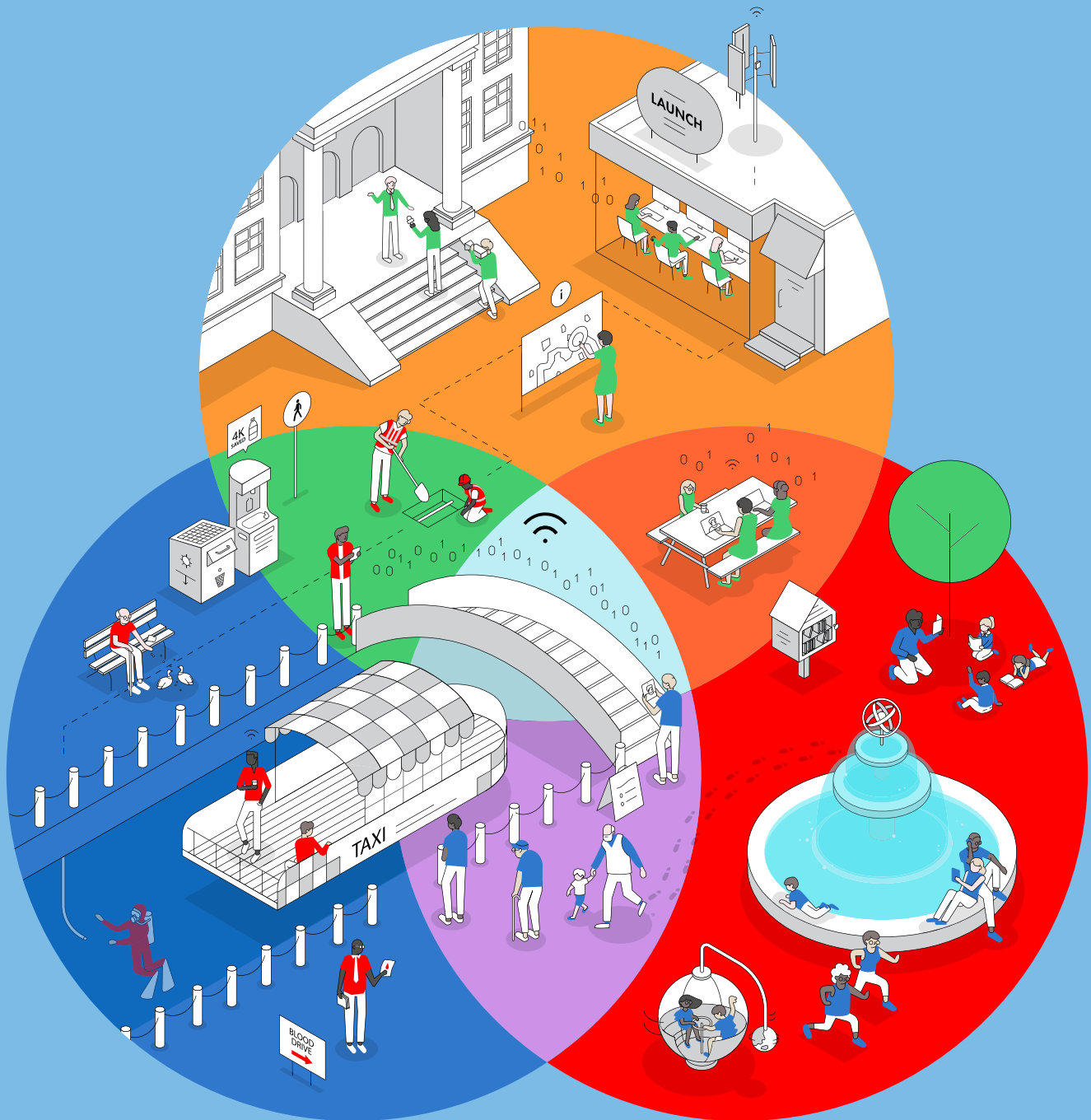# Infrastructure:
Building the World We Deserve

How a new approach can create a more resilient, equitable, and prosperous society

T HIS STORY BEGINS, AS MANY SET IN NEW YORK CITY DO, with the subway. As transportation enthusiasts, we're fascinated by trains, especially the remarkable system that runs above and below the city's streets. It was the discovery of this shared passion for understanding how our subway system works that got us talking about infrastructure a few years ago.

Infrastructure, in the most traditional sense, brings to mind physical constructions: city streets, power lines, the pipes that carry water into your home. But what about all the other things that make society function? Having seen the decline in investment in the country's physical infrastructure, and aware of the many ways the digital world is upending our definition of the term, we began exploring how Siegel Family Endowment could play a role in the future of infrastructure.

Over the past two years of research and conversations with partners across the field, we've realized that our nation's infrastructure is due for a reset. Hearing the term should evoke a different image: an interconnected web of assets, seen and unseen, that make up the foundation upon which the complicated machinery of modern society operates. It's inherently multidimensional.

In 2020, the United States has reckoned with a health pandemic, large-scale natural disasters, and a watershed moment in the fight for racial equity. These challenges highlight how relevant it is to reconsider what society deems the most critical, foundational assets for its citizens—and to ensure they have access to those assets.

Funding infrastructure is often considered the responsibility of government agencies. Yet many of our peers in philanthropy have made important investments in the field. These include working with local governments to fund research, promote novel forms of public-private partnership, and, ultimately, better serve citizens. And if infrastructure is viewed through the broader lens we argue for in this paper, it becomes clear just how much philanthropy, the nonprofit sector, and private entities are investing in our digital and social ecosystems.

We believe that we can do more—and better—if we commit as a country to adopting some of the principles outlined in this paper. However, we also consider this the beginning of a conversation. The time for us to think bigger and bolder about infrastructure is here. Our challenge now is to design it so that more people may thrive.

Sincerely,

David Siegel
FOUNDER &
CHAIRMAN

Katy Knight
EXECUTIVE
DIRECTOR

PREFACE
The Future America Needs

WHAT WILL THE WORLD LOOK LIKE IN 2050? Will schools and universities be recognizable? What kinds of jobs will exist, and what kinds won't? Will we have internet on the moon?

Will we have achieved racial equity? Climate stability? Adequate health care? Our current trajectory signals a dark future. The wealth gap among Americans is greater than it's been in decades, with an increasing divide along racial lines. Black Americans own approximately one-tenth of the wealth of white Americans, according to the Center for American Progress, with impacts cascading into health, education, and systemic inequalities that carry on from one generation to the next.

The world is getting hotter, with increasingly unpredictable weather. And by many measures, we are more politically divided than ever before. Our infrastructure is exacerbating many of these problems. For example, the global built environment is responsible for 39 percent of carbon-dioxide emissions, with carbon-intensive methods of design and operation supported by outdated regulations and tax incentives. And on the digital front, 162 million people in the United States still don't have access to high-speed internet in their homes, including 12 million school-age children—at a time when Americans need it more than ever in order to work and go to school. This divide will create vast disparities that may linger for decades.

Ultimately, the way we build and maintain our infrastructure shapes our future, which is why it's essential that we rethink the foundations of our society at such a pivotal moment. Going forward, infrastructure is more than just roads and bridges. It's also cellular networks and satellite arrays. It's public libraries and classrooms. It's internet access, digital commerce, and tools for social interaction.

To solve issues as urgent as racial injustice, income and wealth inequality, and climate change, we must begin by rethinking our infrastructure. It starts with recognizing that infrastructure is multidimensional, with footings in the physical, digital, and social realms. Good infrastructure can create a fairer and more just society. It uplifts everyone by being accessible to all. In short, it ensures equality of opportunity.

Of course, we don't know how the future will look. But we *do* have the power to start building the world we deserve.

<div style="text-align:center; font-size:1.5em; color:#cc4422;">
Infrastructure influences everything in society, and if we're to solve America's most pressing challenges, we need a new, multidimensional framework for designing, funding, and governing it.
</div>

CONTENTS

SECTION 1

Infrastructure Influences Everything

The history of mankind is the history of infrastructure.

IT SERVES AS THE CONNECTIONS THAT BIND US AND LIFT US UP, from the aqueducts of Rome to Thomas Edison's telegraph lines to the 5G networks of today. Infrastructure is buildings and highways, but it also encompasses broadband cables across the ocean floor and new technologies that become vital to human progress. When it is designed and governed properly, infrastructure is seamless, empowering people, companies, and governments to prosper. But when it's designed poorly, it can literally divide us. Just think of the expression "the wrong side of the tracks"—a division of cities into haves and have-nots.

Take, for example, highways. Starting with the Federal Aid Highway Act of 1956, the U.S. invested in interstate systems to eliminate congestion and help workers commute from their suburban homes to their downtown offices. Building these roads was also considered a national security issue—Cold War concerns made transporting military equipment around the country a high priority—which helped secure federal funds to fast-track construction. In Poughkeepsie, New York, as in so many cities, this resulted in a new high-

way that sliced through downtown, razing houses and businesses in the process and segregating the waterfront district from the rest of the community. It created a barrier that hardened over time between the wealthy and the poor, often dividing white citizens from people of color. Michael Murphy, the CEO and founding architect of the firm MASS Design Group (the acronym stands for Model of Architecture Serving Society), grew up in the city and recalls how the new highway nearly killed it.

