

INVENT2026

technology for US

2016 ASSET AND STRATEGIC REVIEW



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This review was aided by insight provided by many of the Midwest region's leaders in research, entrepreneurship, venture finance, municipal management, and national defense, including: Dr. Jeff Binder, director of the University of Illinois' Applied Research Institute; Dr. Jay Walsh, vice president of research at Northwestern University; Jim Schultz, CEO of the Intersect Illinois; Dr. Matthew Tirrell, dean of the Institute of Molecular Engineering at the University of Chicago; Dr. Andreas Cangellaris, dean of the University of Illinois' College of Engineering; Steve Fifita, executive director of UI Labs' City Digital; Dr. Robert Kephart, director of the Illinois Accelerator Research Center at Fermilab; Dr. Keith Bradley, director of national security programs at Argonne National Laboratory; Ann Schlenker, director of the Center for Transportation Research at Argonne; Dr. George Crabtree, director of the Joint Center for Energy Storage Research at Argonne; John Dallas, CEO of Hillview Partners; and Maj. Gen. Richard Hayes, adjutant general of the Illinois National Guard.

Additional insight was provided by: Alan Matthew, founder and CEO of Tribal Ventures; Dr. Elizabeth McNally, director of the Center for Genetic Medicine at Northwestern's Feinberg School of Medicine; Fred Hoch, CEO of the Illinois Technology Association; David Baker, founder of the University Technology Park at the Illinois Institute of Technology; Vasco Bridges, regional director of Goldman Sachs' 10,000 Small Businesses program; Dr. Erik Ramberg, assistant head of the Particle Physics Division at Fermilab; Samir Mayekar, founder and CEO of SiNode Systems; Dr. Seth Snyder, leader of Argonne's Water Initiative; Scott Mosely, director of investment strategies at The Water Council; Commissioner Debra Shore of the Metropolitan Water Reclamation District of Greater Chicago; and Dr. Santanu Chaudhuri and Scott Wilkin, both of the University of Illinois' Applied Research Institute.

Invent2026 (then calling ourselves "Project 2026") convened task force members four times – three times in Chicago and once at the campus of the University of Illinois at Champaign-Urbana – and dozens of hours of interviews were conducted with additional sources. The focus of these conversations was to understand the new federal procurement environment, as well as changes in our national economy, and compose *and execute* a regional entente for navigating these changing landscapes.

Invent2026 brings together the Midwest's applied researchers and entrepreneurs to collaborate on solving the most urgent problems facing our nation ahead of 2026, America's 250th birthday. This review will support Invent2026 by:

- Providing an objective assessment of the Midwest region's unique economic capacities, and identifying collaborative efforts already underway;
- Enabling a deeper understanding of the dynamics among the universities, federally supported facilities, and the startup community;
- Identifying existing barriers to creating a thriving regional startup economy in strategic sectors.

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Designing a Midwest Innovation Corridor that increases support for applied research, shares brainpower and costs across institutions, grows a robust startup economy, generates solutions to national problems, expands partnerships with federal agencies, and embraces new industries in a collaborative value chain.

I. EXECUTIVE SUMMARY

As modernity presents challenges and opportunities to our nation, American lawmakers and investors are turning their attentions to the American startup economy in search of solutions. Startup entrepreneurs are playing an increasing role in prototyping designs that are emerging from centers of applied research, and federal procurement officials and corporations are taking notice.

Yet far too often, these solutions are emerging from the Bay Area, Boston, and other coastal markets. The Midwest is not competing. Our researchers and entrepreneurs work in silos. Our regional startup economy is failing to leverage the Midwest's critical natural, geographic, and human resources to solve our nation's problems. A collaboration among Midwest leaders of industry, applied research, and entrepreneurship is required to design an innovation corridor that is centered on industries unique to the Midwest and that leverages our region's core capacities.

Invent2026 will provide that collaboration, and this review will issue a call to action. It highlights regional technological capacities and economic clusters, taking an inventory of the applied research centers along the **Midwest Innovation Corridor**, and outlining a comprehensive plan to grow a regional startup economy that embraces new industries and serves our nation's needs.

The Midwest's researchers and entrepreneurs must refocus on solving national problems. Here's the problem set: The American manufacturing base is rapidly eroding, endangering our military's ability to quickly manufacture and scale designs of weapons programs needed to protect national security interests; the American economy is increasingly connected into the Internet of Things with alarming deficiencies in our ability to manage and protect the systems that make this possible; our natural resources are far from being effectively, efficiently managed; the world's population has reached 7 billion people, and we continue to struggle to meet the growing demand for food; governments throughout the world have struggled to update their infrastructures to meet the rapid rise of urban populations, and American governments have no way to pay for the \$1.6 trillion in repairs needed to maintain our once-revered infrastructure; and the threat of climate change is not going away.

These are problems that American corporations have proven unable or unwilling to address with their own R&D budgets, so these problems must be addressed by a collaboration between applied research centers and startups. Applied researchers in the Midwest must pool their resources and strengthen collaboration across institutions, and support responsive technology transfer into the Midwest's startup economy. The Midwest's community of entrepreneurs must become more engaged with regional centers of applied research. The Midwest Innovation Corridor must build a web of maker spaces that is ready to scale designs. The regional startup economy must be supported by a stronger market of venture capital than exists at present. And the Midwest startup economy must be reoriented around solving national problems.

In 10 years the United States will celebrate its 250th birthday. Before that day arrives, consider the incredible technological advances that will change the very fabric of our society:

- Genomic sciences will advance to the point where doctors, with a simple saliva sample, will determine a patient's risk for a range of diseases long before any identifiable symptoms;
- Biological sciences will build a human heart seemingly out of thin air;
- Americans will rely on solar-generated energy to an unprecedented degree, powering the grid with energy generated and distributed not from a sole central source, but from homes, offices, and shops, and shared in neighborhood energy cooperatives;
- Driverless vehicles will begin to integrate into our transportation system;
- Our roads, bridges, waterways, and farms will be managed with the help of sensors that will monitor traffic, levels of toxins in our rivers, and soil fertility in real time.

These are the times that will enrich and renew America. Let's grasp the opportunity history presents us.

For the Midwest region, the next ten years will mark an opportunity to look back at our history, and to look forward in leading the modern economy. A new presidential administration will begin next year. The University of Illinois, the state's flagship Land Grant university, will celebrate its 150th birthday in 2017. The State of Illinois will celebrate the 200th anniversary of its admittance into the Union in December of 2018. The City of Chicago will remember the 150th anniversary of the Great Fire in 2021, a ghastly event that would have crippled a lesser people, yet instead served to resolve Chicago's people to rebuild one of America's greatest cities.

This document will kick off a 10-year process of designing and building a Midwest Innovation Corridor, providing an exportable model of regional collaboration. The applied research centers and natural resources of the Midwest, if collectively organized and activated, could form an innovation corridor that is every bit as productive as what exists in the Bay Area and along Boston's Route 128. Invent2026 will show how.

II. SERVING NATIONAL NEEDS

Midwest leaders of research and entrepreneurship must expand partnerships with federal agencies to successfully build an innovation corridor that serves our nation's needs. To do so, they must first recognize how federal procurement has changed, and why Washington has taken a strong interest in regional startup economies. To a remarkable degree, federal agencies are making a good faith effort to lower barriers to entry for smaller, earlier-stage suppliers.

Something has gone wrong with federal procurement, and there is apparently the will across federal agencies to fix it through a recent push to engage the startup community.¹ The Obama Administration, awoken by several high-profile procurement disasters – including the \$160 billion in cost overruns incurred by the military's F-35 program – has placed special emphasis on integrating centers of innovation and entrepreneurship with federal agencies. Taking a page from the United Kingdom's Crown Commercial Service,² Washington has rigorously sought to engineer collaboration between the federal government and communities of innovation.

Secret history of Silicon Valley

To appreciate the blunt force of government consumption in driving a regional system of startup activity, consider the role of federal subsidies in the emergence of the Bay Area's regional startup economy.

The history of Silicon Valley, as told by retired entrepreneur and author Steve Blank, begins with the Franklin Roosevelt Administration directing massive federal subsidies into research in technologies that would support the Allies in World War II. The Harvard Radio Research Lab, led by Frederick Terman, then one of the most skilled radar engineers in the U.S., oversaw all electronic warfare in World War II. After the war Terman moved to Stanford, taking over Stanford's Department of Engineering. As the temperature increased in the Cold War, the Pentagon again turned to Terman, subsidizing research to design electronics to intercept Soviet communications.

Terman earned the title "father of Silicon Valley" by encouraging his students to explore entrepreneurial paths as an alternative to pursuing PhDs. The playbook went like this: communicate with the military-industrial complex, design prototypes to meet ... (continued on page 7)

¹ Throughout this review, we will use the term "startup community" or "startup economy" to refer to the community of entrepreneurs and early-stage companies in advanced industries, to include information technology and advanced manufacturing, that have the ability to quickly scale, disrupt existing industries, and are typically financed with equity, not debt. Startups should not be conflated with small businesses that do not have the ability (or often even the aspiration) to do any of these things.

² Gov.UK is generally considered the world's most user-friendly, efficient platform for government procurement, and has enabled smaller suppliers to compete for government grants to an unprecedented degree.

In 2015 the Department of Defense launched the Defense Innovation Unit Experimental, or DIUx, in Mountain View, California. DIUx has become the platform for the military to interact with Silicon Valley, hosting forums and pitches from entrepreneurs developing products that answer the military's strategic needs in cyber security, drone technology, robotics, manufacturing, and battery technology, among other priorities. These "Third Offset" technologies are central to the Pentagon's proposed \$70 billion-plus Research and Development budget for Fiscal Year 2017.³

The Department of Defense opened a second DIUx in Boston in July of 2016, and a third DIUx in Austin, Texas, two months later. As of September 2016, DIUx has supported \$3.5 million in agreements with non-traditional suppliers, with the average time between contact to award condensed to less than two months.¹ Secretary of Defense Ash Carter has made clear his intention to more deeply engage the military with the startup community. If successful, this approach would mark a departure from the Department of Defense's standard procurement processes, which are heavily reliant on large defense contractors.

DIUx was just the latest attempt by the federal government to engage the startup economy. The U.S. Small Business Administration has long supported the Small Business Innovation

Research (SBIR) grant program to commercialize federally-supported R&D. In 2014 the Department of

Secret History of Silicon Valley

(continued...) defense needs, support open licensing, and if the prototype worked, transfer the technologies to students for them to start new companies. Two of Stanford's most promising engineering students at the time, William Hewlett and David Packard, followed his advice.

This methodology of receiving federal subsidies for research, integrating basic and applied research labs, opening intellectual properties for low-cost and expedited tech transferring, and encouraging entrepreneurship among Stanford's students is what laid the foundation for the startup economy in Silicon Valley. It consolidated the linear process of turning basic research into applied research and finally taking products to the market.

"Government's role isn't to commercialize new innovations," Steve Case, founder of America Online, noted in his 2016 book, "The Third Wave: An Entrepreneur's Vision to the Future." "It's to push technological advancement forward in areas that the markets won't address on their own - to get ideas and innovation to a point where entrepreneurs with visions can turn them into viable products and businesses."

³ The Offset Strategy was a term coined in the Eisenhower Administration to characterize the nuclear deterrent built to counter the Soviet-led Warsaw Pact. The Second Offset, also designed to counter the Warsaw Pact, led to expenditures in intelligence, surveillance, and reconnaissance platforms, satellite-guided weapons, and stealth fighter jets, built to match the numerically superior Soviet-led forces positioned along the Fulda Gap. Many observers credit the Second Offset with effectively winning the Cold War, denuding the Soviet Union's inability to keep pace with the superior American technological base.

