackling the world's many problems does not require starting with large, ambitious proposals. Instead, we should begin with minimum viable consortia—small, agile initiatives that can learn and adapt as they grow.*

**Conventional wisdom holds that large-scale societal** challenges require large-scale responses. By contrast, we argue that progress on major societal challenges can and often should begin with small, agile initiatives—minimum viable consortia (MVC)—that learn and adapt as they build the scaffolding for large-scale change. MVCs can address societal challenges by overcoming institutional inertia, opposition, capability gaps, and other barriers because they require less energy for activation, reveal dead ends early on, and can more easily adjust and adapt over time.

Large-scale societal challenges abound, and organizations and institutions are increasingly looking for ways to deal with them. For example, the National Academy of Engineering (NAE) has identified 14 Grand Societal Challenges for "sustaining civilization's continuing advancement while still improving the quality of life" in the 21st century. They include making solar energy economical, developing carbon sequestration methods, advancing health informatics, and securing cyberspace. The United Nations has set 17 Sustainable Development Goals (SDGs) to achieve by 2030 for a better future for humanity. They include everything from eliminating hunger to reducing inequality.

Tackling such universal goals requires large-scale cooperation, because existing organizations and institutions simply do not have the ability to resolve these challenges independently. Further note that the NAE's announcement of the challenges stated that "governmental and institutional, political and economic, and personal and social barriers will repeatedly arise to impede the pursuit of solutions to problems." The United Nations included two enabling SDGs: "peace, justice, and strong institutions" and "partnerships for the goals." The question is how to bring such large-scale partnerships and institutional change into existence.

We are members of the Stakeholder Alignment Collaborative, a research consortium of scholars at different career stages, spanning multiple fields and disciplines. We study collaboration collaboratively and maintain a very flat structure. We have published on multistakeholder consortia associated with science[1] and provided leadership and facilitation for the launch and sustainment of many of these consortia.[2] Based on our research into the problem of developing large-scale, multistakeholder partnerships, we believe that MVCs provide an answer.

MVCs are less vulnerable to the many barriers to large-scale solutions, better able to forge partnerships, and a more agile framework for making needed adjustments. To demonstrate these points, we focus on examples of MVCs in the domain of scientific research data and computing infrastructure. Research data are essential for virtually all societal challenges, and an upsurge of multistakeholder consortia has occurred in this domain. But the MVC concept is not limited to these challenges, nor to digitally oriented settings. We have chosen this sphere because it offers a diversity of MVC examples for illustration.

## Minimum Viable Consortia

Consortia are collaborative arrangements among individuals, organizations, and institutions. We define MVCs as consortia having the minimum necessary structure and processes needed to generate positive early results, together with the ability to adjust and adapt as needed. MVCs are liminal[3] initiatives in that they are always in

a state of growth and development. By "liminal," we mean not simply a transitionary phase of development but a key threshold that shapes subsequent possibilities, just as the liminal adolescent phase in biological development shapes the subsequent adult.

MVCs are analogous to the "minimum viable product" (MVP) prototype that companies launch and that entrepreneurship literature describes.[4] Compared with a fully developed product, the MVP allows for an agile development process that can include learning, experimentation, developing, and validating the product with customers. Designers and entrepreneurs cannot foresee how their ideas will be accepted, but the MVP enables them to learn and to make the adaptations or "pivots" that are necessary for success. Similarly, our use of the MVC concept emphasizes how we cannot possibly plan for all eventualities that will make an impact on societal challenges.

The MVC approach has roots in sociotechnical systems theory from half a century ago. When social scientist Eric Trist set forth design principles for organizational development, he highlighted the importance of establishing "the minimum critical specifications, but no less."[5] Overspecification, Trist observed, could result in excess bureaucracy, reduced flexibility, and delays in achieving initial results. Underspecification, by contrast, could result in insufficient channels for communications, decision-making, feedback, and action.

The MVC concept also expands on the collective impact model, as articulated by John Kania and Mark Kramer in their 2011 article "Collective Impact" for *Stanford Social Innovation Review*. Specifically, it addresses the concepts of a common agenda and a backbone organization. According to the model, the participants of a collaboration must "have a shared vision for change, one that includes a common understanding of the problem and a joint approach to solving it through agreed-upon actions." To create and coordinate this cooperation, the effort needs "a separate organization and staff with a very specific set of skills to serve as the backbone for the entire initiative."[6] A follow-up series of *Stanford Social Innovation Review* articles in 2012 on backbone organizations suggests that they are essential in the initial stages of a collaboration and will become more robust over time.