"It divided Poughkeepsie between the north and south, the wealthy and the poor, and isolated the center of the city, which caused it to empty out," he says. "The highway succeeded in getting people from point A to B but failed miserably in uplifting Poughkeepsie, because you can't just put in physical infrastructure like this without considering the social connections that make communities thrive."

Understanding this connection between physical foundations and social outcomes—combined with the massive influence of today's

DEFINING INFRASTRUCTURE

The word first appeared in French in the late 1800s as a way to describe the underlying structures (*infra* means "below") of railroads. Today, Merriam-Webster defines it as the system of public works of a country, state, or region, as well as the foundation or basic framework of a system or organization.

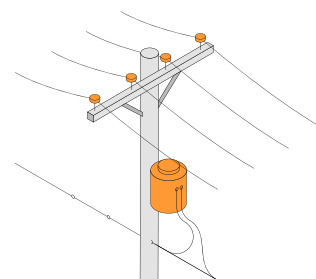
A BRIEF HISTORY OF INFRASTRUCTURE

How technologies once considered novel became essential to everyday life, influencing the outcomes of everyone in a society
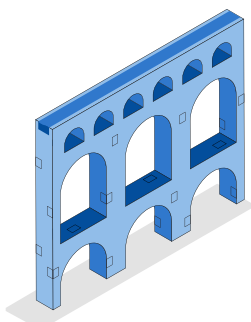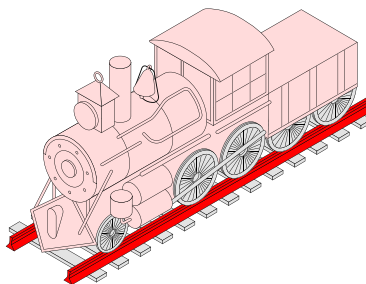
| Third Century B.C. | Early 1800s | Late 1800s |

ROMAN AQUEDUCTS

The Roman Empire, using tax dollars, constructed hundreds of aqueducts to bring water into its cities, where the water supplied free public baths, fountains, and even some private residences. Mining, milling, and farming operations also used this water, which helped to create a thriving economy.

RAILROADS

In the 19th century, most trains were privately owned, and they operated on gauges (the width of the tracks) that were unique to each company. This meant that one train couldn't run on another company's track. Corporations and the government worked to resolve this incompatibility by standardizing gauges, helping to unleash the full potential of the new technology.

TELEPHONE LINES

At first, telephones (and electricity) were a luxury. But the technology soon became critical infrastructure as more and more people relied on it for their basic communication, and the government urged companies to expand service across the U.S. by offering low-interest bonds, among other incentives.

THE DECLINE OF INVESTMENT

Public funding of infrastructure is the lowest it's been in decades, creating a backlog of maintenance, crumbling structures, and limited appetite for tackling necessary projects for the future.

$1.04 Trillion
The total estimated cost of all required maintenance for U.S. infrastructure on the federal, state, and local levels.* Maintenance has been deferred for years to save money in the short term, so the full price tag could be higher, since most states don't disclose the cost of deferred maintenance in their budgets—muddying decision-making and misleading taxpayers.

3.5x
Infrastructure spending by state and local governments in 2017 ($342.1 billion) as compared with the $98.4 billion spent by the federal government.**

$9.9 Billion
The decline in public spending on infrastructure in the United States from 2007 to 2017.**

16%
The decrease in spending on capital projects from 2007 to 2017 (from $207.1 billion to $174 billion). *These large-scale, cost-intensive projects are essential for society to move toward a more cost-effective, sustainable, and prosperous future.

*Source: Volcker Alliance **Source: Brookings Institute*

digital technologies—is crucial to developing a better framework for designing and governing infrastructure, particularly in the wake of disaster.

In 2012, Superstorm Sandy roared into the northeastern United States, causing $65 billion in damage and grinding life to a halt. As part of a project to understand why certain communities suffered more deaths and devastation than others, The Associated Press–National Opinion Research Center for Public Affairs at the University of Chicago (AP–NORC) went into the affected areas to assess what creates resilience. Why did some neighborhoods rebound while others did not? They came away with a simple answer: Social connections, and the physical infrastructure that enables those connections, are key.

"Communities that had low social infrastructure, where people were isolated and didn't have social networks looking out for them, had the highest number of fatalities," says Tom Wright, president and CEO of the New York Regional Plan Association, a nonprofit focused on issues of transportation, public housing, and public institutions. "So while people may assume disaster recovery in communities is based on wealth or height above sea level, in truth, social factors play a key role in their resilience."

The AP-NORC research stated that this social fabric, or social infrastructure, was fundamentally enabled by physical structures: the libraries and faith centers that forge connections among residents, the sidewalks and street layouts that encourage mingling, and the community venues for events, like farmers markets, that

BUILDING THE INFRASTRUCTURE OF THE FUTURE
Infrastructure has evolved from roads and bridges to 5G networks and server farms. Today it's critical to view it through three dimensions: physical, digital, and social. By recognizing the overlapping and interdependent nature of these dimensions, we can design and develop infrastructure that helps create a more equitable society for all.

inspire socializing. The report's ultimate insight was as simple as it was novel: "Investment in neighborhood-based institutions and programs that encourage engagement with neighbors—community centers, public art installations, block parties, Meals on Wheels—may be a cost-effective way to prepare a community to withstand damage and effectively rebuild the community."

Today the challenges facing modern infrastructure are vast. There is a trillion-dollar backlog in deferred-maintenance costs for infrastructure in the United States, according to the nonprofit Volcker Alliance, and public spending on infrastructure declined by nearly $10 billion from 2007 to 2017. The United States' infrastructure is literally crumbling due to lack of funding and public investment in forward-looking projects. For example, according to the Pew Charitable Trusts, 40 percent of public schools and 60 percent of healthcare facilities in rural areas don't have broadband internet. Infrastructure, or lack of it, is partitioning society into haves and have-nots even more so in the digital arena.

But with these challenges also comes opportunity, especially as we consider how to define, design, govern, and fund the infrastructure of the future. So how do we tackle such massive challenges? It starts with reconsidering our definition of infrastructure. ■

SECTION 2
A New Definition of Infrastructure
It's time for a better way of viewing and assessing the underlying structures of society.

F INFRASTRUCTURE IS GOING TO SUCCEED, WE MUST CONSIDER IT in a new way—one that reflects the constantly changing nature of our world. Facing challenges like global pandemics, climate change, and systemic inequalities based on race and wealth, infrastructure must more broadly encompass the key drivers of society: physical, digital, social systems.

For decades, the physical, digital, and social dimensions of infra-

A NEW WAY OF LOOKING AT INFRASTRUCTURE

We introduce a new framework for viewing traditional types of infrastructure that can help create better, more cost-effective outcomes.

THE THREE DIMENSIONS

- **Physical Infrastructure**
  The built world, or the basic structures and networks necessary for a modern society to function effectively. This consists of fixed public assets like roads, bridges, tunnels, and parks, as well as public utilities like subway and train lines, sewage systems, and electrical grids.

- **Digital Infrastructure**
  The data, hardware and software, coding, and operating systems that make up the digital world, as well as the assets through which that world is transmitted: cell towers, broadband cables, computer networks, and satellites. Increasingly, the definition is evolving to include critical digital utilities relied on by everyone, such as search engine capabilities and social media.

- **Social Infrastructure**
  The communities, organizations, and public spaces that shape the way people connect with each other. These include public institutions (libraries, schools, voting booths), public spaces (sidewalks, gardens, green spaces), and community organizations (faith centers, neighborhood organizations, cultural groups).

HOLISTIC LENS

- **Multidimensional Infrastructure**
  A new understanding of physical, social, and digital infrastructure that recognizes the interdependence of these three dimensions. Any decision or change in one dimension of infrastructure must consider the other two dimensions in equal measure. By doing this, we can design and maintain infrastructure that's responsive, resilient, and cost-effective and creates further opportunities for society.

structure have typically been treated as separate issues, leading to siloed thinking and short-term solutions. But infrastructure doesn't exist in isolation in the real world. For instance, a library isn't just a storage facility for books. It's a physical space that forges community bonds and offers digital access. Similarly, a road isn't just a paved surface for vehicle traffic. It's a vital artery for commerce and social connections, one that is now governed as much by digital systems like Google Maps and Waze as by individual drivers. Or consider this: When you post a photo to Instagram or comment on Twitter, you're relying on a vast network of physical structures like cell towers, transatlantic cables, and server farms, as well as invisible structures like radio signals, network protocols, and computer code.