Homeland Security launched the EMERGE Accelerator Program for entrepreneurs developing technologies for emergency personnel. EMERGE's first demo day was held in September 2015.ⁱⁱ

The federal government has historically provided demand for early-stage technologies, from the telegraph, mobile phones, and the semiconductor.ⁱⁱⁱ With startups increasingly introducing new technologies into the market, the marriage between Washington and entrepreneurs is only logical.

III. MIDWEST INNOVATION CORRIDOR

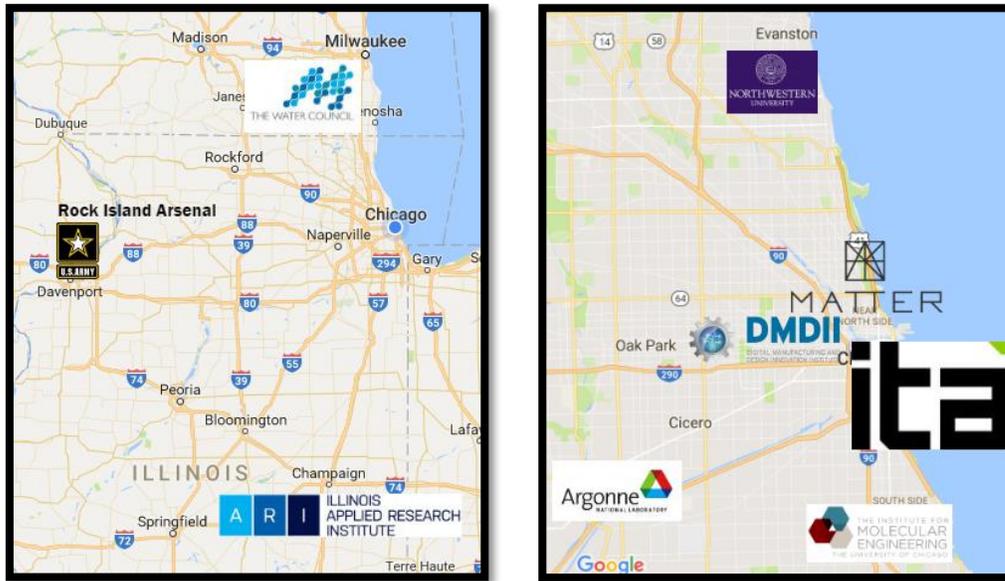


Figure A: A few of the region’s applied research and entrepreneurship institutions, and maker spaces. The left map, taking a wider look at the Midwest, plots The Water Council in Milwaukee, Rock Island Arsenal in Moline, Illinois, and the University of Illinois’ Applied Research Institute in Campaign-Urbana. Right is a closer look at Chicago, including Northwestern University, Argonne National Laboratory, Institute for Molecular Engineering at the University of Chicago, and the “Chicago River Bend Innovation District,” gathered in Chicago’s River North and West Loop neighborhoods, composed of (among other organizations) the Digital Manufacturing and Design Innovation Institute, the Illinois Technology Association, and Matter, a life-sciences-focused open-floor working space.

With these trends emerging from Washington, the Midwest region’s many assets – our centers of applied research, our startup community, our infrastructure, and our manufacturing facilities – are ready to be coordinated and reoriented around solving the nation’s most urgent challenges.

Northwestern University and the University of Illinois have deepened their commitment to applied research, and the University of Chicago will soon launch a department of engineering, a first in the 126-year history of the school. Dr. Jeff Binder, director of the University of Illinois’ Applied Research Institute⁴, calls this movement “an awakening.” Whereas the Midwest’s centers of research previously focused more on basic engineering, the region’s researchers have largely pivoted toward designing solutions with practical applications, including in the life sciences and the physical sciences, the latter encompassing energy and infrastructure design and precision-guided agriculture. This incredibly promising development could form the foundation of new innovations emerging from the Midwest, if technology emerging from these institutions can be effectively transferred into the commercial sector.

⁴ In November of 2016, Binder will leave his role at the Applied Research Institute to take over as the associate laboratory director at Argonne National Laboratory.

Chicago has two national labs, Argonne National Laboratory and Fermilab. The former is now supporting a five-year Department of Energy grant to increase current battery energy storage capacity by a factor of five, a breakthrough that would fundamentally transform the energy grid and help meet the challenge of climate change. Argonne also hosts one of the world's most powerful supercomputers. Named "MIRA," this supercomputer holds the computing capacity of 85,000 off-the-shelf PCs, permitting the analysis of massive amounts of data.^{iv} Fermilab, a national laboratory focused on more fundamental particle science, has expanded the Illinois Accelerator Research Center, a \$38 million facility that will serve as the front door for entrepreneurs seeking to take advanced material designs into the private sector.

The Midwest's growing regional capacities in entrepreneurship are being supported by organizations like the Illinois Technology Association, 1871, and Matter, a 25,000-square-foot workspace incubating new businesses in the health care. The University of Chicago will soon break ground on the Polsky Center for Entrepreneurship and Innovation, a platform for collaboration between the university's Booth School of Business and applied researchers across the region and across the country. Argonne National Laboratory and the Army Research Laboratory are both expected to have a presence at the new Polsky Center. For an MBA program long seen as an academy for financiers, the launch of the Polsky Center could indicate that the Booth School intends to assert its presence in entrepreneurship, competing with business schools, like Harvard Business School and Stanford's Graduate School of Business, that are consistently rated as the strongest for students wishing to explore entrepreneurial paths after graduation.

Finally, the Midwest region is home to manufacturing facilities that are able to scale product designs emerging from the nation's most innovative engineers. For nearly two centuries Rock Island Arsenal has manufactured weapons for the U.S. Army, and it remains ready to build products for both the military and the private sector. Chicago, a city built on manufacturing, is now home to the Digital Manufacturing Design Innovation Institute (DMDII), a facility funded with more than \$250 million in federal, State of Illinois, City of Chicago, and private funds. DMDII could help repurpose Chicago's manufacturing facilities to compete in an ever-evolving manufacturing economy.

Together these and many other organizations, facilities, and initiatives form a Midwest Innovation Corridor that is poised to regain our status as a growth engine for the American economy. What has been missing is a collaborative vehicle to forge a symbiosis between regional research institutions and entrepreneurs, armed with a deep understanding new industries and of national and federal needs.

Solving national problems through applied research and entrepreneurship

The authors of this review recognize that the Midwest region has been largely absent from solving national problems through its community of entrepreneurs and applied researchers. For many reasons the Midwest has not been a fertile environment for innovation. Many of the region's top entrepreneurs and researchers have fled for more hospitable coastal environments. These observations are neither new nor unique to this review.

Bloomberg Magazine, in a brutal October 2000 critique of Chicago's performance as a business capital, noted that both Netscape's Marc Andreessen and Oracle's Lawrence Ellison had to decamp from the Midwest to find venture capital to bring their ideas to scale.^v "You know where I go for Illinois technology seminars?" Michael Ferro, CEO of the then-Chicago based ClickCommerce Inc., rhetorically asked. "I go to San Jose."

While there are indications that Chicago's startup economy is strengthening, it is clear that the city and the region continue to struggle to retain entrepreneurs and applied researchers. A 2015 Chicago Tribune feature noted the inability of the Chicago startup community to retain skilled engineers and entrepreneurs who could form the nucleus of a robust startup economy. "As the Midwest's largest, most vibrant city – one that sees itself as a global economic and cultural force – Chicago attracts a wealth of talent from surrounding states," the Tribune's Mark Caro wrote. "But cities like San Francisco, New York, Boston and Los Angeles serve as even more powerful magnets to Chicagoans who conclude that greener pastures await them on the coasts."^{vi} Peter Thiel, co-founder of PayPal, was more blunt when he visited students at Roosevelt University in September 2016: "If you are a very talented person, you have a choice: You either go to New York or you go to Silicon Valley."^{vii}

Far from being fatalistic, several leaders have launched initiatives to stem this tide, envisaging a Midwest region, with emphasis on Chicago, as a hub of advanced industries. Among them:

- The Illinois Technology Association, a 501c6 organization (a business association, similar to the U.S. Chamber of Commerce) launched in 2005 to advance technology-enabled businesses in Chicago and Illinois. ITA's membership list now numbers several hundred, and including startups and multi-billion corporations such as Google and Comcast.
- ChicagoNEXT, an initiative of World Business Chicago, a nonprofit organization that provides thought leadership and advocacy to support Chicago's economic development strategy. ChicagoNEXT aims to attract technology talent and venture capital in support of new Chicago-based tech-enabled companies.

- 1871, a massive open-floor coworking space for technology-focused entrepreneurs that takes its name from the year of the Great Chicago Fire, opened in 2012 with subsidies from the State of Illinois and backing from Chicago venture capitalist J.B. Pritzker.⁵

By all accounts these organizations have built substantial interest in entrepreneurship within the Midwest's largest market. Chicago's startup economy has made remarkable strides in recent years. Success stories include Cleversafe, a Chicago born-and-bred cloud computing company recently acquired by IBM for \$1.3 billion, and Uptake, a data analytics company founded by Groupon co-founder Brad Keywell. University entrepreneurship programs continue to emerge in the region, including the recently-approved, dual-degree program at the University of Illinois at Urbana-Champaign in engineering and entrepreneurship.^{viii}

But has this legion of kicky open-floor coworking spaces and entrepreneurial-support organizations truly severed the one-way highway of Chicago's most talented entrepreneurs and applied researchers leading to the coasts?⁶ According to Booth School's survey data, only a third of its graduates remain in Chicago, whereas the Stanford Graduate School of Business reports that 68 percent of its alumni remain in the Bay Area. About half of University of Illinois engineering graduates remain in Illinois. And those who stay find little encouragement to collaborate.⁷ "The Midwest has been very passive in engaging the output of the College of Engineering," said Andreas Cangellaris, dean of the University of Illinois' College of Engineering. "It is a pity, especially given the opportunity we have ahead of us in areas where significant innovation and transformation is needed not only for the nation but the world."

Several sources who participated in Invent2026 discussions expressed concern that the region's well-intentioned entrepreneurial support organizations were losing their effectiveness and duplicating efforts. Vasco Bridges, regional director of Goldman Sachs' 10,000 Small Businesses initiative had a particularly incisive recommendation: Start by focusing on developing strong entrepreneurs – rather than on incubating businesses – and assign these entrepreneurs a task. "Let's find the smartest entrepreneurs we can find, take a very specific problem, and just try to solve it."

Bridges' recommendation provides a guiding principle for Invent2026, one that should be heard both at 1871 and at Argonne National Laboratory. Whereas growing startup economies have often focused on reviewing business plans and incubating startups with mentors and eventually venture

⁵ As the City of Chicago rose from the ashes of the Great Fire after 1871 (the year), the new Chicago economy would emerge from 1871 (the coworking space), the thinking went.

⁶ The authors want to emphasize that the question being posed is one of rooting entrepreneurs and applied researchers in a collaborative environment. Is there a strong circle of entrepreneurs working with applied researchers in the Midwest?

⁷ One example of Midwest university-trained entrepreneurs and engineers collaborating is found in SiNode Systems, profiled later in this review.

capital, the Midwest Innovation Corridor should instead look to incubate the strongest entrepreneurs, equip them with effective technology transfer, and orient business development toward solving a critical challenges facing our nation. At the Midwest’s laboratories of applied research, the Invent2026 mandate is to take the billions of federal dollars that have been invested into research in the region and support the maturation of that research into the commercial market. Or put more plainly by Binder, “don’t just say it’s good enough to be published and be recognized by your peers.”