With the MVC model, we update this view by maintaining that the initial scale and scope of the backbone are a matter of strategic choice. In some cases, a formal backbone organization may not exist (e.g., a MVC might operate as a network of volunteers), while in other cases, the "minimum" might require an extensive backbone. The backbone depends on how much is needed to generate initial results and to set the stage for further impact. Moreover, the development of the backbone is not always a linear progression to maturity. This is because the common agenda will be dynamic. The mix of stakeholders and interests (what is "at stake") changes over time and requires liminal adjustments in the structure and operations.

## Align, Act, Adjust

Our MVC model is a simplified form of what has emerged from our research on multistakeholder consortia. (See "Minimum Viable Consortium Cycle" on page 43.) It involves three fundamental phases that together form a cycle: Align, Act, and Adjust. Let us consider these phases in turn.

The need for alignment follows from two foundational assumptions of the model: first, that stakeholders have both common and competing interests, and second, that circumstances will continually change. Stakeholder alignment, the first step in the model, is a negotiated process of surfacing and addressing common and competing interests. Specifically, we define stakeholder alignment as a continuous process by which independent but interdependent individuals, groups, and organizations advance common interests and resolve conflicting interests with agreements that allow them to accomplish together what they cannot accomplish separately.[7]

The Align phase generally involves five elements that together build consensus around central questions, such as who the stakeholders are, what is at stake, what success will look like, how to measure success, and what rules to follow for working together. The process begins by specifying the relevant types of stakeholders and their interests and concerns. A small leadership group may take up this task, often followed by a survey or focus groups to provide a full map of the landscape of stakeholders and interests that can be widely shared. Typically, stakeholders find points of alignment that are stronger than suspected, and points of misalignment that are more consequential than known.

Taking the stakeholder map into account, the participants can make further progress, in which they construct a shared vision of

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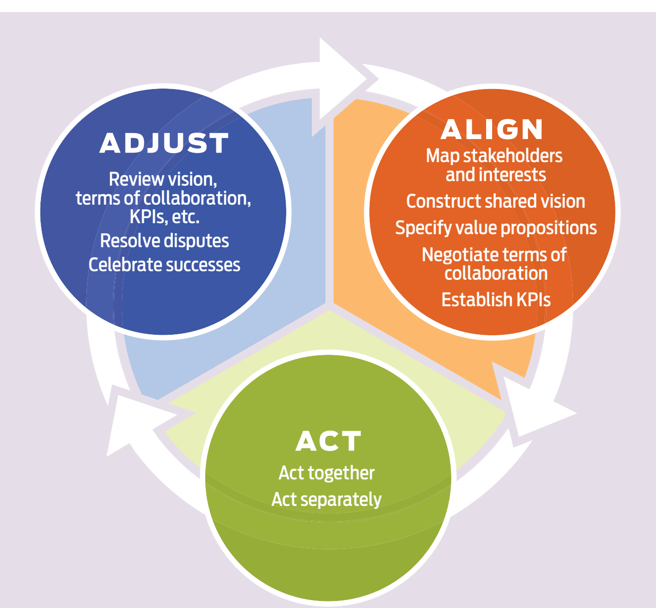
success (emphasis on "shared"). Since stakeholders have both common and competing interests, this step will surface the range of different value propositions in play.[8] Next, the collaboration establishes key performance indicators (KPIs) to track progress and negotiates a living charter, or terms of collaboration, to determine membership, roles, responsibilities, regular operations, conflict resolution processes, and other considerations.

The Act phase begins once the parties achieve sufficient, minimally adequate alignment. It may be undertaken independently or jointly by some or all stakeholders, who will inevitably both collaborate and compete with each other. For areas of potential collaboration, they can advance more quickly by establishing a common format. For example, stakeholders' representatives can work together to articulate the "who, what, when, where, why, and how" for each collaborative initiative. For points of potential conflict, they should use negotiation principles, such as dissuading sides from becoming locked in on positions and instead encouraging them to articulate underlying interests so that they can more effectively find common ground. Similarly, they can explore multiple options and insist that parties not reject options without having alternatives to suggest. Such negotiations can be helped by bringing in facilitators to manage the process so that the stakeholder representatives can focus on the substance. Invariably, some stakeholders (e.g., future generations) will lack representation, so facilitators can remind the representatives to consider their interests as well.