The reality is that the infrastructure reinforcing today's society is multifaceted. It comprises three primary dimensions—physical, digital, and social—that are interdependent. Think of this as a three-legged stool: Should any leg falter or be cut off, it will topple the person sitting on it.

This is why, at Siegel Family Endowment, we consider these three dimensions to be the basic pillars of what we call multidimensional infrastructure. By recognizing the interconnection of all three dimensions, we can use this new framework to strengthen communities, power economic activity, and better design infrastructure systems for the future. ■

Smarter Infrastructure in Action

Creating a new vision for infrastructure is difficult, but we've been here before.

DURING THE GREAT DEPRESSION OF THE 1930S, THE FEDERAL government's massive New Deal program sparked one of the largest waves of investments in infrastructure in U.S. history: the Hoover Dam in Nevada, New York's Lincoln Tunnel, Great Smoky Mountains National Park, and the sprawling Tennessee Valley Authority, to name just a few. But the New Deal was designed to do more than create new transportation routes and produce cheap energy. It was designed to create jobs, uplift individuals and communities, and transform society as a whole by providing economic development to areas that desperately needed it. "The New Deal integrated physical infrastructure with artistry and a sense of place," says architect Michael Murphy. "Today we should be doing the same thing. Instead of building fixed infrastructure systems, we should be constructing living systems—ones that adjust and calibrate to their physical and social environments."

Multidimensional infrastructure, in other words, is designed with an ecosystem approach—one that elevates its environment and the people dependent on it, creating lasting and equitable results for everyone. Going forward, we have the opportunity to reimagine infrastructure, ensuring that physical, digital, and social systems create thriving communities.

Here are three case studies for how to do so.

1

Building Prosperity: The 21st-Century Library

How a public institution transformed from a repository of knowledge to the backbone of community—and economic—growth

THE INNOVATIONS ARE EVERYWHERE.

In Austin, Texas, staff members created a vocational class to teach welding so that out-of-work residents could retrain for high-paying jobs. In Houston, where 66 percent of adults and 34 percent of youth are overweight, employees organized events to promote healthy eating and exercise and also distributed 50,000 pounds of fresh food to more than 3,100 families. In Omaha, Nebraska, staff members established a series of partnerships with re-

MULTIDIMENSIONAL INFRASTRUCTURE

A new framework for understanding the importance of infrastructure

▶ Building and maintaining thriving communities begins with the recognition that today's infrastructure is multidimensional, with elements in the physical, digital, and social worlds. Each of these dimensions influences the others, and it's essential to recognize this interdependence if we're going to design, fund, and govern infrastructure effectively and efficiently. That's why it's crucial to imagine good infrastructure at the center of a triangle representing the three pillars. Because good infrastructure is multidimensional—and multidimensional infrastructure is at the core of a just, equitable society.

Physical

Multidimensional
Infrastructure

Digital

Social
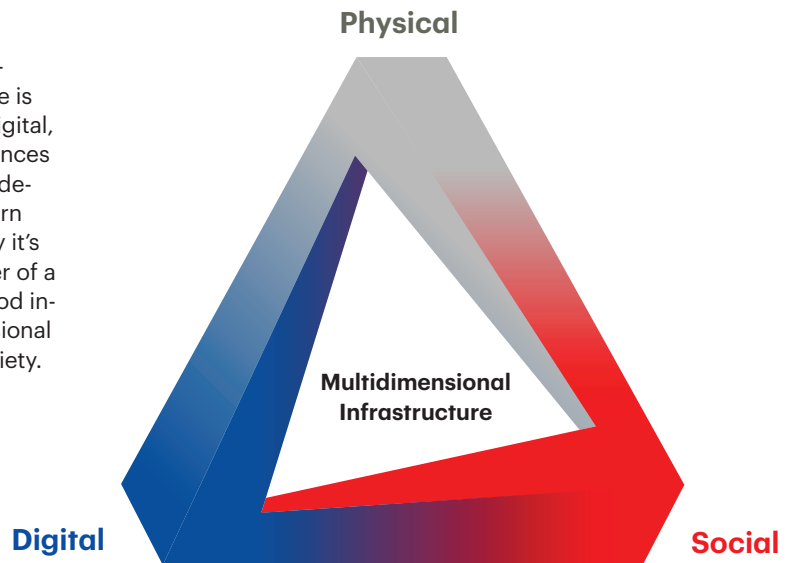
gional software and technology companies to teach residents digital skills, helping to spark a local boom in tech workers.

These projects may sound like the work of universities or local governments, but in fact they're the initiatives of another institution responding to user demand in a transformational way: public libraries.

Mostly thought of as repositories of collective knowledge, libraries are also hubs of civic engagement, providing job training, art spaces, and even coffee shops. They are first and foremost physical places, but digital and social systems are embedded within them, offering a free entry point to the online world and the ability to learn new skills. For people without a reliable internet connection, the public library is a vital way to interact with the broader world. We use it to access email, bank accounts, government services, job-application portals, and educational opportunities.

According to a 2019 Gallup poll, Americans take an average of 10.5 trips to the library each year, making it the "most common cultural activity Americans engage in by far." And the people who go there represent a demographically diverse swath of the population, led by adults aged 18 to 29 (15.5 average visits a year) and those who earn less than $40,000 per year (12.2 visits per year, versus 8.5 visits for those earning more than $100,000 per year). For disadvantaged communities, the library has become a primary resource for learning online skills, with 90 percent of the nation's 16,000 public libraries now offering digital-literacy courses, according to the American Library Association. Roughly half of those libraries also provide free services for small businesses and entrepreneurs. In other words, libraries have become hubs for community resilience, education, and economic growth—making them a key driver in sustaining communities across the United States.

In Kansas City, for example, the public library system is help-

ing to lead a citywide transformation. In recent years, an increasing number of longtime residents have struggled to find jobs in the digital economy. Simultaneously, a growing population of refugees and immigrants have begun relying on local libraries for online access. So in 2010, when Kansas City became the first city in the country to get Google Fiber—the fastest internet connection at the time—the Kansas City Public Library (KCPL) took advantage of the newly available capacity by installing broadband in all its libraries. They also hired staff to teach digital skills ranging from using a mouse to online marketing. Its business courses were so popular among residents that KCPL eventually hired a specialist to assist local entrepreneurs with writing business plans, creating marketing strategies, and starting their own LLCs. KCPL's programs spurred new businesses and helped jump-start the local economy.

"We've had everyone from a lady with a dog-walking and bathing business to an older gentleman who owned a construction firm and suddenly found himself responsible for things like social media and marketing," says Wendy Pearson, manager of strategic initiatives at Kansas City Public Library. Two or three times a year, KCPL has even held group sessions with new and established business owners, which not only helped them learn new skills but also created a sense of community among the entrepreneurs. "We have witnessed very seasoned business owners offering advice and connecting outside of our sessions, developing friendships," says Pearson. "So there's this secondary, underlying support network that's coming out of this learning format."

Libraries are a prime example of the power of a more holistic approach to infrastructure for a simple reason: They're human-centered institutions focused on supporting communities and adapting to their needs. As R. David Lankes, one of the foremost

THE POWER OF MODERN LIBRARIES

How an established institution helps individuals and communities thrive through innovative programs anchored in a multidimensional approach

Coworking space with free broadband access to the internet

Reading room that doubles as a classroom for new skills acquisition

Community space for local gatherings and events

Multipurpose classroom for teaching skills to community members of all ages
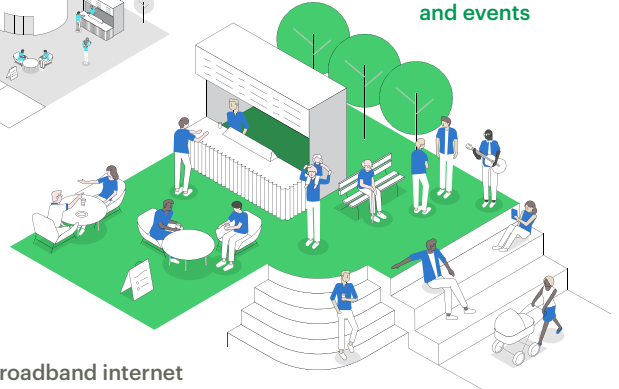
Broadband internet allows community members to get online and access the digital world
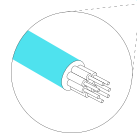
PHYSICAL

The buildings themselves, once just repositories for books, now provide dedicated space for lifelong learning, workforce training, and community events.

DIGITAL

Online access is free for everyone. Digital-focused classes are taught on a range of subjects, from computer basics to coding and social media marketing.

SOCIAL

Social connections formed by learning together and attending events create a deeper sense of community. In many cases, libraries serve as physical meeting places and source of news, information, and opportunity.

End Goals Met

In addition to reading materials, communities receive reliable online access, educational opportunities, meeting spaces, and professional training, which in turn contribute to thriving local economies.

library advocates in the U.S. and the director of the School of Library and Information Science at the University of South Carolina, says, "Bad libraries build collections. Good libraries build services. Great libraries build communities." ■

Modern Libraries

KEY TAKEAWAYS

Traditional View: Libraries, if only viewed as spaces for books and reading, risk losing their relevance in communities where a wide swath of the populace is using the public institution to access and participate in the digital world.