Invent2026 is a coalition of researchers and entrepreneurs joining together to solve national problems. The chasm between entrepreneurs in the Midwest and researchers must close. Entrepreneurs need to be reaching out to our region’s researchers, and our scientists need to be applying their research to real world problems.

IV. SUPPORTING APPLIED RESEARCH

The current environment for centers of applied research is characterized by limitless possibility and limited resources. Dr. Matthew Tirrell, dean of the Institute of Molecular Engineering at the University of Chicago joked: “Flat is the new up.” Universities have long depended on federal funding, often from the National Science Foundation, to support their research across different disciplines. In recent years, however, university laboratories and the national laboratories have subsisted on increasingly tight budgets.

This trend of declining federal support is paralleled by a sharply declining interest in supporting applied research from America’s corporations, historically a strong source of innovation.⁸ America’s dominance in research and development in previous eras was largely driven by corporate laboratories, like AT&T’s historic Bell Labs and Xerox’s Palo Alto Research Center.^{ix} In recent years, however, corporations have struggled to capture the full benefit of their own research, confounded by knowledge spillovers that have accrued to industry rivals, and by what Harvard Business School Professor Clayton Christensen has termed the “Innovator’s Dilemma,” or the reality that research can only deliver value over many years and cannot drive short-term quarterly growth. Adding to the downward pressure on R&D budgets: powerful shareholders who demand that corporations aggressively cut costs, including R&D, and turn over profits in the form of stock buybacks

Tech transfer from applied research centers

“Just get it out there. **Don’t let the language of license get in the way of a technology getting out the door.**” – Dr. Jay Walsh, vice president of research at Northwestern University

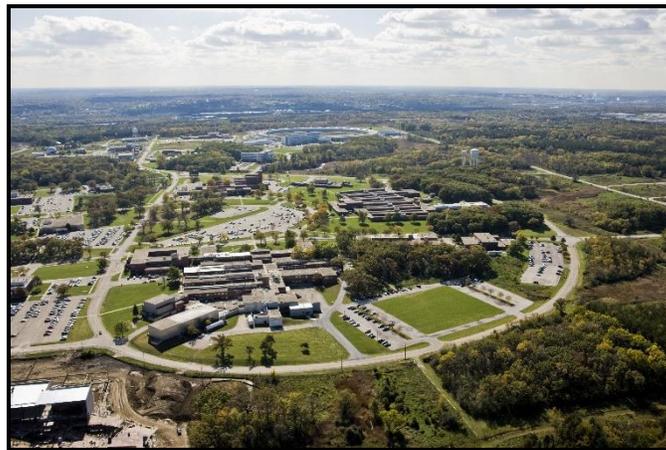
“Place primary value on getting it into the world, rather than early struggles about what the financial return is going to be. **The financial return will come if you actually do something valuable.**” – Dr. Matthew Tirrell, Dean of the University of Chicago’s Institute for Molecular Engineering

“We want to accelerate the transition of the innovative ideas to the marketplace. **This requires awareness of the national imperatives, the national security needs, the homeland security needs,** and in partnership with the private sector, taking our innovative research to address national challenges.” – Dr. Jeff Binder, director of University of Illinois’ Applied Research Center

⁸ A notable exception is Alphabet Inc.’s X, a research laboratory that Google launched in 2010, that has been the source of Google Glass and Google’s autonomous vehicle. However, Alphabet’s “moonshot” research projects have been viewed with skepticism by Chief Financial Officer Ruth Porat, according to several published reports. Porat, the former CFO of Morgan Stanley, is believed to be behind the company’s first-ever stock buyback, a \$5.1 billion payout to Wall Street in 2015.

and dividend payouts.⁹ Many large corporations have complied, shuttering applied research laboratories.

“I see that as an opportunity,” said Dr. Keith Bradley, director of national security programs at Argonne National Laboratory, of the challenges facing applied researchers. “I think we all recognize that you need to infuse R&D to remain competitive economically in a global market (and) also from the national security perspective.”



Argonne National Laboratory in Lemont, Illinois

The “opportunity” is two-fold. First, given the constraints on R&D budgets, there is an apparent need to share brainpower in applied research, providing *opportunities* to support collaboration across research institutions, gaining efficiency through pooling of resources across laboratories, universities, agencies, and corporations. Second, the decline in corporate R&D presents *opportunities* to build out new models for university-based laboratories, where researchers can receive R&D needs from corporate clients and design solutions for the commercial market.¹⁰

There’s another opportunity that this new R&D environment poses, this one for entrepreneurs. Researchers now appear more willing to let entrepreneurs step into the research process and develop applied technologies into commercial products. “The startup community has formed, if you will, a rapid prototyping portion of traditional and institutional R&D,” said Steve Fifita, executive director of UI Labs’ City Digital. For this reason Invent2026 focuses on startups as the destination of technology transfer.

Corporations that once funded their own patenting activity are now more likely to acquire startups that have demonstrated value in the market. Corporate venture capital investment has burgeoned in recent years, driving more than \$7.5 billion into 905 deals during 2015, according to PricewaterhouseCoopers and the National Venture Capital Association.^x “What the big companies are finding is that they don’t have the expertise in the new areas, so that working with these small companies is great,” said Dr. Jay Walsh, vice president of research at Northwestern University. “Suddenly they don’t have to hire a whole R&D team in a whole new area.”

⁹ An exceptional account of this trend is found in Time Magazine’s Rana Foroohar’s 2016 book, “Makers and Takers: The Rise of Finance and the Fall of American Business.”

¹⁰ This is a basic description of the revenue model employed by the University of Illinois’ Applied Research Institute. Founded by Dr. Jeff Binder in 2013, the Applied Research Institute presents a different take on university-based laboratories that respond to federal funding requests and largely exist separate from the university’s academic mission. The Applied Research Institute instead takes a more proactive posture toward identifying and addressing federal- and corporate-client needs, and integrates the university’s faculty and students into their research.

This model offers incentives to startups, corporations, and universities alike. The Bayh-Dole Act of 1980 allowed universities to patent federally grant-funded discoveries that emerged in its labs, and to negotiate exclusive licensing agreements with private sector partners and startups.^{xi} Stanford received more than \$336 million after Google's initial public offering, a benefit received because Google's search algorithm was discovered at the university with the aid of a federal research grant.^{xii} Stanford's windfall might explain the recent surge in university-based incubators, venture capital funds, and entrepreneurship-focused coursework and degree programs.^{xiii} The trend has reached Illinois, which now ranks eighth in university R&D expenditures according to the Illinois Science and Technology Association.^{xiv}

This system of collaborative tech transfer, the Invent2026 task force agreed, could only benefit all of the actors involved within a capable regional economy. The task force was deliberate about first designing such a regional economy through the lens of entrepreneurship and economic "clusters."

V. SETTING THE CONDITIONS

The Invent2026 task force was careful to avoid the well-trodden path of designing “the next Silicon Valley.” The task force never seriously considered advocating for tax incentives targeting a particular industry, or building an industrial park, as a fundamental element of supporting a regional startup economy. We do not advocate bringing to life a satirical 2014 headline in *The Onion*: “States Now Offering Millions In Tax Breaks To Any Person Who Says ‘High-Tech Jobs.’”

Rather the Invent2026 discussions sought to design a Midwest Innovation Corridor built on sectors in which the region is competitive, and retaining and attracting the most promising entrepreneurs and applied researchers to collectively address national needs.

CLUSTERS

The Invent2026 task force’s work in designing an innovation corridor was largely guided by the “business cluster” theory, first introduced by Harvard Business School Professor Michael Porter in the 1980s. Porter has advised municipalities across the country, most notably helping to revive the manufacturing economy of Chattanooga, Tennessee, in the 2000s. In part with Porter’s guidance, Chattanooga has cast aside its image as an old industrial city and became one of the most remarkable stories of post-Great Recession economic development, sharply growing its capacities in advanced manufacturing, slashing unemployment, and raising median household incomes by double digits.^{11xv}

Regional economic growth – measured in new business starts and patenting activity – is driven by geographic critical masses in particular sectors, according to Porter.¹² Complementary growth in innovation is fueled by the proximity of buyers, sellers, supporting institutions, and entrepreneurs. “Individuals working within a cluster can more easily perceive gaps in products or services around which they can build businesses,” Porter wrote in the *Harvard Business Review* in 1998.^{xvi} “Needed assets, skills, inputs, and staff are often readily available at the cluster location, waiting to be assembled into a new enterprise.”

¹¹ Porter’s clusters theory has also recently begun to guide the U.S. Economic Development Agency. Since 2010 the EDA’s Office of Innovation and Entrepreneurship has provided grants for “cluster-focused” regional innovation strategies.

¹² As notable for what Porter’s theory advises it what it does not. He criticizes four alternative approaches to regional economic development that he contends have failed to deliver regional growth: the “Open for Business” approach, which involves removing regulations and improving infrastructure; the “Big Game Hunting” approach, which dictates that state and local governments lure large corporations into the region through generous tax subsidies; the “Next Big Thing” approach, which involves identifying and aggressively targeting an emerging leading sector, regardless of whether or not the region is uniquely situation and qualified to support that sector; and the “If You Build It, They Will Come” approach, which Porter notes has been employed through massive public investments in largely-aesthetic municipal development projects.

These clusters cannot be built without a realistic assessment of regional production “inputs,” such as a large pool of specialized employees, access to materials through a nearby transportation hub, and existing factories, Porter emphasizes.

Finally, Porter defines the supporting role of institutions in building an economic cluster. In the example of California, the state’s wine-manufacturing cluster supports numerous institutions, including the viticulture and enology program at the University of California at Davis; the Wine Institute, a San Francisco-based policy advocacy organization; and the California State Assembly Subcommittee on Wine.

PEOPLE

Brad Feld, founder of TechStars and managing partner of the Foundry Group, a Colorado-based venture capital firm, has outlined several principles for a regional startup economy in what he terms the “Boulder Thesis.”

The fundamental principle of Feld’s Boulder Thesis holds that regional startup economies must be led by entrepreneurs – in his words, “leaders.”¹³ Feld defines a second stakeholder group as “feeders” – universities, politicians, investors, service providers, and others who support the startup economy but do not themselves launch new businesses. “They become a part of the fabric of the startup community, but the feeders can’t be leaders,” Feld said in an online video produced by the Kauffman Foundation. “The leaders have to be entrepreneurs.” Research from the Kauffman Foundation confirms the observation, noting that entrepreneurs are far more likely to follow the social media accounts of other entrepreneurs than those of feeders. “In entrepreneurship, especially at the very early stages, there is no hierarchy,” Feld said. “If the hierarchy tries to drive the startup community, it essentially stifles it.”

Given this note of caution for policy makers looking to centrally-plan a startup economy, Invent2026 advises that feeders recognize their roles and make greater investments in incubating entrepreneurs. This could take the form of summer internship opportunities for college students and especially stronger mentorship networks. “I hear the complaints, I hear the comments, about ‘well the cost of living in Silicon Valley is very high,’” said Andreas Cangellaris, dean of the University of Illinois’

¹³ Other principals of the Boulder Thesis: Entrepreneurs, or leaders, have to take a long-term and patient approach, twenty years or more, and re-incorporate entrepreneurs who have recently led failed ventures. Feld also encourages leaders of startup economies to build an engaging, inclusive, “fun” environment, and have regular events that seek to support regional new ventures. Toward this aim, TechStars regularly holds events where entrepreneurs pitch their companies to interested venture capitalists.

College of Engineering. “When you are 23 years old, you will sleep in the park if you want to have the opportunity to be right next to the founder of Google.”