Finally, the Adjust phase starts with participants surfacing and resolving disputes; appreciating and celebrating successes; and revisiting the stakeholder map, shared vision, value propositions, KPIs, and charter. Geophysicist and National Academy of Sciences President Marcia McNutt has referred to this phase as "self-correction by design."[9] Others have called it "designing for redesign."

## Minimum Viable Consortium Cycle

The three fundamental MVC phases of Aligning, Acting, and Adjusting can go through multiple cycles involving many players and steps.




The Adjust phase should be not a declaration of victory but rather a sober assessment of what has been accomplished and a look ahead at what changes are needed to bring about further accomplishments.

## The Importance of Open Data

To illustrate the concept of MVC, we focus on data and computing infrastructures, which are essential in addressing many societal challenges. Further, the growing open science movement supports open sharing of research data across diverse fields in the sciences, engineering, social sciences, the humanities, and other domains—within appropriate limits for protecting privacy, proprietary information, national security, and other adverse impacts, such as those to the natural environment. More open research data and increased collaboration in data sharing promote reproducibility in science, accelerate discoveries, and can help to better achieve broad societal impacts.

New consortia centered on the sharing of research data and related cyberinfrastructure are forming at an accelerating rate. We identified 24 consortia that arose in the 50 years between 1950 and 1999 to advance the open sharing of data in science, cyberinfrastructure, and related matters; 97 such consortia were created in the 20 years between 2000 and 2020—a tenfold increase. Many of these consortia began with elements of the MVC approach and evolved longer-term structures or robust digital platforms. Others disbanded.

We have chosen four case studies to illustrate different aspects of the MVC model. The first, the Minority Serving - Cyberinfrastructure Consortium (MS-CC), closely follows our model. Next, EarthCube (EC) illustrates liminal adjustments with enabling architecture. The National Data Service (NDS), by contrast, did not achieve the minimum structure and alignment it needed to be viable. The fourth, the Biomarkers Consortium (BC), showed that the minimum viable architecture was an extensive organization with a substantial budget and staff required to operate in a regulatory context. (See "Four Consortia Case Studies" on page 44.) In what follows, we review the societal challenge motivating each consortium, explain what makes each distinctive, and demonstrate how each followed the Align, Act, Adjust framework.

## Minority Serving - Cyberinfrastructure Consortium (MS-CC)

Our first case study, MS-CC, illustrates how a consortium can start with a minimum viable initial structure before expanding to provide a larger structure necessary for and concurrent with the growth of the enterprise. MS-CC seeks to address the digital divides that limit education and research opportunities for faculty, students, and staff at historically Black colleges and universities (HBCUs), Hispanic-serving institutions (HSIs), tribal colleges and universities (TCUs), and other minority-serving institutions (MSIs). (Note that MSI is not the umbrella category but a classification for institutions that do not fit into established categories.) These higher-education institutions are all limited in their separate abilities to build out the cyberinfrastructure they need to flourish.

The National Science Foundation's (NSF's) Established Program to Stimulate Competitive Research (EPSCoR), which targets funds for NSF-designated underserved states, helped to set the

foundation for MS-CC through more than a decade of cyberinfrastructure investments, including a 2002 NSF award of $1 million to EDUCAUSE for advanced networking for HBCUs, TCUs, and other MSIs, and a 2006 $1 million NSF award supporting the formation of a coalition of cyberinfrastructure professionals at minority-serving colleges and universities. Most of the early NSF awards expanded cybercapabilities for individual campuses and professionals but did not result in an ongoing consortium.

Then, in 2015, the NSF awarded Clemson University funding to build cybercapacity at HBCUs, including Jackson State University, South Carolina State University, Claflin University, and Morgan State University. Even though the initial 2018 workshop held under this grant involved only HBCUs, the original vision contemplated HBCUs, HSIs, TCUs, and other MSIs. Active MS-CC members were primarily university CIOs, cyberinfrastructure professionals, and computer science faculty.