Multidimensional Lens: Libraries are perceived as knowledge centers for local communities, offering online access, digital and entrepreneurial training, language learning, safe havens for youth education and recreation, and multiuse spaces to jump-start innovation. In the process, they connect the disconnected segments of society physically, digitally, and socially.

Better Outcomes: Multidimensional libraries create stronger community connections and resiliency while stimulating the local economy. These expanded 21st-century offerings should prompt us to reconsider the outsize value that libraries create relative to their cost—and should qualify them for a broader set of funding opportunities like digital-access and workforce-development grants.

2

The Unexpected Areas Fueling a Surge in High-Tech Jobs

How tech infrastructure can revitalize rural America

IN 2000, IN WHITE RIVER JUNCTION, VERMONT, MATT BUCY MADE A crazy decision: He scrounged up his savings and recruited investors to buy a defunct industrial bakery that dated to the 1880s.

Like many rural areas in the U.S., White River Junction had fallen on hard times when its main employer, the railroads, closed. However, as an intersection for rail lines, the town was one of the first rural areas in the country to get broadband internet, in 2000, as companies like Verizon used railroad-owned land to install their high-speed cables alongside the tracks. This gave Bucy, a Yale-trained architect and engineer, a simple idea: to develop a retail, commercial, and coworking space across the street from a Verizon switching facility, using all the connectivity to create a startup hub for high-tech businesses.

Twenty years later, Bucy's space is still going strong, with more than 40 artists, gig workers, and transportation, consulting, and software businesses thriving there. Over time, the site has added a café, loft apartments, and even a craft beer scene. Despite having only 2,000 residents, White River Junction has managed to attract many young graduates from nearby Dartmouth College, creating an economy that's diverse, affordable, and growing. It's just one example one example of how rural America can thrive in the digital age.

Despite strides to improve online access, rural areas across the United States continue to struggle in the digital age. Just 25 American cities—hubs like New York, San Francisco, and Austin—have accounted for more than two-thirds of job growth in the past decade, according to the McKinsey Global Institute. This trend is expected to continue as more and more jobs are automated and the majority of growth (particularly in high-paying jobs) is concentrated in the digital arena.

A big reason for this disparity is high-speed internet—or lack thereof. According to the Pew Research Center, just 63 percent of rural residents have access to broadband, compared with 75 percent of urban and 79 percent for suburban residents. And 98 percent of Americans in urban areas have access to services with 25 Mbps speeds or greater while just 69 percent of those in rural areas do, according to the Federal Communications Commission. These disparities in download speeds essentially means the difference between being able to have two kids join a remote classroom or just one.

As venture capital funding has flowed into startups in Silicon Valley and cities across the country, wages in many rural areas have stagnated, and communities have often been forced to confront crises like the opioid epidemic. But towns like White River Junction offer another vision. It's a lesson about how digital infrastructure—in this case, broadband—combined with physical and social infrastructure can lift an entire community.

This is the main idea behind the Center on Rural Innovation (CORI), a nonprofit that helps rural communities address economic challenges through digital jobs, technical training, and entrepreneurship. "In the age of the internet, there should be no limit to where digital-economy jobs and innovation can take place," says founder and executive director Matt Dunne, who also started Google's Community Affairs division, which played a significant part in rolling out Google Fiber in towns across America. "It's one of the few parts of the nation's economy that's growing, and it needs to happen in a more equitable way across geography."

To illustrate his point, Dunne—who also served in the state legislature in Vermont for 11 years—points to U.S. cities CORI is working with. In Pikeville, Kentucky, the heart of Appalachia coal country, residents and officials recognized they were going to be left behind if local organizations didn't start participating in the digital economy. So, in 2018, they launched a workforce program to train former miners how to code. It turned out that the miners—natural problem solvers—were good at it, and many found new employment. A few even started their own companies. The project is ongoing and will get a significant boost this year from CORI's Rural Innovation Initiative, which helps communities design strategic plans to create scalable startups, access capital, and spur positive local partnerships with universities, nonprofits, and businesses.

In Red Wing, Minnesota, in 2018, hundreds of local workers pressed leaders to create new jobs when a nuclear power plant was slated for decommissioning. The city invested in fiber-to-the-premises broadband infrastructure—the fastest form of internet—and created a tech incubator in a former office space, which over the

ELEVATING RURAL AMERICA

Small towns across the country are boosting their economies by pairing digital investment with social and physical infrastructure. Here are a few of the communities that the Center on Rural Innovation is working with.

1

RED WING, MINNESOTA

In 2012, this manufacturing hub on the Mississippi River received fiber-optic internet through a public-private partnership. Piggybacking on that, the nonprofit Red Wing Ignite opened a coworking space that offered free internet access, provided business classes and mentors for budding entrepreneurs, and even connected business owners to potential investors. It has spurred a local economy that's diversifying, with more high-paying digital jobs.

2

WATERVILLE, MAINE

With central Maine's economy split between heavy industry and, more recently, higher education, the Central Maine Growth Council has long worked to retain graduating students and create more diverse job opportunities by offering consultation services for startups and coworking spaces. Ongoing educational opportunities like Tech Night, an evening for local entrepreneurs to share their stories and offer advice on building a successful business, bolster the economy and help secure federal grants for more innovation hubs.

3

PIKEVILLE, KENTUCKY

With jobs dwindling in blue-collar fields like mining, the nonprofit Shaping Our Appalachian Region convened a series of summits to envision a new future for eastern Kentucky, which included boosting the presence of digital jobs through broad-band investment and workforce training. An adult-education center and business incubator was created, and the early result is more jobs in advanced manufacturing, remote tech work, and food production.
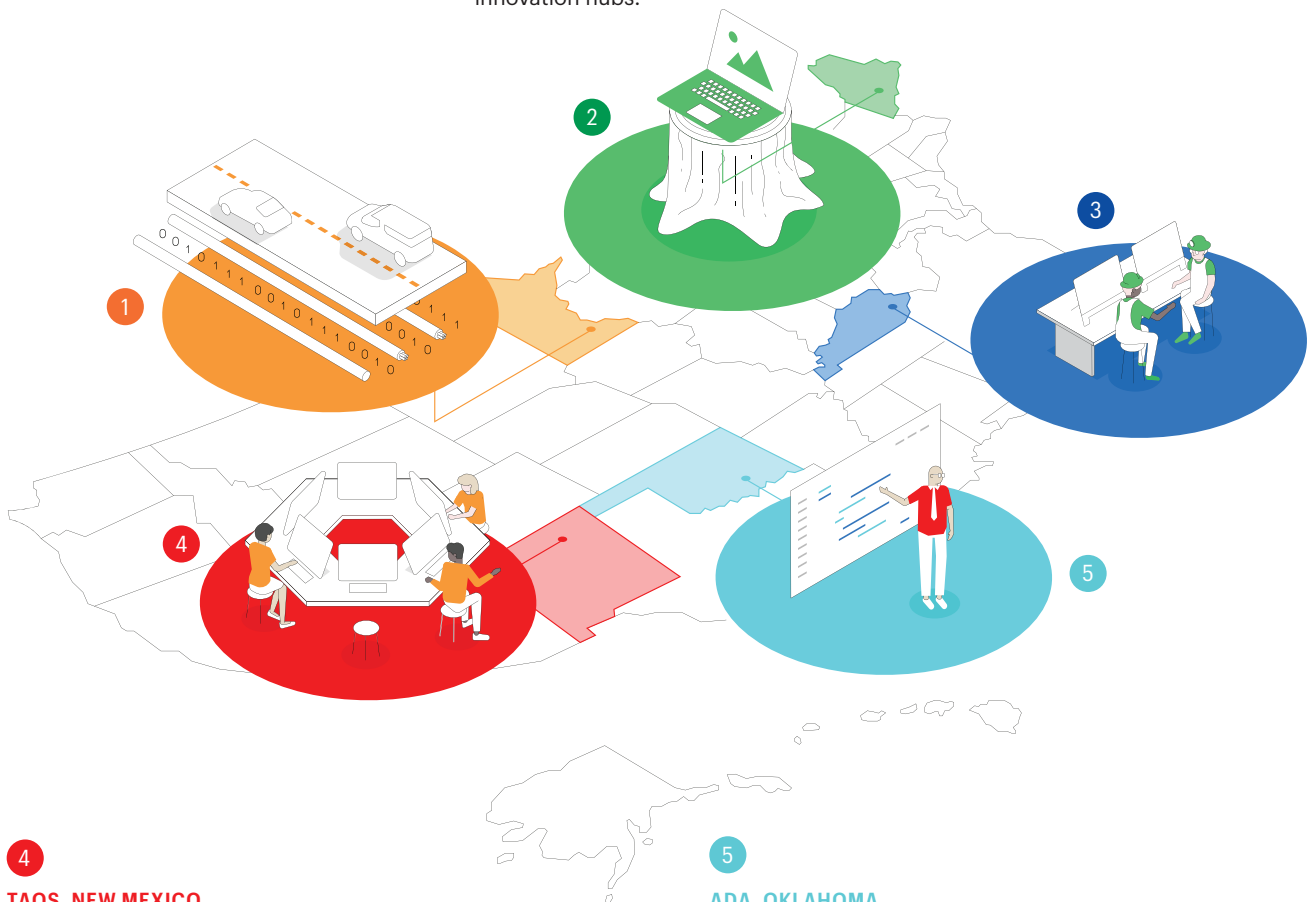
4

TAOS, NEW MEXICO

In a community with a large population of adults without high-school or college degrees, the nonprofit Taos HIVE opened a coworking space so locals could access the internet for free and take classes in basic reading and math skills. Taos HIVE also provides hands-on tutorials for digital-technology and busi-ness-development skills. Now a community that has often been left behind by traditional education models can access a life-long educational resource that offers pathways out of poverty.