UNDERSTANDING NATIONAL NEEDS

Invent2026 approached cluster development by first reviewing the national economic and security gaps. “The infrastructure is there, it’s just about changing the focus,” said Dr. Jeff Binder, director of the University of Illinois’ Applied Research Institute. “Being aware of the actual national needs, the national security needs, the homeland security needs, and taking that research and applying it to those needs.”



Figure B: This model illustrates the Invent2026 approach to targeting federal support, beginning with identifying national needs.

Applying Feld’s Boulder Thesis, the Invent2026 task force identified five essential resources – “feeders” – that would equip the region’s clusters to serve national needs. In descending order of importance:

1. An endowment of natural and human resources that would enable growth in the identified cluster: The Invent2026 task force agreed that there are certain sectors in which the Midwest, by virtue of its geography, is poised to compete. Additionally, given the strategic capacities of the region’s universities – electrical engineering at the University of Illinois, or nanotechnological engineering at Northwestern University – there are sectors that the Midwest’s workforce was uniquely qualified to drive growth.
2. Strong publicly- and privately-funded centers of applied research: The ability to drive patenting activity and build new businesses to introduce technologies into the market, the Invent2026 task force agreed, rested on strong centers of applied research, residing at the region’s universities or the national labs.
3. Institutions to advocate for the interests of the cluster: Growth-enabling institutions include public advocacy organizations that lobby for the interests of the economic cluster, nonprofit organizations that train workers in requisite skills, and public agencies that prudently support the cluster’s regional growth.

4. The availability of venture capital to support startup companies: Venture capitalists famously insist that the companies they fund reside in close geographic proximity.
5. Seamless technology transfer to startup ventures: It is not enough to be making discoveries enabled by applied research; neither is it enough to be transferring technology into the private sector through large corporations. The Invent2026 task force agreed that tech transfer into the startup community holds the unique potential to drive value creation in the Midwest region while nimbly responding to federal procurement needs. As noted in Richard Dobbs, James Manyika, and Jonathan Woetzel's 2016 book, "No Ordinary Disruption," early-stage companies can more quickly adapt to technological advances. "For many established companies, placing big bets on early technologies is simply not an option due to strictly defined risk appetite, high hurdles for new investments, and legacy IT systems," they write. They add later: "Technology is shifting the balance of power from large, established incumbents to small businesses, startups, and entrepreneurs...technology has allowed small, nimble attackers to compete with large, established companies."

How solving a national need drives innovation: robots in Japan

Much of the robotics sector is being advanced in Japan, fueled by massive Japanese public investments in robotics research driven by the need to supplement the dwindling service sector workforce, particularly in caring for Japan's senior citizens. As Alec Ross notes in his 2016 book, "The Industries of the Future," the Japanese government, recognizing that the country has far too few younger workers to care for the 34 million Japanese citizens age 65 and older, have made investments in robotics as a way of filling the void. Japanese engineers have designed robots that can perform basic household chores, and they are becoming more sophisticated in having human conversations.

While recognizing the diversity of the Midwest economy, the Invent2026 task force came to understand that the potential to grow the region's capacities to serve national needs reside in developing strong advanced manufacturing capacities, and in growing our capacities in the life sciences and especially the physical sciences.

1. Life Sciences: The costs associated with sequencing a human genome – a feat within humanity's power for only a decade and a half – is falling, and with it has the potential to target potential health risks, including cancer. Other potential industries have emerged from the historic advances in biological and genomic sciences: "In the nineties we learned to read DNA; now we're learning to write DNA," Dr. Jay Walsh, vice president of research at Northwestern, said during an August roundtable discussion. How can the Midwest advance the field of life sciences? The

answer is not readily apparent; many advancements in life sciences have come from coastal research centers. Yet the region's core capacities in pharmaceutical manufacturing and medical device design, coupled with a recent federal and private sector investments in the region in life sciences, could soon clarify where the Midwest fits in the broad and fast-moving life sciences value chain.

2. **Physical Sciences:** Advancements in design and sensors will enable society to monitor soil fertility in our farms, direct autonomous vehicles navigating our highways, monitor contaminants in our public waterways, and power distributed energy grids in our homes and office buildings. Securing and advancing the nation's system-of-systems will require a strong focus on the Midwest's water resources, highways and bridges, and the region's robust agricultural sector. There is a real opportunity to take the clay of the Midwest's abundant natural resources and mold an economy in the physical sciences, with a special focus on the food and agriculture sector, that the region's startup economy is missing, blinded by what Jim Schultz, director of Intersect Illinois, calls the "me-too" approach to new technologies. "We need to focus on what our strengths are and build upon those," Schultz said.

These strategic clusters were determined after a great deal of thoughtful analysis and deliberation that carefully considered the Midwest region's ability to serve national needs and drive economic growth. The Invent2026 task force is aware of several new industries that present exciting possibilities for the American economy: virtual reality, robotics, and drone technology, to name a few.¹⁴ Entrepreneurs in sectors not explored by the Invent2026 task force should not view this review as rejection of the region's capacities in those sectors.

Yet during Invent2026's inquiries, we were constantly aware of the potential hazards of appearing removed from reality in challenging other regions that are in a far stronger strategic position to compete in other new industries. In the sections that follow, we will first evaluate the region's growing capacities in advanced manufacturing, then discuss the three critical industries that will fuel the Midwest's growth in the next ten years. We will define regional capacities, institutions, and ongoing efforts to support growth in these sectors.

¹⁴ Globally the strongest economic cluster in robotics is surely in Japan; what exists in the United States is largely centered on Pittsburgh. Since 1979 Carnegie Mellon University has supported The Robotics Institute, leading a regional robotics cluster that is largely credited with reviving the City of Pittsburgh after many of the region's the steel mills shuttered. As yet there appears to be no center of mass in virtual and augmented reality, though the industry leader, the Facebook-owned Oculus VR, LLC, was launched in Los Angeles before relocating to Menlo Park, California, after its acquisition.

VI. DEVELOPING MIDWEST CLUSTERS

Clusters and regional brainsharing have long defined urban economies: philosophy in sixth-century Athens, painting in Renaissance Florence, finance in New York, and information technology in contemporary San Francisco. These clusters flourished within environments where innovators shared ideas. So too should it be in the Midwest and in Chicago.

What is outlined in the following pages is a regional startup economy built on the physical sciences and enabled by the region's maker spaces and finance. In short, the Midwest in the next ten years should focus on growing a cluster in the physical sciences, defined as science that enables smart infrastructure design, makes efficient use of energy and water, and maximizes food and agricultural production. At present, the startup economy of the Midwest is characterized by a collective failure to leverage the region's proximity to inputs. Recalling the model on page 19, the innovation process begins with an endowment of resources – the Midwest's most valuable being fertile soil, potable water, and the confluence of highways and rail lines that intersect in the region.

At the same time, the Midwest should continue growing capacities in the life sciences, with a strong focus on medical devices and pharmaceutical discovery.

What undergirds the entire economy of the Midwest is its traditional strength in manufacturing, which has evolved to encompass advanced manufacturing technologies. The region should leverage these assets – which are absent from many coastal cities – to drive growth in the life and physical sciences.

ADVANCED MANUFACTURING

The national interest in advanced manufacturing is to revive the once-great American manufacturing economy, and drive interest among manufacturers to refit abandoned factories, currently more likely to be turned into condominiums than resume production under different occupants.

The Department of Defense's interests are more tactical: halting the erosion of the American manufacturing base in order to contain its procurement supply chain within the United States. Naturally the Pentagon is averse to weapons programs, or sub-components of weapons programs, being manufactured in a foreign country. Yet given how many industrial manufacturing facilities have shuttered in recent years, and the attendant decline in manufacturing workforce – just eight percent of American workers were employed in manufacturing of any kind in 2014, according to the Bureau of

Labor Statistics, down from more than a quarter of the workforce in the 1950s^{xvii} – it may have very little recourse.

“If we had a World War II today, and if we wanted to manufacture parts at a rapid rate, we would not be able to do it,” said Dr. Santanu Chaudhuri, the principal research scientist for University of Illinois’ Applied Research Institute, who recently led a team that to examine the Army’s Rock Island Arsenal’s operations.¹⁵ “We would not be able to do what we did in World War II. Our manufacturing base is gone, [and] our supply chain is all over the place.”

The question facing the American military and, more broadly, the American economy: How to manufacture more with less? The development of advanced manufacturing technologies have been surely driven by downward pressure from foreign competition capable of manufacturing products more cheaply; yet, somewhat paradoxically, advanced manufacturing holds the capacity to revive the American manufacturing base.

Antoine van Agtmael, senior advisor to Garten Rothkopf, a public policy advisory firm, and Fred Bakker, the former editor-in-chief of the Dutch financial newspaper *Het Financieele Dagblad*, investigated manufacturing cities in developed markets that have thrived in the face of a seemingly global consensus that low-wage, low-cost economies would sweep up manufacturing jobs. What they found has particular relevance for the Midwest. In their 2016 book, “The Smartest Places on Earth: Why Rustbelts are the Emerging Hotspots of Global Innovation,” van Agtmael and Bakker describe recent interest among manufacturing companies in locating near concentrations of research, entrepreneurship, and institutions that would show how to integrate the most modern electronics into their production processes.^{xviii} “After several decades of a near-obsession with making things as cheap as possible,” van Agtmael and Bakker opined that manufacturers in the coming decades would “focus on making things as smart as possible.” Or put more plainly: “Cheap [is] giving way to smart.” With corporate manufacturers constrained from investing in R&D, companies must learn from one another in a mutually-dependent environment, van Agtmael and Bakker argue.

If they are right, the Midwest’s hearth of advanced manufacturing technologies, the Digital Manufacturing Design Innovation Institute (DMDII), would elevate in many orders of significance.

¹⁵ Chaudhuri recently led a team that to examine Rock Island Arsenal’s operations. He left with deep concern that the installation is “over blown” overhead costs, and could that the facility could compete with private sector manufacturing facilities only “for emergency no-bid contracts...when cost is not a factor.”



The Digital Manufacturing and Design Innovation Institute in Chicago

DMDII, a \$250 million facility run by UI Labs¹⁶, opened its doors in the summer of 2015.¹⁷ It was among the first sites in the National Network for Manufacturing Innovation (NNMI), which aims to become a system of manufacturing institutes that mirrors the national laboratories. The NNMI was launched in 2011 as the national economy was just emerging from the Great Recession. The stated goal of the Obama Administration was to support 45 NNMI institutes, initially with public financing but with an expectation that private-

sector investment would sustain the institutes after the first few years. To date the Obama Administration has announced the creation of nine NNMI institutes.¹⁸

The explicit purpose of DMDII is to spearhead new, lower-cost, smarter, and more precise manufacturing processes, encouraging its members – some of whom compete against each other – to collaborate in an open-source environment. This sharing of brainpower is surely a product of necessity: with the decline of corporate-funded R&D, collaborative research enables companies to share costs.^{xix}¹⁹

“What big companies tell me,” said Dr. Jay Walsh, the vice president of research at Northwestern and member of the DMDII board of advisors, “is that [DMDII] has allowed them to work with each other on problems that were of mutual interest.” Walsh provided the example of Ford and Boeing leveraging DMDII to design windshields. “There’s a lot of win-win here,” he added. To support the “win-win” for its members (big and small), DMDII launched the Digital Manufacturing Commons, or what UI Labs CEO Caralynn Nowinski Collens calls the “Facebook for manufacturers,”^{xx} to provide a platform for openly sharing data and manufacturing designs. The Digital Manufacturing Commons provides precisely the kind of brainsharing environment that, according to van Agtmael and Bakker’s thesis, is drawing manufacturers back to developed markets.

¹⁶ UI Labs was launched by and later spun off from the University of Illinois; it no longer has any formal association with the school.