The group was able to align within six months, thanks largely to a stakeholder mapping survey that revealed a shared priority for developing campus cyberinfrastructure plans, ensuring cybersecurity, and fostering career development for cyberinfrastructure professionals. The survey revealed that faculty and staff were willing to collaborate across colleges and universities on these matters; this had historically not been the case for HBCUs. The survey data motivated the group to quickly develop a charter and a shared vision statement emphasizing that increased infrastructure capacity would enable them to advance research on topics of central importance to them.

The same NSF grant enabled four HBCUs to submit proposals to the NSF for cyberinfrastructure, three of which were funded: Jackson State University, South Carolina State University, and Claflin University. Although these grants were helpful for the institutions involved, the colleges wanted to achieve broader impact. To that end, the group engaged in further discussions (an Adjust phase) and collaborated with Internet2, a nonprofit consortium set up by research-intensive universities to advance services building on the foundation of the university-based predecessors to the internet. The two sides held a series of intensive conversations in which the HBCUs tested Internet2's commitment to diversity, equity, and inclusion. This Alignment process culminated in a presentation by the HBCUs to Internet2's board of directors, which secured Internet2's goal of broadening its focus to include HBCUs, HSIs, TCUs, and other MSIs. In fall 2021, for the first time, HBCUs had representation on the Internet2 board.

In 2020, the NSF supported TCUs in conducting their own stakeholder mapping survey. This step helped to advance TCU educational programs dedicated to data science and related matters. Meanwhile, Internet2 funded a second stakeholder mapping survey, of HBCUs and HSIs, using most of the same questions from the TCU survey. WayMark Analytics, the survey provider in both cases, combined the data and enabled a series of briefings by MS-CC leaders for university presidents and provosts, research faculty, and other key stakeholders. This prompted a new round of alignment. Based in part on the survey data and insights from the briefings, the NSF has now funded a grant proposal to launch a minority-serving research collaboration network. The MS-CC has also begun working with a number of government agencies and private funding organizations to bring broadband connectivity and high-performance computing to these colleges and universities and their surrounding communities.

The original MS-CC charter was rarely consulted or utilized. It had been adapted from a highly legalistic charter from another consortium. In another Adjust process, the group drafted a more informal charter in 2021 that makes it easier for all minority-serving universities and colleges to participate. The charter also clarifies roles for affiliates at predominantly white colleges and universities, nonprofits, and commercial organizations.

MS-CC started without staff or a central organization. Its members were drawn from HBCUs and TCUs. The impacts of MS-CC are still emerging but include increased data and computing capabilities for a number of HBCUs, a commitment to broader inclusion by Internet2, and prospects for major investments to bridge the digital

## Four Consortia Case Studies

These four MVCs launched with different time scales, backbone organizations, and resources.

| CONSORTIUM | MOTIVATING CHALLENGE | YEAR FOUNDED | ALIGNMENT TIME BEFORE FORMAL LAUNCH | BACKBONE RESOURCES AT FORMAL LAUNCH | 2021 BACKBONE RESOURCES |
|---|---|---|---|---|---|
| **Minority Serving - Cyberinfrastructure Consortium (MS-CC)** | Expanding data and computing capabilities for underserved institutions | 2018 | 6 months | Volunteer leadership and contributed resources | Funded grant proposal has a combined $1.5 million per year for the backbone staff, office, and programming |
| **EarthCube (EC)** | Cyberinfrastructure for understanding the earth as a system | 2011 | 1 year | Volunteer leadership and funding for individual projects | Approx. $1.8 million per year for the backbone staff and office, with $5-10 million in grant funding for projects |
| **National Data Services (NDS)** | Enabling national-scale research data services | 2014 | 6 months | Volunteer leadership and contributed staff and resources | Volunteer leadership and contributed staff and resources, and funded work for specific science cases |
| **Biomarkers Consortium (BC)** | Advancing precision and personalized medicine | 2006 | 2 years | Contributed leadership and contributed staff and resources for backbone home office | Approx. $1.2 million per year for the backbone staff and office, with more than $100 million in funding for R&D projects |

divide for hundreds of colleges and universities. MS-CC now envisions research data and computing enabling students, faculty, and staff at TCUs, HSIs, and other MSIs to better advance knowledge on matters important to them.