5

ADA, OKLAHOMA

For more than two decades, the Ada Jobs Foundation has served this small town by supporting entrepreneurial opportunities through business seminars and public pitch sessions for budding businesses. To stem the outflow of tech workers and jobs to nearby Oklahoma City, the nonprofit has focused more of its workforce training and seminars in the digital realm, which has helped to diversify the local economy through tech-focused startups and remote-work opportunities.

> # "Put the three B's together—broadband, blues, and beer—and you can create the energy that will reverse the exodus of rural people from these places."

past two years has helped more than a dozen digital entrepreneurs get their companies off the ground. And in Cape Girardeau, Missouri, local officials built a fiber-to-the-premise network and leveraged it to create training and dozens of new jobs in a town of just 40,000 people. The local school system even held coding competitions to encourage kids to think about digital opportunities from a young age.

All these cases had one thing in common: Digital infrastructure helped spur revitalization. But it wasn't just broadband internet that jump-started economies. It was also the social infrastructure built around it—the spaces for tech or software businesses to thrive, for programs to help train locals in coding and other high-tech skills, and for the coffee shops, breweries, and small music venues to make those workers want to stay. In this way, the physical, digital, and social infrastructure came together to revitalize communities as a whole.

"We have this joke," says Dunne, "that the real drivers of rural economic development are the three B's: broadband, blues, and beer. Put all those good things together and you can create the energy that will reverse the exodus of rural people from these places." ∎

Rural Tech Hubs

KEY TAKEAWAYS

Traditional View: Rural areas, if they're going to revitalize their economies and retain residents—especially younger, skilled residents—need to create higher-paying jobs and a more dynamic business sector not entirely dependent on industries such as farming and manufacturing.

Multidimensional Lens: Installing high-speed internet is the first step in making the most of an underutilized workforce. When broadband is paired with dedicated space for job training and supportive social infrastructure, residents can launch new careers in the tech economy. Coworking spaces spaces can appeal to freelancers and entrepreneurs, and communities can develop stronger connections through digital hubs.

Better Outcomes: Rural communities and small towns have an entry point into the tech economy through local entrepreneurs and remote work. Also, they can create a more diversified regional economy compared to one based on a single employer, allowing them to weather economic downturns and shifts in industries.

3

The Future of Power
How a boundary-pushing startup is rethinking energy

WHAT IF STREETS, ROADS, AND SIDEWALKS WERE MORE THAN JUST CONVEYOR belts for cars and pedestrians? What if they became the building blocks for a futuristic city, embedded with technologies like power delivery systems, data-collecting devices, and information and communications technology (ICT)?

These may seem like wild notions, but they're the focus of Uncharted Power, a New York–based company leveraging an underutilized public asset—the ground we walk and drive on—to combine civil infrastructure with power grids and digital technologies.

Uncharted Power first gained attention in 2013 for designing the Soccket, a soccer ball that converted kinetic energy into power that could be used for portable lights. The Soccket eventually inspired the company to focus on a larger problem: fixing unreliable energy infrastructure.

Today, the company's mission is to outfit the built environment with solutions that help streamline the development and operation of critical infrastructure. The primary component of the Uncharted System, as the technology is called, are "pavers." They're essentially road and sidewalk panels designed to accommodate power lines and tech capabilities. Cities can equip them with fiber optics to provide internet access, for example, or embed sensors and ICT hardware to monitor sidewalk wear and tear and respond to citizens' behavior. For example, a sidewalk may sense that a pedestrian is walking slowly and relay that information to a crosswalk signal so it can provide more time for that person to cross the street.

Once deployed, the Uncharted System converts the ground beneath our feet (and our tires) into a multiuse space for electricity delivery, data technologies, and smart-city applications. The system can then be used for things like monitoring citizen safety, creating resilient electrical grids, and offering affordable broadband. It's also easily upgraded as new technologies emerge.
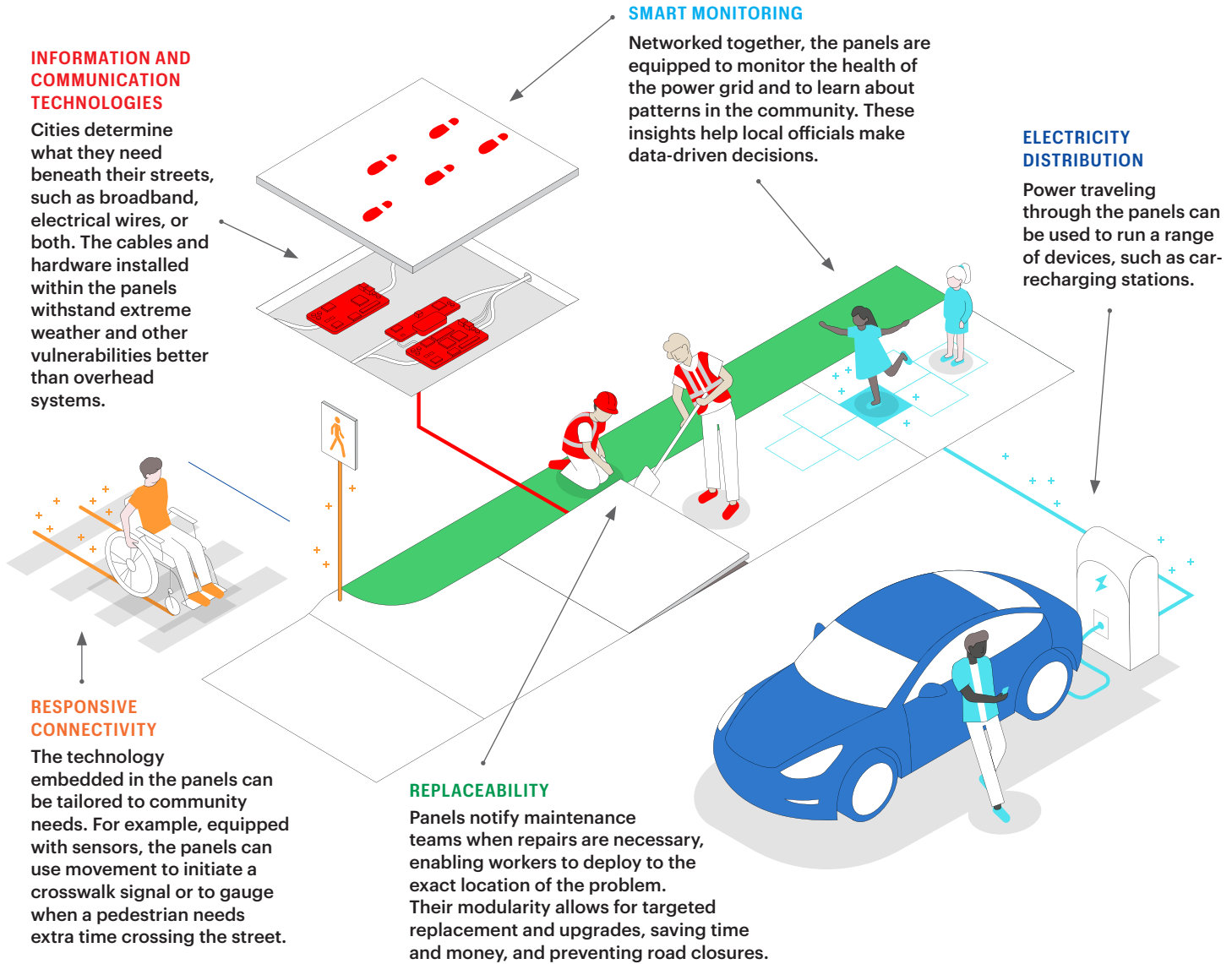
"There's been very little innovation in power in a long time," says Jessica O. Matthews, Uncharted Power's founder and CEO. "Right now it mostly comes from large, centralized power plants, whether they're renewable or nonrenewable."