¹⁷ DMDII was initially supported with \$80 million in Department of Defense funds. The State of Illinois and the City of Chicago also provided initial financial support.

¹⁸ The ninth NNMI institute was announced in June of 2016; the Smart Manufacturing Innovation Institute is being launched in Los Angeles with an initial \$70 million federal grant. The Obama Administration has said it intends to announce the launch of at least six more Institutes for Manufacturing Innovation before the end of the administration.

¹⁹ As van Agtmael and Bakker note, collaborative research between competitors skirts U.S. anti-trust laws by doing so in a university-supported environment. DMDII has dozens of university partners.

DMDII is but a year old; Rock Island Arsenal, another critical element of the Midwest Innovation Corridor, is 184 years old. With the possibility of base realignment and closure (BRAC) shuttering Rock Island Arsenal in the next presidential administration, the Invent2026 task force members acutely recognized the importance of demonstrating its value.

Rock Island Arsenal, located on the Illinois-Iowa border near Moline, Illinois, is home to the Joint Manufacturing and Tech Center (JMTC), the Army's fully integrated manufacturing facility. JMTC receives about \$70 million in estimated workload annually – its loss would strike a devastating blow to the Quad Cities' economy. It would also create strategic risk for the Army. Rock Island has served as a manufacturer of last resort, quickly producing materiel when the Army's private sector partners cannot. In 2004, as insurgents in Iraq launched attacks on U.S. troops using Improvised Explosive Devices (IEDs), Rock Island expedited the delivery of uparmored vehicles to deployed units, surely saving American lives.

“The problem is that the Army doesn't want to pay for (Rock Island) when they don't need it,” said Maj. Gen. Richard Hayes, the adjutant general of the State of Illinois.

Market opportunity:

DMDII and Rock Island Arsenal hold the potential to be core elements of what John Dallas, CEO of Hillview Partners, calls the “world's largest maker space,” referring to the manufacturing facilities that dot the regional map. So too does mHUB, a new 60,000-square foot facility launched to serve Chicago-based startups that manufacture physical products, providing access to automated manufacturing machines that would otherwise be inscaccessible and unaffordable to small businesses.

The opportunity for the region is to build out this maker space by keeping a finger on the pulse of the market, refit facilities with equipment capable of manufacturing products at the nanometer scale, and provide users – public and commercial – maximum agility and flexibility to amend manufacturing processes as the market changes. Rock Island Arsenal could become a critical element of this maker space if the installation were to open its facilities to commercial manufacturers.

One particular exchange, between an author of this review and Dr. Keith Bradley, director of national security programs at Argonne National Laboratory, demonstrates an urgent market opportunity for makers to partner with researchers to bring research to a higher technology-readiness level and into the commercial market. “I don't believe we can attract the interest of people [researchers] tackling really tough problems if we can't do even the smallest amount of prototyping on site,” Bradley said. “But if we had a strategic partner who could take our concepts...”

The author interjected: Could that strategic partner be DMDII? Bradley responded that DMDII could be a strategic partner, and added that “it may be something that has yet to be created. It may be an entity that exists that just isn’t on my radar.”

LIFE SCIENCES

In 2000, President Bill Clinton, in a joint press conference with British Prime Minister Tony Blair, announced that an international team of scientists assembled under the Human Genome Project had produced the first map of the human genome. “Without a doubt, this is the most important, most wondrous map ever produced by humankind,” Clinton said. Three years later the sequence was complete.

The cost of sequencing the human genome was \$2.7 billion. Soon the cost of sequencing an individual human genome may be about what you spend on a nice dinner. The San Diego-based Illumina, Inc., has recently designed a device to sequence a genome with a small blood or saliva sample for about \$1,000, a tiny fraction of the cost five years ago. “Our ability to sequence genomes is actually moving faster than Moore’s Law,” Dr. Jeff Binder said. “It’s not going to be very long before someone is going to be able to swab my cup, stick something in their phone, and have my genome sequenced.” Researchers believe that the ability to map a human genome could lead to detections of certain health risks, including cancer, and provide physicians the ability to intervene before risks materialize and metastasize.

“At some point probably in most of our lifetimes,” said Dr. Elizabeth McNally, director of the Center for Genetic Medicine at Northwestern’s Feinberg School of Medicine, “every single person is going to have their genome sequenced.”

The advances in genomic sciences have paralleled advances in synthetic biology. As noted by Dr. Jay Walsh, the scientific community is now figuring out how to manufacture materials from an individual cell – “using the cellular mechanisms to be manufacturing plants” – a once unthinkable development that has stopped federal and defense procurement officials dead in their tracks. “If you go to the Department of Homeland Security, and the Department of Defense, you hear synthetic biology on a regular basis,” Walsh said. “For example, reprogramming the cell to make Kevlar-like materials, that is happening. Reprogramming the cell to make nylon.”

It’s not just the national security community that’s thinking about the recent and coming advances in synthetic biology. As Dr. Elizabeth McNally notes, researchers at Northwestern are seeking

support to grow new stem cell lines to “think about growing organs in a (petri) dish.” Heart replacements may soon be manufactured from a single cell.

We are now living in the most promising time period in science since the beginning of the atomic revolution. The advances emerging from the American and international scientific community are pushing well beyond what was imaginable even a decade ago, and may fundamentally change the fabric of our society.

The Invent2026 task force identified two dominant economic clusters in the life sciences: the long-standing strength in medical devices in Minneapolis, and the concentration of pharmaceutical company headquarters in the Chicago area.

Anent the former: Twin City natives and medical industry experts describe the 80 miles of highway connecting the Mayo Clinic with Minneapolis and St. Paul as “Medical Alley.” The first wearable external pacemaker was designed in Minnesota in the 1950s. Medtronic, the world’s largest medical device company, maintains its operational headquarters in Minnesota.

The Chicago region is home to the Lake Bluff-headquartered AbbVie and Abbott Laboratories, among many other large players in the pharmaceutical space. This proximity to senior leadership in the pharmaceutical industry, Jim Schultz notes, provides newer players opportunities for mentorship and eventual acquisition.

Many see Boston, Baltimore, and San Francisco as the putative centers of life sciences’ newest frontier – the biosciences, including genomics.^{xxi} A sensible regional strategy to align with the advances we are seeing in the life sciences would be to offer support to genomic scientists at places like Johns Hopkins University’s Center for Excellence in Genomic Sciences and the Broad Institute, a collaboration between the Massachusetts Institute of Technology and Harvard. The region should also seek to leverage new laboratory space, and take advantage of a recent federal grant, to drive advancements in drug development.

At the University of Chicago, the capacity to engineer materials at the school’s Hyde Park campus will soon go from zero to 100. Until recently, the school did not offer a degree program in engineering. That has changed with the launch of the Institute for Molecular Engineering, under the leadership of Dr. Matthew Tirrell, which will award its first bachelor's degrees in 2018. The school has already awarded engineering PhDs to students who transferred from other programs, and expects to award first “home grown” engineering PhDs – students who began and will finish their doctoral research at the University of Chicago – in 2018 and 2019.

The Institute for Molecular Engineering recently opened the Pritzker Nanofabrication Center, the school's flagship research laboratory. Within its walls, engineers are using microfluidic devices to separate individual cells like cards on a table. The ability to examine single cells and test different treatments at the cellular level could lead to breakthrough insights into the human immune system and potentially massive breakthroughs in the treatment of cancer. "All of this really does depend on advanced technology for separating cells from one another and applying actions to individual cells," Tirrell said.

Moreover, the Chicago region's biomedical research may soon be supported by a vast pool of medical data, with samples from throughout the country.

Recently the National Institutes of Health awarded \$50 million to four consortia of universities and medical centers through the Precision Medicine Initiative (PMI), an effort to collect a million genomic samples for a national clinical and genetic database. The Illinois Precision Medicine Cohort (IPMC) – a collaboration among Northwestern University, the University of Chicago, the University of Illinois at Chicago, the Ann and Robert H. Lurie Children's Hospital, and the Alliance of Chicago Community Health Services – was one of the four applicants selected.²⁰ The IPMC will collect genomic samples from 150,000 people in Illinois to support the effort. Through the PMI, the American medical community will be able to better define genetic, environmental and lifestyle risks and ultimately use this information to reduce risks. The Mayo Clinic in Minnesota will serve as the biosample repository site.

The Illinois life sciences community has assembled under the Illinois Biotechnology Industry Organization (iBIO), which since 1999 has brought under one umbrella members ranging from small startups to major universities. iBIO is committed to making the region a life sciences hub, including a robust effort to advocate for stronger science, technology, engineering, and math (STEM) requirements in public schools.^{xxii}

Another asset worth noting is Matter, a 25,000-square-foot open-floor workspace focusing on incubating healthcare startups. Matter has the potential to support what Vasco Bridges, regional director of Goldman Sachs' 10,000 Small Businesses, advised the collective Chicago startup community: find the best entrepreneurs, assign them a problem, and go fix it through entrepreneurship.

One startup doing just that is Tempus Health Inc., a potential flagship startup for Chicago in genomics. Tempus is founded by former Groupon CEO Eric Lefkofsky. Their blue sky mission: cure cancer through genomic research. For much of 2016, Lefkofsky built the company in stealth, pulling the curtain in late September of 2016 only after he had hired nearly 100 data scientists and PhDs, including

²⁰ The other grantees: The University of Arizona, University of Pittsburgh, and a New York consortium between Columbia and Cornell universities. Three to four more sites will be added.

one of the University of Chicago's top genomic researchers, Dr. Kevin White.^{xxiii} In partnership with Northwestern University's Lurie Comprehensive Cancer Center, Tempus will provide doctors with genetic profiles of their patients, and allow doctors to analyze their patients' genomic profiles against a database of similar cancer patients.^{xxiv}

The ability to drive technology through the startup community is complicated. Venture capitalists must be courageous to navigate the terrain. The failure rate of startups in the biosciences and genomics is well above that of most other industries.

Market opportunity:

The context and magnitude of what is happening in biomedical and genomic research must be appreciated to understand the regional economic opportunity. As McNally noted, after the Precision Medicine Initiative has completed the collection of genomic samples and patient data, researchers will have opportunities to sequence and analyze the cohort data. NIH grant opportunities will then likely emerge that involve genomic sequencing, proteomic analysis, and metabolomics analysis. It is expected that data from the PMI will yield new drug targets and pathways.

In order to be competitive for federal grants to support future analytic research, researchers must demonstrate their capacity. For researchers in the Midwest, that will surely require expanding laboratory space, training personnel and having the right infrastructure, which includes sequencing equipment and access to supercomputers.

Another capacity the Midwest region must collectively expand upon is the ability to transfer research into the commercial space. To be sure, things are moving in the right direction. Licensing at Illinois universities has increased at a rate more than double the national average, according to the Illinois Science and Technology Coalition.^{xxv} Yet it appears university tech transfer offices remain understaffed and severely limited in their capacity to protect intellectual properties, which is a prerequisite to commercial development. "Less than one percent of the ideas get tapped into and get processed," McNally said, adding that only researchers who are "being pushy enough" are likely to be supported by their tech transfer offices.

Finally, Argonne National Laboratory's MIRA supercomputer can and should be used to the hilt to design new pharmaceuticals. MIRA is among the ten most powerful supercomputers in the world. It is so powerful that it can simulate a human experiment using hundreds of different variables.

PHYSICAL SCIENCES

It is the firm belief of the authors of this review that the Midwest's core economic growth engine resides in the physical sciences, encompassing infrastructure design, water technology, and especially food and agriculture. Building a strong physical sciences cluster in the Midwest will demonstrate a commitment to work with the endowment of resources that we have, not the resources we want.