In the current phase of work, Internet2 will serve as a fiduciary agent and MS-CC will increasingly assume responsibility for organizational operations, ultimately spinning off as its own nonprofit. Internet2 has served this role before with a nonprofit consortium called The Quilt, which provides regional networking services to research universities.

## EarthCube (EC)

The next case study, EarthCube (EC), is an example of a consortium that initially involved a limited group of several hundred researchers. The collaboration then expanded and developed a correspondingly extensive governance structure, but one that was, in some respects, unwieldy. Eventually, the initiative adapted to a smaller, more flexible governance structure.

The NSF launched EarthCube in 2011 to better understand the earth as a system during a time of global climate change, severe weather, resource scarcity, and other challenges that threaten human existence. The project sought to bring together geoscientists and cyberinfrastructure researchers and builders. EarthCube began as a grant-funding program, not a consortium. Crucially, NSF began EarthCube as an open-ended solicitation that allowed for amendments. In this way, the NSF signaled a long-term commitment and a liminal approach in which adjustments could be made.

The EC's initial Align phase consisted of two design meetings, each with around 200 computer and data scientists with deep experience in the geosciences. Very few geoscientists attended, outside those with expertise in data and computing infrastructure. Many participants argued that the NSF could advance EarthCube's mission simply by funding projects that they were already working on. However, a stakeholder survey revealed that the end users of cyberinfrastructure were not aligned with the underlying assumption of open sharing of geoscience data. Some were very supportive, others deeply opposed. The NSF realized that if EarthCube became just a program funding existing cyberinfrastructure projects, it might build infrastructure that few scientists would eventually use. An adjustment was clearly needed.[10]

The NSF put cyberinfrastructure funding on hold and invited proposals from diverse fields and disciplines for focused workshops on data sharing. Twenty-seven workshops in different domains (such as geochronology, sedimentary geology, atmospheric modeling, and others) were held over a year and a half. Each workshop included opening remarks from NSF representatives, a presentation of stakeholder survey data on the relevant field or discipline (compared with overall views), and a discussion in which participants identified implications for their field or discipline. The strongly divergent opinions that participants voiced demonstrated the work on internal alignment that was needed. For example, one workshop participant commented, "You can pry my samples from my cold, dead hands when I am gone."

Amid the increased awareness of its mission, EarthCube began a chartering process in 2013, under which the group elected a leadership council of scientists and cyberinfrastructure professionals for a trial period. It applied the collective impact model to develop an elaborate backbone organization with a science team, technology and architecture committee, liaisons committee, and nominations committee. All were part of the governance structure, supported by an informal EarthCube office set up under the leadership of Lee Allison at the Arizona Geological Survey. During this "test governance" period, EarthCube received a supporting grant of $3.6 million for critical backbone functions in fiscal years 2013 and 2014 (ICER-1340233).

After this period, the group found that its governance structure was too complex, so it reduced the number of committees. Some work, such as creating partnerships with other organizations, still needed to be done by the backbone organization. Further, the group found that many dozens of NSF-funded research projects (made possible through a succession of amendments to the original solicitation) were operating mostly independently, with less collaboration than was desired. This problem was poignantly illustrated at a 2015 meeting of the principal investigators (PIs) of the funded projects, in which all were invited to place sticky notes indicating interdependency on flip charts representing all the projects. Many dozens of sticky notes were posted. But instead of celebrating the many connections, the PIs protested that their grants didn't include enough money to help each other's projects. As a result, the group established a Council of Funded Projects to foster interoperability across EarthCube products. The NSF then issued recommended standards and specifications for collaboration across EarthCube projects[11] in its annual solicitations.

The test governance phase lasted for three years and extended into the first official EarthCube Office, which was covered by a three-year grant to the University Corporation for Atmospheric Research (UCAR)/UNIDATA in Colorado. After three years, the office was opened up for bids (what the NSF terms "re-competing"). Today, the third iteration of an EarthCube Office is housed at the San Diego Supercomputer Center (SDSC) and has secured $5.6 million in funding over three years. This EC Office focuses on software application tools and interoperability across projects and has worked with community leadership to realign governance to adopt an MVC approach.

EC's community-led approach contrasts with other NSF efforts to build large-scale cyberinfrastructure, in which project goals and specifications are predefined and infrastructure developers are chosen at the beginning of the process via competitive proposals. EC's open-ended solicitation approach and adjustments in the home office have achieved both continuity and flexibility. Liminal cycles of Align, Act, and Adjust have now become part of the grantmaking process for the geosciences.