Currently, just 18 percent of the electricity generated in the U.S. is renewable, according to the federal government's Energy Information Administration. And a large barrier to increasing that share is structural: A top-down, centralized grid, often run by government-sanctioned monopolies, has made innovation difficult if not impossible. "By contrast," says Matthews, "we look at power more like a mesh network, with inputs from all over—a democratization of energy sharing across a dynamic network."

The Uncharted System, which the company is hoping to launch

REIMAGINING ELECTRICITY FOR A MORE EQUITABLE SOCIETY

How the startup Uncharted Power is disrupting the energy grid—and democratizing the future of electricity through a new infrastructure approach

SMART MONITORING

Networked together, the panels are equipped to monitor the health of the power grid and to learn about patterns in the community. These insights help local officials make data-driven decisions.

INFORMATION AND COMMUNICATION TECHNOLOGIES

Cities determine what they need beneath their streets, such as broadband, electrical wires, or both. The cables and hardware installed within the panels withstand extreme weather and other vulnerabilities better than overhead systems.

ELECTRICITY DISTRIBUTION

Power traveling through the panels can be used to run a range of devices, such as car-recharging stations.

RESPONSIVE CONNECTIVITY

The technology embedded in the panels can be tailored to community needs. For example, equipped with sensors, the panels can use movement to initiate a crosswalk signal or to gauge when a pedestrian needs extra time crossing the street.

REPLACEABILITY

Panels notify maintenance teams when repairs are necessary, enabling workers to deploy to the exact location of the problem. Their modularity allows for targeted replacement and upgrades, saving time and money, and preventing road closures.

with a pilot program in Poughkeepsie in 2021, is a vision of how resilient, community-driven infrastructure may function. Each community designs its system to fulfill its own unique goals—goals that transcend any one department or agency. And as modular units, the panels and technologies inside them can be easily replaced, reducing upgrade costs and development time lines. This allows the system to scale alongside the community.

"You have this catch-22 of providing new services to a community without the technology becoming obsolete by the time you're finished building," says Matthews. "Making sure the system is upgradable is critically important, as it should be with any infra-structure system."

This is more than smart-cities stuff, wherein the Internet of Things harnesses data to optimize lives. Uncharted Power is looking to an uncertain, ever-changing future and thinking bigger. The company wants to help governments and private industries solve energy and social problems in sustainable, equitable ways, ensuring the best interests of people and their data are at the center of it all.

"If we don't figure out power, then what's the point of all these other issues?" Matthews says. "Energy affects the stability of our health system, the stability of our education system, and the stability of our communication systems. It powers everything." ∎

Overall, these examples have one thing in common: They've taken an ecosystem approach to creating smarter, more equitable infrastructure that accounts for physical, social, and digital dimensions. Once the problems are examined through a multidimensional lens, the solutions that come to the foreground are often naturally synergistic and create value across every dimension—whether that's leveraging a relatively new technology, like the internet, to help revitalize communities or reimagining an old system, like the power grid, to create a more equitable and just society. Using a multidimensional framework to assess infrastructure challenges, in other words, is the most practical and effective way of arriving at the forward-looking solutions the United States needs.

Uncharted Power

KEY TAKEAWAYS

Traditional View: As a public utility, the current power grid offers electricity that's often from a single source and controlled by a few major companies. This creates monopoly-like systems that are prone to disruption during severe weather events and other crises, and are difficult to upgrade to better, more sustainable technologies.

Multidimensional Lens: By treating physical infrastructure such as roads and sidewalks as a conduit for digital tools and capabilities, communities can amplify the value of public assets and democratize access to services. Because the panels are modular and upgradable, they can scale and adapt the technology inside to meet evolving needs while remaining sustainable and extreme-weather resilient.

Better Outcomes: With built-environment items like sidewalks and roads able to house power-delivery systems and digital infrastructure, communities can provide targeted services like high-speed internet and edge computing (data centers that are spread out rather than centralized). Additionally, the technology could create opportunities for private investment, with small companies or individual entrepreneurs able to purchase the panels and enter the market.

SECTION 4
Shaping the Infrastructure of the Future
How to approach the major issues: defining, designing, governing, and funding.

TODAY THE UNITED STATES FACES IMMENSE CHALLENGES, MOST urgently the systemic inequalities of race and wealth and their cascading effects on health, education, employment, upward mobility, and a host of other disparities. As we've seen, the COVID-19 crisis has forced government officials, private interests, and the general public to open their minds (and wallets) to big changes. For the first time in decades, the country seems ready and willing to debate the need for massive public and private investments in society.

But amid all this talk of change, it's important to keep one thing in mind: Infrastructure must meet future needs, not just current ones.

"We're always building back to the last disaster, but we never have the same disaster twice," says Amy Chester, managing director of Rebuild by Design, a coalition of government, business, nonprofit, and neighborhood organizations that helped communities recover in the wake of Superstorm Sandy. "With COVID-19, for example, we know there's going to be recovery and funding for big projects. But the real focus should not be on returning to 'normal'—it should be envisioning what we want our new normal to be."

Rebuild by Design was created as part of the $60 billion–plus Hurricane Sandy Rebuilding Task Force, and the program is a prime model for how to tackle big challenges with a holistic approach. Perhaps its signature aspect is how it operates. In a highly uncommon approach for the federal government, teams of experts from diverse fields, including architecture, urban planning, and environmental science, were created and then assigned to specific communities to help them envision what rebuilding their neighborhood would look like. Rather than jumping into devising solutions, members of the Rebuild by Design coalition first spent months getting to know the communities that would be affected by their designs—and only then did they begin devising new infrastructure ideas.

"For us, the research phase is crucial," says Chester. "We don't just bring experts into a room and brainstorm. Instead, we spend an enormous amount of time educating each other and learning about the places and their people and problems. That way there's a lot of trust and understanding that gets built from the ground up."

This inclusive, synergistic design process is creating groundbreaking solutions for the northeastern communities hit hardest by Superstorm Sandy, such as flood barriers in Manhattan that double

"We're always building back to the last disaster, but we never have the same disaster twice."

as outdoor art galleries and an inner-city greenbelt that protects a food-distribution center in one of the most impoverished congressional districts in the United States. Rebuild by Design is changing how the U.S. approaches infrastructure—a vision that aligns with Siegel Family Endowment's multidimensional approach.

For years, Siegel Family Endowment has been working with experts to address the challenges of creating, maintaining, funding, and regulating infrastructure. There are no easy answers, but with Americans yearning for change, there is now a window of opportunity to push forward and advance a more just society, with equality of opportunity for all. To meet this unique moment, we've laid out some of the issues and ideas we can use to guide conversations about the future of infrastructure. We've grouped them into the following categories: define, design, govern, and fund. ■

1

Define: Assess and Evolve Our Definition of Infrastructure

Since what we consider infrastructure changes over time, what will it look like years from now—and why will it matter?

MOST PEOPLE AGREE THAT ROADS, ELECTRIC GRIDS, AND SANITATION pipelines are critical infrastructure. But what about schools and libraries? Search engines and public data? As the digital world changes how we live, the definition of infrastructure becomes increasingly blurry.

One thing is clear: There's no "end state" for infrastructure. As societies and technologies change, infrastructure must adapt along with them—otherwise people get left behind. To avoid that, what we consider to be infrastructure must be regularly assessed and updated to make sure it aligns with economic and social goals.

But how do we decide what constitutes infrastructure and why it matters? Josh Greenberg, program director at the Alfred P. Sloan Foundation's Digital Information Technology program, believes something should be considered infrastructure when a number of other essential things depend on it—a concept he calls inbound dependencies. Roads, for instance, are the backbone of economies because businesses need them to transport their goods. In other words, businesses are dependent on functional public (and sometimes private) roads.

Similarly, in the digital world, businesses are increasingly dependent on search engines and social media to market and sell products. As a result, these digital tools should perhaps also be considered infrastructure, as they're vital to commerce, social interactions, and community cohesion.

Of course, once you label something critical infrastructure, it becomes subject to possible government oversight. On one hand, oversight may hinder innovation. On the other hand, unchecked infrastructure can reinforce systemic problems. Additionally, it's important to remember that what we consider critical infrastructure was often never planned as such—it simply developed that way (think roads and telephone networks).

"Many pieces of our society were not initially designed as mass infrastructure but evolved to become public goods," says Greenberg. ■

Define

KEY TAKEAWAYS

- There is no "end state" for infrastructure: What we consider infrastructure must be regularly assessed and updated when necessary.

- A key feature of infrastructure is its essential role in the functioning of a healthy society. The more things rely on it, the more critical it becomes, regardless of whether it was intended as infrastructure or evolved to become so.

- Labeling something as infrastructure has consequences. It brings protections but also allows government greater power and oversight, which could be commodified or abused. But not labeling something as infrastructure also has consequences, perhaps exacerbating issues like racial injustice and economic inequality.

2

Design: Articulate and Communicate Shared Goals

How should we devise and implement infrastructure to improve the entire life cycle of projects?