Our region's geographic and natural resources can drive technological advances emerging from the physical sciences. The nation's water and food supply chain flow from and through the Midwest region. By definition, the Midwest's transportation hub provides closer proximity to customer bases across the country than do the coastal markets.

As Intersect Illinois Director Jim Shultz noted, 80 percent of the potable water in North America sits in the Greater Midwest. Sixty percent of products that travel by rail in the United States travel through the State of Illinois; half of the products that travel by all means of transportation in the United States travel through the Prairie State.^{xxvi} About a half-dozen bridges in the State of Illinois are critical to maintaining the food supply chain, Schultz added. "If our logistics systems get knocked out, you're going to have a food crisis," he said, adding that many towns regionally have only a two-day supply of food. In a sense, the "heartland" sobriquet that has long defined the Midwest region isn't just rhapsodic; the Midwest truly does pump the lifeblood into the American economy, and protecting America's heartland is existential.

This proximity to inputs provides researchers in the physical sciences strong opportunities to drive innovation from the Midwest, and entrepreneurs the opportunities to prototype their designs. In the coming years sensor technology will be provide the ability to aggregate and analyze data to drive precise agricultural production, quickly manage traffic congestion, and detect lead contamination before a crisis like the recent disaster in Flint, Michigan, paralyzes our water grid. The Midwest's regional economy stands on a foundation of its agricultural productivity and logistical connectivity to markets throughout North America – all of which will be tied into the Internet of Things, or "system of systems," that will be increasingly threatened by natural disasters and foreign enemies.

The Midwest's geographic position and natural resources make the region a focal point of any strategy to ensure the safety of the nation's physical and digital infrastructure, feed our 320 million Americans, and ensure our infrastructure remains competitive.

WATER

In a cabinet a few feet from her desk, Metropolitan Water Reclamation District (MWRD) commissioner Debra Shore keeps a ready supply of small containers containing what appear to be rock salts. The containers actually contain small phosphorus crystals, which can be used by farmers as a fertilizer to help stabilize soil nutrients and increase yield. The MWRD, mandated by federal law to decrease the amount of phosphorus in wastewater discharged into the public waterways, turned to Ostara Nutrient Technologies, a Vancouver-based company, to monetize what would otherwise be a pollutant. By extracting phosphorus from the discharged water, the MWRD now expects to produce about 10,000 tons of the phosphorus crystals annually to sell at \$400 a ton, Shore said.

Shore keeps the phosphorus containers to distribute to guests to illustrate how the MWRD is maximizing the Midwest's most valuable resource: water. Water is perhaps the foundation on which the Midwest economy is built. The access to water attracts water-intensive industries – agriculture, energy production, industrial manufacturing – to locate to the Midwest to irrigate farms and cool machines. At the Ford Motor Company's South Side Chicago manufacturing plant, auto workers use water to wash vehicles before painting them.

Yet as Shore cautions, the region's supply of water isn't limitless. Each state is capped under the Great Lakes Compact in the amount of water they can use, providing opportunities to use (and reuse) water more effectively. And as the recent crisis in Flint, Michigan, demonstrated, the market for products to monitor toxins in water is large and growing. Flint's water supply was contaminated for months, continuing to pump water to its residents, before officials were made aware and took action.

Water technology – a broad sector that encompasses real-time sensor technology to monitor water infrastructure, water preservation technology, and desalination – is a clear sector in which national priorities and Midwest's growth capacities clearly align. At present, two organizations – one in Chicago and one in Milwaukee – exist to coordinate water-related businesses, advocacy organizations, and public initiatives related to the Midwest region's vast water resources.

The first is The Water Council, based in Milwaukee. As Alan Matthew, founder of Tribal Ventures, noted, "Milwaukee is branding themselves as the 'Saudi Arabia of water,'" and The Water Council is the Milwaukee water industry's chieftain. Since 2009 The Water Council has sought to bring together government agencies, nonprofit organizations, and water technology companies around a common "commitment to finding innovative solutions" to water-related issues.^{xxvii} In March 2016

World Business Chicago announced the launch of Current, a public-private partnership to drive thought leadership and cross-sector cooperation around leveraging water as an economic resource for Chicago.²¹

The two organizations differ in approach, not just geographical bailiwicks: The Water Council appears to view water as an industry in and of itself, while Current views water as a valuable input for other industries.²² Regardless, both would benefit from cooperation and brainsharing.

Since European immigrants brought beer-brewing technologies to Milwaukee in the early 19th century, researchers and entrepreneurs have seen the city as the country's intersection of all technology related to treating and protecting water. Milwaukee-area brands in water technology include Kohler and A.O. Smith Corporation, and according to Scott Mosely, director of investment strategies at The Water Council, there are more than 200 identified water technology companies in southern Wisconsin. The Milwaukee water cluster is also aligned with academia. In 2008 the State of Wisconsin approved the creation of the School of Freshwater Sciences at the University of Wisconsin at Milwaukee.^{xxviii} In doing so the University of Wisconsin at Milwaukee became the first American university to offer advanced degrees in freshwater sciences.

In June of 2016 The Water Council opened the doors of the Global Water Center, a seven-floor building in downtown Milwaukee that will serve as an intersection between water technology startups, interested corporations, and researchers, including those from the University of Wisconsin at Milwaukee.^{xxix} Mikroflot Technologies is one of the tenants. Mikroflot provides a kit to manage industrial wastewater and avoid surcharges levied by municipal water authorities that, for some companies, can reach \$100,000 annually.^{xxx} The Mikroflot kit works by generating microscopic bubbles that separate contaminants before the wastewater goes down the drain and potentially into the water table (and thus incurring surcharges from municipal authorities).^{xxxi}

“If you think of the water distribution grid as almost identical to the electrical distribution grid, water is probably 25 years behind in terms of technology adaptation,” Mosely said. “The control systems, the monitoring systems, those industrial processes are not in the water grid. Big problem, but also big opportunity to integrate things like real-time, bio-detection capacity in drinking water systems, so if there was some type of bio-terror attack, that would be known rapidly and you could disconnect that infected system.”

²¹ Three members of the Current board of advisors participated in the Invent2026 review drafting process, yet not everyone from the Illinois side of the Invent2026 task force expressed support for Current's stated mission, which is strongly focused on Chicago's, rather than the greater Midwest's, interests. “We ought to be working together instead of building fiefdoms,” Jim Schultz of Intersect Illinois said. “And that's the problem I see with Current.”

²² As of September 1, Current has not yet hired an executive director, so it is difficult to determine precisely what Current's mission will be.

Chicago's water interests appear to center on the many municipal water management challenges the city faces. Out of necessity, Chicago could soon become the source of revolutionary control systems that dramatically advance our ability to efficiently use potable and non-potable water. Since the City of Chicago was forced in 1900 to reverse the flow of the Chicago River to stop pollutants from going into Lake Michigan, the city has repeatedly faced tougher challenges than most municipalities in flooding and water treatment. Big problem, big opportunity.

Shore is now advocating for a proposal – \$1 billion over ten years, she said – to install 2,000-gallon rain-capture systems with smart valves throughout the Chicago area. These systems would be connected to weather telemetry sensors that would activate the valves in advance of an approaching storm, capturing and distributing rainwater before it goes to the sewers. CH2M, a Colorado-based consultancy specializing in sustainable municipal design, has produced predictive analytics to support the rain-capture system to help determine what level of rainfall will lead to storm water flooding in specific neighborhoods. The MWRD has now tested this design, and “it seems to be the only thing that can eliminate basement backups in the City of Chicago,” Shore said. Additionally, Shore notes, the \$1 billion price tag compares favorably to proposals to improve existing infrastructure.

If the MWRD moves forward with the smart rain-capture proposal, it could make Chicago home to one of the most advanced and exportable water management systems in the world.

The City of Chicago may also soon provide invaluable insight in decontaminating urban waterways. Shore often speaks of the potential to grow the Chicago River's ecosystem and enable recreational swimming in Chicago's waters – something once thought so hazardous as to be nearly suicidal!²³ Now, with about three dozen monitoring sites throughout Chicago's waterways, researchers at Argonne Laboratory are taking samples of discharged water to determine what methods of decontamination are working. The City of Chicago is prohibited, under the Great Lakes Compact²⁴, from discharging water into Lake Michigan that contains more than 1.3 parts per trillion of mercury, a level the city has not reached as of yet. Chicago's waterways have also been found to contain harmful levels of pharmaceuticals and hormones. But they're getting better.

“The goal,” said Dr. Seth Snyder, the leader of Argonne Laboratory's Water Initiative, “is to eventually bring microbial concentration low enough that the rivers become swimmable, and maybe even eventually return the river to the lake.”

²³ When Commissioner Shore was interviewed for this review, her aide, Alfred Saucedo, as if to prove a point, had just days earlier joined the Metropolitan Water Reclamation District Executive Director David St. Pierre in plunging into the Calumet-Saganashkee Channel, a short distance from the MWRD's Thornton Reservoir. “Alfred says he hasn't gotten sick yet,” Shore said. “We'll be watching him.”

²⁴ The Great Lakes Compact began as a good-faith agreement between states surrounding the Great Lakes to prudently share water resources. In 2008 it became a legally-binding agreement signed into federal law by President George W. Bush.

Market opportunity:

It is clear the Midwest Innovation Corridor has an endowment of natural resources, applied research at Argonne Laboratory, and a strong network of supporting institutions to support a growing water technology cluster. In fact, federal investment is already happening in the Midwest. The seven-county Milwaukee metropolitan area was designated by the U.S. Department of Commerce's Economic Development Agency as an Investing in Manufacturing Communities Partnership (IMCP), with a focus on water technology, providing the region with direct support from the Department of Commerce in coordinating federal aid and grants to support its economic-development plan.^{xxxii}

The market opportunity is to expand federal support coming into the region, and export solutions being found both in Milwaukee and Chicago. As Mosely noted, the U.S. Environmental Protection Agency and especially the National Science Foundation, likely as a consequence of the Flint disaster, are dramatically increasing federal investments toward water technology. There is also interest from the U.S. State Department in ensuring safe potable water supply in developing nations. The Invent2026 task force agreed that a collaborative, rather than competing, relationship between The Water Council and Current would best be positioned to seize this opportunity.

TRANSPORTATION

In 2015, unbeknownst to the hundreds of thousands of commuters who traverse Chicago's streets and highways every day, the City of Chicago began approving selected streets for use by driverless vehicles.^{xxxiii} In doing so, the city may have begun the process of remaking the vast web of roads that weave through the Midwest.

According to Ann Schlenker, director of the Center for Transportation Research at Argonne, vehicles with hands-free cruise control features that scan the road in front of the driver, automatically reacting to the movements of other vehicles, will begin finding their way onto Midwest highways as early as 2017. This development will augur a new driverless era in American transportation, potentially shaking the American economy at its foundation. A transportation grid with driverless vehicles could enable companies to safely and quickly transport goods on American roads, obviating the need to rely on slower rail systems. It may also call into question the need for families and commuters to rely on personally-owned vehicles.

The history of driverless vehicles began with a 2004 Defense Advanced Research Projects Agency (DARPA) challenge, issued to researchers around the world to design a driverless car that could navigate a 142-mile course in Nevada. None of the entries went further than 7.5 miles, but DARPA's

challenge catalyzed research into driverless vehicles that catalyzed advancements we are now seeing 12 years later.^{xxxiv} This history is still being written, of course. Before driverless vehicles are commercially viable, engineers must first make dramatic advances in Light Detection and Ranging (LIDAR) surveying technologies. “The challenge so far has been having 360-degree perception of the vehicle and the environmental surroundings under all conditions,” Schlenker said. “Part of the issue, going back to the DARPA challenge, is that LIDAR is very, very expensive.”