EarthCube has also increasingly clarified the role of the backbone organization to focus on coordination and integration. It has created dozens of research tools and methods for data sharing and reuse and has initiated relationships that enable rapid responses to geoscience challenges.[12] For example, EarthCube associates are combining data from multiple sources to better understand the dynamics of severe weather events and the long-term implications of global warming.

A separate initiative, the Council of Data Facilities (CDF), which was formed under the auspices of EarthCube, is now its own consortium. CDF works with leading scientific journals, such as *Science* and *Nature*, to enable the curation, storage, and sharing of geoscience data, models, and software associated with scholarly articles.

This step demonstrates a further liminal adjustment in which one consortium, EarthCube, enabled the formation of another, the CDF.

## National Data Service (NDS)

The next case study, the National Data Service (NDS), exemplifies a collaboration that did not find the minimum viable structure. NDS launched in 2014 to provide "federated, interoperable, and integrated national-scale services" for the use of "big data" at the frontiers of science. Leaders from high-performance computing facilities saw that demands for big data in the science community were expanding rapidly. Although it modeled itself after the Australian National Data Service, the NDS did not realize this goal and is no longer functioning as the consortium it originally envisioned itself to be.

NDS began with a bold vision to offer a set of services spanning diverse fields and disciplines that would help to integrate data needs nationally. In the first year, NDS drafted a charter and launched a steering committee. Consortium members arranged to contribute staff time, data storage, and other resources. The charter adopted MVC language, stating that "the degree of specification will vary for all components of NDS so that only the minimum critical structure is specified—no more and no less." But that stated intention for a minimal approach was not sufficient to overcome what emerged as a lack of a shared vision with a key stakeholder. Meetings were held two to three times a year, each with a host and a working agenda. For example, the October 2014 meeting, hosted by the National Institute of Standards and Technology (NIST), included agenda items such as codifying a shared vision of success, reporting on pilot projects, aligning technology architecture, identifying fundable projects, and increasing alignment with parallel initiatives.

In March 2015, a founding stakeholder organization, the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign, funded an NDS core office for two years. This commitment fell far short of what would be needed for a national-scale service-delivery organization. NDS hoped that other funds could be identified. Unfortunately, its founder and sponsor took on a major university leadership role and had to reduce his focus on NDS. NDS targeted NSF for funding but was not able to secure it, so, by the end of two years, core office work shifted from a backbone organization driving committee work to more limited support of an executive committee focused on sustainability. NDS stopped hosting its own workshops and shifted to focusing only on software development and presenting at established meetings.

Several cofounders of NDS had been program officers at the NSF. Nearly all had extensive experience as principal investigators on large research projects. Nevertheless, NSF recoiled from using the name National Data Service and the NDS vision of national-scale services. To pursue this goal, NDS needed more alignment with NSF. Alternatively, NDS could have set forth a less ambitious vision, commensurate with the alignment that it did have. But ultimately NDS could not reach a viable structure and the consortium was reduced dramatically. NDS struck agreements with two other consortia, the Research Data Alliance (RDA) and Earth Science Information Partners (ESIP), to provide an ongoing home for some NDS initiatives. Some work continues under the banner of NDS Labs, a software development and testing environment, and NDS Share, which makes innovations available to fields and disciplines. Both are housed at the NCSA and the SDSC.

The 2021 NDS vision statement leaves out "national-scale services," emphasizing the transformational potential of digital data from "experiments, instruments, observations, sensors, and/or surveys" across "every field of science." The NDS website states that it operates as a consortium, bringing together publishers, campuses, national cyberinfrastructures, international partners, communities, and industrial partners. However, NDS currently hosts no membership meetings, workshops, or other consortium activities. The consortium's adjustments have reduced operations and shifted focus. NDS now seeks to serve advanced researchers and cyberinfrastructure professionals by making innovations developed during its initial years available through open-source channels, with targeted additional support for these innovations.