DESIGN, AT ITS BEST, IS THE PROCESS OF ENVISIONING AND COMMUNicating purpose. Though it's primarily about creating some sort of function (often paired with aesthetics), it's also a reflection of social norms and values. If a society aspires to achieve racial equality, for example, that norm must be considered at all stages when designing infrastructure—not simply as an afterthought. It has to be baked into the cake.

In order to achieve the desired outcome of infrastructure, the first step should be to make its purpose visible. "Infrastructure has often failed to communicate effectively what it's doing," says Michael Murphy of MASS Design Group, the interdisciplinary architecture firm that works with experts in fields like engineering, furniture design, and filmmaking. "We need better ways to articulate, visualize, and spatialize the infrastructure around us and how it's affecting us."

To have a clear purpose, infrastructure must embed features within it that help communicate its goals. Examples of projects that convey purpose include clocks in subways stations that count down the arrival of trains, rooms in libraries that are designated as "digital labs," and privacy warnings on search engine results. All these types of infrastructure need to visually relay their purpose in order to ensure a positive user experience and create trust in the system.

The design process is not a single exercise. Instead, designing infrastructure requires multiple moments of decision-making throughout a life cycle. For example, the construction of a bridge is often viewed as a simple solution to continue a road. However, its

actual design is the result of a sequence of negotiations—from funding meetings and inspections to maintenance and management—all of which come with constraints and incentives. A bridge is not just a bridge; it's a series of decisions that continue to impact society.

To fully account for the overall effects of infrastructure, we as a society need to make sure we're properly conveying the outcomes we want. In other words, we need to keep the end goal in mind—a very specific end goal.

"We often use metrics like 'high school completion' as a proxy for the factors we really care about, like 'critical thinking' or 'conscientious citizenship,'" says Dr. Ellan Spero, a historian of science and technology at MIT and cofounder of the higher-education nonprofit Station1. We need to dream up better ways to tabulate what we're really aiming to achieve when we design infrastructure, taking into account both the visible and invisible. For instance, there are numerous social expectations, behaviors, and mindsets that we assume are conferred to students if they merely attend school but that aren't incorporated into the design or flow of the learning space or curriculum.

"There are a lot of infrastructure projects that are designed around achieving funding and sustaining projects as projects," says Tom Wright of the New York Regional Plan Association, "and not necessarily increasing any explicit outputs."

Unless we articulate the specific outcomes we want, we risk poor understanding and ineffective infrastructure. So, to better integrate multidimensionality into our built world, we propose four principles to use when designing infrastructure:

1 **INTERDISCIPLINARY VISION AND PURPOSE**
Designs must offer multiple layers of functionality across all physical, digital, and social dimensions.

2 **ACCESSIBILITY AND EQUITABILITY FOR ALL CITIZENS**
To ensure this, the process should involve those who will be primarily affected by the infrastructure and should remain accountable to them over time as it evolves.

3 **CONTEXT-FORWARD AND EVIDENCE-BASED SOLUTIONS**
Infrastructure cannot be designed in a vacuum. Design should be based on research and data while also considering local realities and constraints. Taken together, this info helps tailor solutions to each unique circumstance.

4 **LONG-TERM STEWARDSHIP**
This includes taking into account performance, maintenance, and adaptability to environmental, societal, and technological advancements.

Design
KEY TAKEAWAYS

- Multidimensional design principles (outlined in the previous column) need to be considered throughout the life cycle of a project or technology—from conception and implementation to management and overseeing its natural endpoint.

- Stakeholders should articulate both the explicit and implicit goals for each piece of infrastructure.

- To ensure we meet those goals, we must create better ways of measuring and documenting the infrastructure's impact across all dimensions throughout its life cycle. Where goals are hard to quantify and new or approximate metrics are needed, we should make our assumptions transparent so they may be examined and improved when possible.

- We need to design infrastructure that lasts but can also change with the times.

3

Govern: Invite New Perspectives and Capacities to the Governance Table

What new actors, disciplines, and frameworks can be incorporated to ensure all dimensions of infrastructure are considered?

EFFECTIVE, EFFICIENT GOVERNANCE IS PROBABLY THE MOST COMPLIcated hurdle in creating and maintaining good public infrastructure. Even seemingly banal or straightforward considerations like ensuring public input and building consensus can at times be overwhelming.

So it's a good idea to step back and consider what governance is in the first place.

Broadly speaking, governance is the act or process of overseeing the control and direction of something, such as an organization, technology, or country. While government is the largest and most obvious authority overseeing these entities, governance is also undertaken by private actors such as corporate boards of directors and field-specific professional organizations. Even homeowners associations are a form of governance.

When something is deemed to be public infrastructure—whether it's publicly controlled and funded like road systems or has become an essential technology in everyday life like telecommunications—the government has a duty to implement some form of governance to ensure that all people can access it. This can be through direct management, outsourcing, or a mixture of the two. Depending on the situation, the government can even allow sanctioned monopolies, wherein pricing or regulations are overseen by a public entity, such as with electric companies.

Determining who should govern—whether public or private en-

Societies face problems collectively and can only solve structural issues, especially if they are created or exacerbated by infrastructure, in the same way.

tities—and how is a key concern for infrastructure. In general, the best forms of governance come when decision makers have access to and rely on a variety of experts, gather input and build consensus among those who will be most affected, leverage data and evidence to weigh trade-offs and opportunities, and respond effectively to new technologies as they become essential to societies. Also, given today's interdependence of physical, digital, and social infrastructure, governance must be addressed by a mix of sector professionals (trained in specialized fields, such as education or health care) and technical experts (such as computer engineers, data scientists, and cybersecurity professionals).

A primary concern is when to regulate. Regulate too soon, and innovation is stifled. Regulate too late, and it becomes impossible to rein in some forms of critical technology. Innovations that begin to veer into the terrain of critical infrastructure, such as social media, often push the boundaries of our legal system, creating tensions between existing laws and the need for new ones. Ben Wizner, director of the ACLU's Speech, Privacy, and Technology Project, suggests we think about the overarching paradigms we want—and then align innovation and regulation accordingly.

"We shouldn't start with the assumption that innovation sits at the top of the hierarchy and law is chugging behind, trying to catch up," he says. "We require oil companies to innovate around environmental regulations to help prevent disasters. We need to do the same thing in the digital realm."

A thornier question is how to approach the governance of new infrastructure. Perhaps the most conspicuous examples lie in our digital world, which is largely unregulated, unlike the built environment. Both public and private actors have been slow, limited, and disjointed in addressing digital issues. In the absence of clear oversight, some companies have responded with public commitments, such as "ethical AI" and "data for good," which can be an effective form of regulation outside of the government. However, these efforts are nonbinding and based on the goodwill of those in charge, who are often accountable, first and foremost, to their shareholders.

This formula of using private sector pledges to help offer guidance may work for some issues but not others. For example, strong governance that extends far beyond goodwill is especially pivotal in consequential areas such as algorithmic decision-making systems, which are increasingly automating sensitive tasks like screening job applicants or jury pools. Ultimately, we must strive to bring companies, the public, and government to the table to decide how to govern things that are essential to the public yet not publicly controlled.

Finally, we should reflect on the deeper issue of who is innovating in the first place. Companies are often viewed as disruptors that produce new ideas that governments must respond to and govern. As a result, there have been calls for companies to be more thoughtful about, or shift entirely away from, being "disruptors." Yet although the "move fast and break things" mentality can be harmful, disruption in and of itself does not have to be. In fact, more innovation and disruption is needed from nonprofit, nongovernmental, and third-sector actors. Catalyzing more research and development in the public interest can help overcome some of the coordination and financial barriers for the third sector.

Societies face problems collectively and must solve structural issues, especially if they are created or exacerbated by infrastructure. So it's crucial that all sides have the space, opportunity, and funding to innovate and disrupt the systems that do not serve their communities. Social movements, which often have widespread positive impacts on society, are also disruptions. "The civil rights movement was a disruption," reminds Wizner. "You have to look at who's doing the disrupting."

There are no easy answers to governance questions. Strong governance can set guidelines and boundaries around disruption, opening up opportunities for a diverse set of actors to be a part of

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Govern

KEY TAKEAWAYS

- The government has a duty to ensure universal access to public infrastructure, whether through direct management, outsourcing, or a mixture of the two.

- To take informed action regarding infrastructure, decision makers should have access to experts (including a diverse range of interdisciplinary field professionals), to the people who are most affected, and to data and evidence.

- When designing new infrastructure or attempting to regulate technologies that have become essential, we need to outline the overarching goals we want and then align the regulation accordingly. Govern too early and you may "stifle innovation," but do it too late and it becomes difficult to regulate.

- Innovation comes from many sources, including third sector actors like NGOs, civil society, and philanthropic organizations. Research, development, and funding for their initiatives can help solve problems in the public interest.

it while protecting against societal harm. By considering solutions within the framework of multidimensional infrastructure, both planners and policymakers can begin to transition from siloed perspectives to broader goals. ■

4

Fund: Develop Smarter Ways to Calculate and Distribute Investment

How do we determine the value of multidimensional infrastructure to create the appropriate mix of public and private funding?