Driverless vehicles must be supported by a centralized network capable of communicating to vehicles with real-time Signal Phase and Timing (SPAT) data. With strong SPAT data, vehicles can react to nearby traffic congestion and even know where to find the nearest available parking spot. “It’s less about the vehicle and more about the system that [a driverless] vehicle operates in,” said Steve Fifita, the director of UI Labs’ City Digital.²⁵

This SPAT data must include data collected from private-sector sources, raising privacy concerns weighed against the need to build the required network to improve traffic flow and congestion. Schlenker and her team are working to help design the network, creating transportation vehicle energy models that utilize supercomputing to simulate human driving behaviors and decisions. But they are limited by the data available to them. “For me to understand the travelers’ decisions over how you move, and at what times, and for what destination, and even your mode of transportation, all these are critical inputs to future planning in a connected transportation system that can be overlaid with autonomous vehicles and technologies,” Schlenker said.

In short, there’s a lot of work to be done, and questions to be answered, in building that environment that supports driverless vehicles in the Midwest.

If water is the Midwest’s most valuable asset, roads can’t be far behind. It is the Midwest’s roads that provide accessibility to customer bases throughout North America. The Midwest Innovation Corridor, if it is to export solutions to national problems, can begin by looking at the region’s transportation grid. Any effort to build a national smart highway system, connecting the Pacific to the Atlantic, would almost surely begin by building out from the Midwest. Several potentially-transformative organizations and initiatives are driving infrastructure investment in the Midwest.

In June of 2016, the City of Columbus (Ohio) was awarded \$40 million from the U.S. Department of Transportation – supplemented by \$100 million in private sector funds, including \$10 million from Microsoft co-founder Paul Allen’s Vulcan Inc. – to design and build a transportation system that leverages real-time data to manage traffic flow and direct autonomous vehicles.^{xxxv26} With the grant

²⁵ City Digital is led by UI Labs, one of two main initiatives under that organization, with the other being DMDII.

²⁶ The Department of Transportation restricted the grant to medium-sized applicants; Chicago was far too large to compete.

money, Columbus will soon have the smartest transportation system of any municipality in the country, with autonomous vehicles connected to sensors planted throughout the city.^{xxxvi27}

In late August of 2016, “Array of Things” – a partnership between the University of Chicago, Argonne Laboratory, and the City of Chicago – began installing 50 nodes at traffic lights around the City of Chicago. Funded with \$3.1 million from the National Science Foundation, Array of Things has planned to affix 500 nodes around the city to monitor air quality and traffic, collecting data to drive predictive analysis on traffic patterns and potential flooding.^{xxxvii}

The University of Illinois’ Applied Research Institute has supported its Critical Infrastructure Resilience Institute (CIRI) with a \$20 million Department of Homeland Security grant. CIRI has a partnership with the University of Illinois Information Trust Institute, and has collaborated with the national laboratories, to train homeland security practitioners and system engineers, and generate thought leadership on cyber infrastructure resilience.^{xxxviii}

And City Digital, a UI Labs-sponsored initiative led by Steve Fifita, is leading the charge to design “smart cities” that seamlessly converge physical and digital municipal design, using Chicago as a laboratory. The City of Chicago’s willingness to open its data to researchers has made City Digital an especially promising initiative.

If regional actors in the Midwest want to build a strong cluster in infrastructure technology, no organization would be happier than the U.S. military. Scott Air Force Base in Belleview, Ill., is home to the U.S. Transportation Command, a joint command that is responsible for managing the military’s entire global transportation system.²⁸ “They own everything,” said Maj. Gen. Richard Hayes, adjutant general of the State of Illinois. “If you want to talk about (military) logistics, it’s all decided here in Illinois.” The U.S. Transportation Command is composed of three service commands – the Air Force’s Air Mobility Command, the Navy’s Military Sealift Command, and the Army’s Surface Deployment and Distribution Command – who all report to a four-star commanding general, garrisoned at Scott Air Force Base.²⁹

In the logistics sector’s startup economy, one flag, flying high, has already been planted in the Midwest. Uptake Technologies, founded by Brad Keywell, a cofounder of Groupon, reached “unicorn” status in 2015, meaning the company was valued at more than a billion dollars. Incredibly it achieved

²⁷ As of August of 2016, seven states – Nevada, California, Florida, Michigan, Hawaii, Washington, and Tennessee – have passed laws allowing for autonomous vehicles. It would follow that the State of Ohio will likely soon join these seven states.

²⁸ The Defense Logistics Agency and the U.S. Transportation Command may seem duplicative. In fact the commander of the Defense Logistics Agency reports to the Assistant Secretary of Defense for Logistics and Materiel Readiness, whereas the Transcom commander reports through the Chairman of the Joint Chiefs of Staff to the Secretary of Defense.

²⁹ The current U.S. Transportation Command commanding general is Air Force Gen. Darren McDew.

unicorn status in less than a year of operations.^{xxxix} Uptake provides clients with the kind of operational real-time data and analytics – the movement of goods, performance of critical equipment – that has so far eluded the Department of Defense. Forbes called Uptake the number 1 “hottest startup of 2015.”

Market opportunity:

As both Ann Schlenker and Steve Fifita emphasized, realizing the possibilities of a modern transportation grid will need to involve modernizing public policy.³⁰ What state and local governments can do is make their transportation grids smarter through investments like Array of Things, authorize sensors on public roads, and explore driverless lanes for highways. The Midwest should be preparing its infrastructure for autonomous vehicles with a sense of urgency. The competition to build a modern transportation grid is a competition American cities are losing. Cities like Barcelona and Singapore are well outpacing any American municipality in smart grid technology, Fifita said.

Of course realizing these possibilities takes money, money our governments don't have. The American infrastructure is in urgent need of modernization. City of Chicago residents walk over *telegraph* lines and drink from water that flows through wood pipes. According to the American Society of Civil Engineers, more than \$1.6 trillion more than what is currently being spent on infrastructure in the United States is needed just to maintain our roads and bridges.^{xl} This is clearly not achievable under current public budgets – federal, state, or local.

A new model for infrastructure spending is needed. This model is what Dr. Keith Bradley, director of national security programs at Argonne National Laboratory, calls “Infrastructure 2.0.” At present the American infrastructure is so damaged that utility companies, engineering companies, and especially insurance companies are exposed to significant risk. “Who’s liable if things go wrong?” Bradley rhetorically asked. “It’s the insurance company ... So the question is: Can you make an attractive value proposition to the insurance companies that if they invest in the technology and the design of future infrastructure, in the end of the day, they’ll make money?”

Let’s take advantage of the insurance industry leaders in Illinois – only Connecticut has more insurance companies headquartered in their state than Illinois – to come up with a public-private design to fund infrastructure so Illinois becomes a leader in smart infrastructure design, while allowing insurance industry partners to profit.

³⁰ In September of 2016, the U.S. Department of Transportation and the National Highway Traffic and Safety Administration issued a set of guidelines for states to manage the emergence of driverless vehicles. The guidelines included a 15-point set of safety standards for manufacturers, and urged manufacturers to show how their vehicles will share data and communicate with other drivers on the road.

ENERGY AND BATTERY TECHNOLOGY

About 25 miles down Interstate 55 from the Chicago Loop is Argonne National Laboratory, one of the U.S. Department of Energy's national laboratories. Since World War II, the national laboratories have formed the backbone of American scientific research. Researchers at Argonne designed the first power-producing nuclear reactor. Today Argonne's researchers maintain a broad portfolio, focusing on energy technology advancement. Dr. George Crabtree, director of the Joint Center for Energy Storage Research (JCESR, or "J-Caesar"), is working on research that could achieve the kind of market disruption comparable to the discovery of nuclear energy 70 years ago.

Since 2012 Crabtree and JCESR have been under a \$120 million, five-year grant from the Department of Energy to increase the energy storage capacity of existing batteries while, at the same time, lowering the costs. Their work puts Argonne in middle of the battery technology value chain, whereby designs emerging from Europe and coastal universities receive accretive, or dramatic, improvement in the Midwest.

If JCESR is successful, their work could transform the battery market that has been dominated by the lithium ion battery, which was first commercialized by Sony in 1991. When introduced into the market, the lithium ion battery doubled the storage capacity of then-contemporary nickel-metal hydride batteries that long powered consumer electronics. Lithium ion batteries have since been advanced to the point where they have three times the energy storage capacity than they did when they entered the market, a factor of six increase from the nickel-metal hydride battery. "That's what made personal electronics what it is today," Crabtree said. "If [the lithium ion] battery were six times heavier and six times bigger, would you really have a cell phone? Probably not."

Now existing battery technology is failing to keep pace with advances in solar energy and electric cars, and only a "factor of five" increase in energy storage capacity of batteries can enable these markets to sharply grow, Crabtree argues. To do that, Crabtree and JCESR have scrapped the lithium ion design altogether.

In transportation, JCESR have turned to a lithium sulfur design, which Crabtree hopes can jump ahead of lithium ion batteries. The Nissan Leaf, an electric car that in 2012 could drive up to 80 miles on a single charge, acts as a research baseline. Can JCESR design a car battery that will cost-efficiently move a car 400 miles on a single charge? A May 2016 piece in Forbes Magazine seemed to temper expectations. Four years into JCESR's research, Kevin Gallagher, a JCESR electroengineer, warned a University of Chicago audience he believed that it would be "incredibly difficult" to beat lithium ion

batteries in the marketplace, according to Forbes' Jeff McMahon.^{xii} Yet Crabtree remains optimistic that JCESR can meet its goals by the end of the Department of Energy grant next year.

To power the energy grid, there appears to be less uncertainty about JCESR's work, which has focused on the "organic flow" battery model, first designed by researchers at Harvard and described in a scientific paper published in 2014.^{xiii} Organic flow batteries store energy in tanks carrying two liquid solutions, one negatively charged and the other positively charged, generating an electric current by pulling electrons from the solution in the positively charged tank and pushing them into the negatively charged tank.^{xiii} The flow battery process is metal free, or "organic."

The organic flow batteries may soon power neighborhood energy cooperatives that could upend the one-way power grid, where consumers flip a switch when they need power and flip it again to turn it off. Utility companies are, slowly, supporting smart grid technologies. This development could be coupled with the rapid fall of solar energy prices. Energy utilities are poised to discard the gas turbines they have long relied on to support the energy grid in favor of solar panels. With solar panels affixed to single-family homes, large residential buildings and commercial buildings, consumers will soon be able to "net meter" the energy they use against the energy they are collecting, and sell surplus energy back into the energy grid. Under this system, energy would be stored at a nearby battery.

That's an exciting possibility at a time when solar energy supplies a relatively small share of the

What collaboration can do: SiNode Systems

SiNode Systems, a Chicago-based startup, has built battery technology that has added a composite of silicon and graphene to the standard lithium ion battery that is found in consumer electronics. The graphene adds greater conductivity to the battery's compound, allowing SiNode's battery technology to add 40 percent greater energy storage capacity without expanding the size of the battery device.

Samir Mayekar, SiNode's co-founder and CEO, is not a scientist. In fact, his career has largely been in politics – his major at Northwestern was political science and he briefly worked in the Obama White House before returning to Northwestern to earn his MBA.

As a Master's student at Kellogg School of Management, Mayekar was introduced Cary Haynar, then a PhD candidate at Northwestern's McCormick School of Engineering, through a cross-departmental program designed by Northwestern faculty to attract their business students to entrepreneurship and help their engineering students bring their technological advances into the market. The matchmaking worked. Haynar is SiNode's Chief Science Officer.

Since the company's founding in 2012, SiNode has benefited from a proximity to Argonne National Laboratory, which Mayekar calls "a Disneyland for scientists." Argonne personnel have guided the SiNode Systems team with grant applications.