## Biomarkers Consortium (BC)

The final case study concerns the Foundation for the National Institutes of Health's (FNIH's) Biomarkers Consortium (BC), an example of a multistakeholder collaboration in which the minimum viable consortium required a substantial backbone organization at launch. Founded in 2006, the BC is a public-private biomedical research partnership managed by the FNIH, dedicated to advancing precise, personalized medicine to transform the diagnosis and treatment of human disease.[13] Specifically, its research focuses on biological markers (biomarkers), defined characteristics that are measured and indicate normal biological processes, pathogenic processes, or responses to an exposure or intervention, including therapeutic interventions. They are critical to drug development and disease assessment.[14]

The BC is essentially an industry-level operation for shared research and development. Prompted by separate R&D efforts into a particular molecule that were all found to be fruitless at the same time, the members of BC established the consortium as a "precompetitive space" in which they could pool resources and information.[15] In other words, BC exemplifies a case in which stakeholders can better accomplish together what they cannot do separately.[16]

The alignment phase took more than two years, as industry partners established ground rules to avoid violating antitrust provisions. They had to agree to protocols for taking attendance and notes in all meetings and to avoid discussing pricing. Government agencies needed to ensure that all activities complied with legislative requirements. BC enabled the Food and Drug Administration (FDA) and pharmaceutical companies to participate in new scientific developments in ways that could inform all parties during later regulatory approval stages—a crucial step for both the regulators and the regulated.

BC's leadership architecture has remained largely as it was originally established, with an executive committee and four steering committees (Cancer, Inflammation and Immunity, Metabolic Disorders, and Neuroscience), each with more than 40 members from industry, government labs, academia, and patient advocacy organizations. The steering committees oversee multiple projects. Founding stakeholders of the BC included an industry association, pharmaceutical companies, the FDA, and the National Institutes of Health (NIH). Each could veto any project, though no veto has ever been formally invoked.

Other important stakeholders included the Centers for Medicare & Medicaid Services (CMS), a biotech industry association (BIO), university researchers, and patient advocacy organizations. Continuous adjustment has increased additional stakeholders' involvement over time. Such broader engagement presents challenges to the shared agenda. For example, research information that is pre-competitive for pharmaceutical companies may be competitive for many biotechnology firms. As a result, each project requires alignment among stakeholders (who are in or not in on a given project) before it continues the Align-Act-Adjust cycle.

The BC has affected all facets of biomarker development, from early disease definition to late-stage FDA qualification. BC projects have contributed to the enhancement of 6 FDA guidance documents and the advancement of 14 therapeutics through FDA approval. The BC has been instrumental in progressing an innovative adaptive trial design for cancer; validating novel imaging tools for use in cancer, autoimmune disease, and Alzheimer's treatment; and establishing an evidentiary framework for biomarker qualification.

## Dynamics in the Four Cases

Although the four cases are distinct, they illustrate shifts in at least two dimensions that are important for leaders and members of multistakeholder consortia. First, two of the four cases shifted to feature *more* structure and hierarchy, while one (NDS) shifted to feature *less* and one (BC) did not change substantially. For leaders and members of consortia, the amount of structure and hierarchy is an informed design choice[17] that can and will change over time. Second, two of the cases shifted to have *more diversity and complexity of stakeholders and interests*, one (NDS) shifted to have less, and one (EarthCube) did not change in this dimension. For leaders and members of consortia, the number and types of stakeholders to include also represents a strategic choice at launch that can and will change over time.

The two dimensions demonstrate important points about the Align and Adjust phases of the MVC model. In the Align phase, choices are being made about just how much structure and hierarchy is needed. The "minimum viable" ranged from very low to very high in the four illustrative cases. Similarly, as multistakeholder consortia, the four cases began with a range from low to high diversity and complexity of stakeholder types. The changes over time were in multiple directions. These were all liminal adjustments, and illustrate that multistakeholder consortia will not all follow the simple maturity model of always moving in the direction of becoming formal, stable organizations. The amount of backbone and nature of the shared vision will be different at the start and will evolve in different ways.

## What Is "Minimum"?

Even collaborations intended to address our greatest societal problems need not start with ambitious structures. Few large-scale plans survive contact with reality. The potential for early misalignments is even greater in today's interconnected world. Coping with surprises requires the agility and liminality that the MVC approach provides. MVCs enable faster activation in addressing societal challenges, followed by periodic learning and adjustment. They also offer funders, change agents, and policy makers a lightweight and responsive tool. They complement existing institutions and are often launched by innovators in these institutions. Rather than attempting to foresee and prepare for all contingencies from the beginning, collaborations should expect to adapt. MVCs provide an agile structure that enables adaptation.