LIKE GOVERNING, FUNDING INFRASTRUCTURE IS A VAST, COMPLICATED, and agonizing issue. It's almost a given that there's never enough money to effortlessly build, maintain, and govern critical systems. But when something becomes essential public infrastructure, it must be properly governed and funded, whether that's through government allocation or, increasingly, through a public-private partnership (PPP).

Each year, the United States spends trillions of dollars on infrastructure, roughly 2.4 percent of its GDP. But that's less than half of what most European nations allocate. China invests more than 8 percent of its GDP in infrastructure each year, the most of any nation. The U.S. is falling woefully behind. The American Society of Civil Engineers, in its most recent report card—which assesses the condition of the United States' infrastructure, from airports and roads to public parks and schools—gave infrastructure a D+ rating. Improving roads and bridges alone would require $1.1 trillion more than states, localities, and the federal government have allocated in their current budgets.

Chronic underfunding isn't only creating a backlog of crucial investments; it's also harming the U.S. economically. The World Economic Forum, in its latest Global Competitiveness Report, moved the United States down to 13th place for quality of infrastructure, well behind Germany, Spain, and Singapore. And with roughly 11 percent of the total U.S. labor force—about 14 million people—currently employed in infrastructure-related sectors, according to the Brookings Institution, it's easy to see how underfunding infrastructure can cause cascading negative consequences.

Of course, the solution isn't as simple as spending more money. Government departments at all levels—federal, state, and local—need to work together more transparently and across silos to fund projects. Politicians need to expand their view of what they consider infrastructure to make more robust and forward-thinking investments, especially with digital infrastructure shaking up the dynamics of power, profit, and public good. And it's crucial that they assess the pros and cons of various economic models to pay for these investments. Whichever model is employed—public, private, or a combination of both—it's key that each dollar invested in infrastructure creates value on multiple levels.

When viewed through a multidimensional lens, a dollar is much more than a unit of currency. It's a tool to help reach desired goals. Some of its value can be measured easily and immediately, as with bridge tolls. But much of that value is indirect and manifests over time and in nonlinear ways, such as fostering an environment that's conducive to entrepreneurship. Furthermore, we don't always take into account the total cost of infrastructure, which includes maintenance and performance management. "All dimensions of infrastructure—from roads to software to social structures and skills—depreciate over time," says Matt Dunne of the Center on Rural Innovation. "We need to continually invest and reinvest."

All sectors have a role in funding. The largest player is government, which continues to pay for infrastructure, although it has stepped back in the past few decades. Private companies often create and finance early versions of products or services that later become essential infrastructure. For example, railroads, telecommunications, and energy grids all migrated from private enterprise to public utilities and are now supported with tax dollars. And finally, there is the third sector, which supports much of our social infrastructure using charitable dollars generated by special government tax policies. There is also a mixed history of success in PPPs, where the government and the private sector come together to leverage expertise and resources to maximize outcomes. Smarter funding calculations could help ensure that these sort of collaborative efforts equally benefit all sides.

Incorporating these additional factors and disciplines into the return on investment (ROI) equation provides a full account of the costs and a more holistic calculation of the value brought by multidimensional infrastructure. And reconsidering both value and long-term cost in infrastructure projections can bring about new funding sources. It may justify further government expenditure, or it may lead us to conclude that private investment is warranted in places where companies might not otherwise have considered it.

Ultimately, a multidimensional lens can help funding become smarter. Leaders need a clear vision, strategy, and incentives to spend wisely. New methods, such as holistic calculations, can help make the most of every dollar. ■

Fund

KEY TAKEAWAYS

- Infrastructure investments should create value on multiple levels. We must develop new means of calculating ROI in order to influence better funding decisions.

- All types of infrastructure depreciate over time, including roads, software, and social structures. As a result, budgets should account for the total cost of infrastructure through a holistic calculation that includes maintenance and performance management.

- Leaders can make smarter funding decisions with clear strategies by understanding who profits, who benefits, and who is left out. These economic models are crucial to ensuring critical infrastructure is funded adequately, sustainably, and by the appropriate actors.

BUILDING THE WORLD WE DESERVE

How multidimensional infrastructure is creating a more resilient and equitable society—now and into the future

Digital

Physical

Social

1 Physical innovations, such as water bottle stations and solar trash compactors, orient community behavior toward sustainable practices that improve society's long-term well-being. Moreover, the data they collect helps measure the impact of these decisions and reveals further opportunities for improvement.

2 Citizens engage with their local representatives, while tech workers build civic tools based on government data. The increased use of technology within government can help unlock insights and innovations for improved responsiveness and service.

3 Digital tools, like touchscreen information boards and public Wi-Fi, help people navigate their physical space and provide information about social events around town.

4 With online instruction and lifelong digital learning opportunities, education is no longer just a classroom activity. Adults and children can learn new skills together or individually.

5 Public spaces are touchpoints for social connection, whether that's kids at play, young adults hanging out, or folks of all ages enjoying outdoor activities.

6 A diver performs maintenance on broadband cables that connect communities across the globe. These connections are evident throughout the image, from person-to-person communication to remote working teams to real-time public transportation schedules.

JOIN US

Help Create a New Future for Infrastructure.

THE UNITED STATES IS IN DESPERATE NEED OF ACTION if we are going to turn the tide on many of our most pressing issues, such as racial and wealth inequality, climate insecurity, and social upheaval. There's never been a better time for big ideas and bold solutions. To help institute and socialize a multidimensional view of infrastructure—along with designing, funding, and governing it more effectively it—Siegel Family Endowment needs your help to transform words and ideas into reality.

Please help us make the U.S. a more just and prosperous society. Here are a few ways you can contribute:

1

Dive Deeper and Join the Conversation

This report is just a starting point, and we look forward to exploring the opportunities and challenges of infrastructure in greater depth online at www.infrastructure.siegelendowment.org and through LinkedIn (Siegel Family Endowment) and Twitter (@siegelendowment). As we move forward, we'll publish insights and updates about the field and share a series of case studies about multidimensional infrastructure.

2

Collaborate With Us

We can't implement this vision alone. Shifting the focus toward multidimensional infrastructure requires experts from across the board—scientific researchers, civic leaders, philanthropic leaders, government officials, and more—to come together. Here are some ways you can collaborate:

- **If you conduct research** that relates to this concept, we would love to hear from you and amplify your work through our channels. Please get in touch with us if you have relevant knowledge to share.

- **If you run a social impact organization** (civic, nonprofit, philanthropic), tell us how you're implementing multidimensional infrastructure systems in your work.

- **If you serve in any level of government** and are interested in enacting some of these ideas, please get in touch with us to share more about your process.

- **If you have any resources relevant** to our multidimensional approach (such as reports, frameworks, data-based evidence, or case studies), please share them with us.

3

Take Action in Your Community

Change doesn't only happen from the top down. To build the world we want, we must first engage with our local communities. Going forward, Siegel Family Endowment will share digital resources and action items to help transform communities across the United States as our network grows. Here are some other ways you can get involved, too:

- **Participate as a responsible citizen.** Vote, if you can, and encourage those eligible around you to vote. Participate in local community boards and civic processes.

- **Engage in your community**. Find issues you care about and then engage. Sign petitions, respond to requests for comment on legislation, and participate in public hearings. Remember that the bulk of infrastructure funding is distributed at the state and local level—closer than you may realize.

- **Learn from experts and get involved with our partners.** Our partner network and experts are working across a variety of spaces and offer a wealth of resources. You can find a list of our partners on our website, and we encourage you to reach out to them for more information and to see how you may be of service.

4

Share Feedback With Us

At Siegel Family Endowment, we take an inquiry-based approach to our work. We ask the questions that help develop an informed hypothesis. We also support work that uncovers evidence, help track and interpret outcomes, and apply that knowledge to inform the next phase of our work.

Our approach is grounded in the idea that our findings don't represent the end of the conversation. Rather, they're an invitation to keep iterating, to shape and reshape our own ideas, and to bring in others to build together. We welcome your feedback to this white paper at **www.infrastructure.siegelendowment.org**, or email us at **infrastructure@siegelendowment.org**.

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About Siegel Family Endowment

We are a foundation focused on understanding and shaping the impact of technology on society.

S IEGEL FAMILY ENDOWMENT employs an inquiry-driven approach to grant making that is informed by the scientific method and predicated on the belief that philanthropy is uniquely positioned to address some of the most pressing and complex issues facing society today. Our grant making strategy supports organizations doing work at the intersection of learning, workforce, and infrastructure. It is designed to help build a world in which all people have the tools, skills, and context necessary to engage meaningfully in a rapidly changing society. Siegel Family Endowment was founded in 2011 by David M. Siegel, co-founder and co-chairman of financial sciences company Two Sigma.

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