Defining "minimum" is a challenge in every case. The case studies we have reviewed suggest that the minimum varies considerably, and that the processes of stakeholder alignment indicate what is and is not the minimum viable. With MVC, practitioners and policy makers can make informed design choices when launching, sustaining, or disbanding consortia. Ultimately, MVC helps diverse stakeholders facing societal challenges accomplish together what they cannot accomplish separately. ■

### Notes

1 Our publications include articles in *Science*, *Nature*, the *Data Science Journal*, the *Negotiation Journal*, and other venues.

2 Members of the Stakeholder Alignment Collaborative have been involved in NSF-funded research supporting more than a dozen stakeholder mapping surveys and extensive stakeholder interviews. We have also helped to launch or sustain two dozen consortia associated with research data and computing.

3 Bjorn Thomassen, "The Uses and Meaning of Liminality," *International Political Anthropology*, vol. 2, no. 1, 2009.

4 "Minimum viable product" is a term that was coined in 2001 by SyncDev CEO Frank Robinson to replace "minimum feature set." See Steven Blank, "Why the Lean Start-Up Changes Everything," *Harvard Business Review*, vol. 91, no. 5, 2013.

5 Joel Cutcher-Gershenfeld, interview with Eric Trist, 1981.

6 John Kania and Mark Kramer, "Collective Impact," *Stanford Social Innovation Review*, Winter 2011.

7 Joel Cutcher-Gershenfeld, Betty Barrett, and Chris Lawson, "Building the Internal Organization to Support Lateral Alignment: A Case Study of the Office of Environment and Energy, Federal Aviation Administration," Cambridge, Mass.: MIT Project on Lateral Alignment in Complex Systems, 2005.

8 Earll Murman et al., *Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative*, New York: Palgrave Macmillan, 2002.

9 Marsha McNutt, "Self-Correction by Design," *Harvard Data Science Review*, vol. 2, no. 4, 2020.

10 Joel Cutcher-Gershenfeld et al., "Build It, but Will They Come? A Geoscience Cyberinfrastructure Baseline Analysis," *Data Science Journal*, vol. 15, 2016.

11 Ken Rubin et al., "Recommended Standards and Specifications for EarthCube Projects," in EarthCube Organization Materials, UC San Diego Library Digital Collections, May 7, 2020.

12 Ibid.

13 Joseph P. Menetski et al., "The FNIH Biomarkers Consortium Embraces the BEST," *Nature Reviews Drug Discovery*, vol. 18, no. 8, 2019.

14 Barbara Mittleman, Garry Neil, and Joel Cutcher-Gershenfeld, "Precompetitive Consortia in Biomedicine—How Are We Doing?" *Nature Biotechnology*, vol. 31, no. 11, 2013.

15 Eric Knight, Joel Cutcher-Gershenfeld, and Barbara Mittleman, "The Art of Managing Complex Collaborations," *MIT Sloan Management Review*, vol. 57, no. 1, 2015.

16 Mittleman et. al. "The Role of Consortia," 2013.

17 Informed decisions operated across a "continuum of urgencies" short- to long-term. See Paul Arthur Berkman et al., "The Arctic Science Agreement Propels Science Diplomacy," *Science*, vol. 358, no. 6363, 2017.

18 NSF grants for this research covered the visual display of stakeholder alignment (VOSS EAGER 0956472); data sharing in the geosciences (OCI RAPID 1229928); transformation in the social sciences, geosciences, and cyberinfrastructure (GEO-SciSIP-STS-OCI-INSPIRE 1249607); the design and operation of research centers (OAC 1059153); organizational and institutional implications for large-scale research projects (OCI 1256163); technical assistance to public-private partnerships (I-CORPS 1313562); launching and sustaining big data hubs (OAC 1916481); the cyberinfrastructure for the National Ecological Observatory Network (DBI 1636461); the EarthCube home office (GEO-1928208); collaborative strategies for large-scale science and engineering projects (CISE 1939224); the Campus Research Computing Consortium (OAC 1620695); Pan-Arctic Options (NSF-ICER 2103490); and cyberinfrastructure at Historically Black Colleges and Universities, Tribal Colleges and Universities, Hispanic-Serving Institutions, and other Minority-Serving Institutions (OAC 2137123).