American energy demand. At the moment the possibilities are largely theoretical. As solar power's share of the aggregate energy demand grows, battery technology will need to rapidly keep pace. With current lithium ion batteries, these microgrids cannot be supported cost-efficiently. That would change if JCESR can advance the organic flow design to the point where it can store energy more densely than lithium ion batteries by a factor of five, Crabtree says. JCESR has spent the spring and summer months of 2016 building battery cells that should approximate the final organic flow battery that will be produced next year.

The Joint Center for Energy Storage Research is part of a refocused effort by the Department of Energy in the field of material science to more quickly develop basic research and transfer their work into private sector. Aware that its researchers often need between 15 to 20 years to take a research discovery and deploy it to the market, the Department of Energy recently launched several initiatives to hasten this process.

In February of 2016 the U.S. Department of Energy launched the Energy Materials Network, a national laboratory-led effort to partner with universities and industries to accelerate materials development, across different fields.^{xliv} This element of collaboration is critical in hastening the process of developing discoveries in material science.³¹ Additionally, Argonne recently launched "Chain Reaction," an initiative to incubate startup companies bringing Argonne technology to the market.

To date, JCESR has forged partnerships with 15 entities, including the Chicago-based Clean Energy Trust, to help advance and commercialize their research. Companies from Asia are also reaching out to JCESR, Crabtree said, suggesting that Midwest actors should not assume that the benefits of JCESR's research will remain close to their origin.

Market opportunity:

If we are now at the starting blocks in a race to develop a battery manufacturing cluster, Nevada already got a big head start when Tesla CEO Elon Musk opened a battery manufacturing "gigafactory" the size of 262 football fields just outside of Reno.^{xlv} The gigafactory will be producing lithium ion batteries for Tesla's newest model, the Model 3, which will cost about a more middle class-friendly \$35,000.^{xlvi}

That development set aside, there are abundant opportunities to make the Midwest a hub of battery development and manufacturing activity. Argonne National Laboratory, like nearly all of the national laboratories, is a Federally-Funded Research and Development Centers (FFRDCs). Its status as

³¹ Recall the collaboration required to launch and support SiNode Systems, profiled on page 39

a FFRDC requires that all patents emerging from Argonne be made available to the public sector for licensing. These words from Crabtree should sound a clarion call heard throughout the Midwest startup economy: “I would make the prediction, and I’m sure I’m on safe ground here, that lithium sulfur will start developing commercial applications very soon.”

Additionally, once the organic flow prototype battery is completed, JCESR will require partners to test and scale the prototype, and introduce it into the commercial market. Attendant opportunities in designing microgrids, centered on neighborhood organic flow batteries, will follow.

The new markets in battery technology extend beyond increasing energy storage capacities. As noted by Dr. Santanu Chaudhuri, the principal research scientist at University of Illinois’ Applied Research Institute, there is now a growing market for batteries custom manufactured at a lower volume for specific devices and applications. The Pentagon has sought lighter-weight batteries to alleviate the strain forced on ground troops carrying large, condense batteries on foot patrols. U.S. Army and Marine Corps officials, at a June 2016 conference in Arlington, Va., pleaded for more lightweight batteries for their frontline troops, noting that their troops can carry as much as 17 pounds of batteries in their rucksacks during a 72-hour mission.^{xlvii} It is clear that the federal checkbook is open to address these strategic needs.

FOOD AND AGRICULTURE

Fermilab is the Chicago region’s second national laboratory. The work done at Fermilab is surely more recondite than that done at Argonne National Laboratory. At Fermilab researchers work in the more basic sciences, studying particle physics and the forces that make up the universe. “We start with blank sheets of paper and design entirely new accelerators,” said Dr. Robert Kephart, director of the Illinois Accelerator Research Center (IARC) at Fermilab. A particle accelerator, as Kephart describes it, “translates wall-plug power into accelerated beams of particles, each one of which contains a large amount of energy.” Fermilab has the largest collection of accelerator scientists in the world, some 650 accelerator scientists on staff. According to Kephart, accelerators are now a \$2 billion a year industry and support around \$500 billion in products.

Their work in designing new accelerators catalyzes the advancement of a range of consumer electronics, from cellphones to laptops to printers. “What we want to do is use that capability to design the next generation of accelerators in industry,” Kephart said. “We think there’s an even longer list of potentially new applications [for accelerators], which is why we started IARC.”

The Illinois Accelerator Research Center opened its doors in 2015, launched to support what Fermilab has often struggled to do: develop the work done in their labs into commercial products. The IARC couldn't have opened up at a much more fortunate time, Kephart explains. Particle accelerators and particle detectors will soon open new frontiers. High-energy beams will soon allow for the treatment of wastewater, and break down heavy oil so producers can move supply through their pipelines faster. Researchers at Fermilab have recently produced particle detectors to design one of the most powerful cameras in the world.

The new frontiers in accelerators and particle detectors include transformative applications in food and agriculture production. "If you can build high-powered mobile accelerators, which we think you can, you can use them for a variety of environmental remediation applications, such as cleaning contaminated soil," Kephart said. Accelerators could revive Midwest soil that has decreased in fertility from use of pesticides. That would put Fermilab at the center of advancing food and agriculture production in the Midwest Innovation Corridor.

The Midwest economy was arguably built on the agriculture and food production, with its roots in cornfields of Iowa and Chicago's meatpacking plants. The agricultural sector of the Midwest is easily the strongest of any region in the United States; according to data from the U.S. Department of Agriculture, seven of the Midwestern states of Iowa (second), Illinois (fourth), Nebraska (fifth), Minnesota (sixth), Kansas (seventh), Wisconsin (ninth), and Indiana (tenth) compose the top 10 states in farm output.^{xlviii}

But while the region's agriculture sector remains robust, the market is dramatically changing. Global food prices are increasing, with the rising demand of feeding the world's 7 billion people, and 3 billion new entrants into the consuming class since 1990.^{xlix} To preserve and advance the cluster, the Midwest must change with it. As noted by a recent report by RW Ventures and Illinois Manufacturing Excellence Center, while Chicago's workers in the food industry continue to be more productive than the national average – in 2010 Chicago's worker productivity in the food industry was 13 percent higher than the national average – the gap is shrinking.¹

With the Midwest's abundant potable water and fertile soil, there is little danger that the Midwest's agriculture sector could be threatened by another region of the United States. It is the vertically integrated agriculture and food cluster that hangs in the balance. Put plainly: leadership in agriculture and food production will determine if the Midwest food cluster survives. With massive layoffs at Chicagoland manufacturing facilities of Kraft Heinz and Mondelez in 2015 – part of what the Chicago Tribune's Greg Trotter called "the Summer of the Pink Slip" – it has become clear that proximity to food processing inputs will not guarantee that food production will remain in the Midwest.^{li}

Many of the agriculture technologies allowing for smart, sensor-enabled farming are being designed on the coasts. In the agriculture technology space, early stage companies from coastal markets have come to the Midwest region to pillage.

The regional mission with respect to agriculture is this: to build a Midwest Innovation Corridor where the agricultural and food production process is vertically integrated, with food products manufactured in the Midwest from the soil to the end product, production inputs are efficiently harvested using smart farming technologies, and smart farming technologies are being designed in Midwest laboratories and commercialized by Midwest startups. Absent such a Midwest Innovation Corridor, outside actors can simply come in and use our natural resources to create value for themselves.

The Midwest's agriculture and food production cluster needs to become smarter. Agriculture technology is characterized by precise farming driven by sensor-enabled data, providing real-time awareness of soil fertility and external threats. Maximizing a farm's yield now involves massive data files and potentially thousands of sensors, measuring soil fertility and moisture, tying real-time data to a farmer's mobile device.^{lii} It also potentially involves supercomputers – like Argonne's MIRA – to simulate environments to predict crop yields. Researchers at the University of Illinois' Applied Research Institute have designed software that employs several decades of data – daily, sometimes hourly observations of temperature, rainfall, humidity, soil radiation measurements – to understand weather patterns, and couples that data with soil data compiled by the U.S. Geological Survey, to keep farmers informed and minimize risk through their planting seasons.

The Midwest's agriculture and food production cluster also needs to become safer. As the Department of Homeland Security's 2013 National Infrastructure Protection Plan makes clear, our national food supply chain remains vulnerable to extreme weather, technical failure, pandemics, and physical and cyber attack. At each point in the food supply system – from the farms to processing plants to distribution stations to the grocery stores and to the restaurants – vulnerabilities exist.^{liii}

The threats posed by pandemics are dramatic and can spread quickly. In 1981 an outbreak of Foot and Mouth disease in France swept across the English Channel in three days.^{liv} And the stakes are high. When a single cow in Washington State was infected with Mad Cow disease in 2003, customers in Canada, Mexico, Japan and South Korea immediately suspended imports from American suppliers, incurring \$4.7 billion in losses.^{lv}

There is evidence that terrorist networks are at least aware of the potential human and economic impact of a successful attack on the U.S. agricultural sector. In 2002 U.S. troops in Afghanistan found Al Qaeda documents expressing interest in attacking American farms as a way of

disrupting the U.S. economy.^{lvi} Then-Secretary of Health and Human Services Tommy Thompson was quoted in 2004 that, “I for the life of me cannot understand why the terrorists have not ... attacked our food supply, because it is so easy to do.”^{lvii} National needs require a real-time awareness of biological threats to American livestock and crops, as well as a real-time awareness of the movement of goods.

Regional venture capital is available for startups in the agriculture sector. Jim Shultz, recalling his time as a managing partner for the Effingham, Illinois-based Open Prairie Ventures, said that “we couldn’t bring capital from the coasts until we started doing ag.” In October of 2015, S2G (Seed to Growth) Ventures announced they had raised a \$125 million venture fund to back food and agriculture businesses.^{lviii}³² If the venture capital is available in the Midwest in food and agriculture, are investment opportunities available? Of the eight investments made in early-stage companies announced on the S2G Ventures website, only one, the Michigan-based Midwestern BioAg, calls the Midwest home; the other seven companies are based on the coasts.

Market opportunity:

Any effort for the Midwest startup community to capitalize on the market opportunity presented by the food and agriculture sectors must begin by recognizing its growth potential, and weaving an interest in food and agriculture into the schools of entrepreneurship and the coworking spaces. It is inexplicable that S2G Ventures couldn’t find more than one investment opportunity in the Midwest. By all appearances, the Midwest startup community appears largely uninterested in food and agriculture.

With the region’s abundance of water and potable soil and the urgency of the market demand, as well as the research being done at Fermilab, the Midwest must reestablish its tradition of food and agricultural production. This could and should be driven by collaborative research and commercialization. The particle detector and accelerator designs emerging from Fermilab hold the potential to drive agricultural production at a time when the world needs to feed more people than we are able with current technologies.

Leadership should come from those with the ability to spark interest in the food and agriculture sector among the entrepreneurial community. The Polsky Center for Entrepreneurship and Innovation³³, a new facility that will soon be launched by the University of Chicago’s Booth School of Business, could be a great starting point for a Midwest food and agriculture technology cluster to re-emerge.

³² Chuck Templeton, founder of OpenTable, is one of the managing directors of S2G Ventures.

³³ The Polsky Center will be financed in part by a \$35 million donation from Michael Polsky, founder and CEO of Invenergy LLC, in May of 2016.

VII. CHALLENGES

What does success look like? Perhaps most critically, success looks like the bottom of the model provided on page 19: more federal investment in the Midwest. To a certain extent, more federal investment would signal that the Midwest is solving national problems, a core element of the Midwest Innovation Corridor.

Yet more federal investment into the region would be an end product of our own regional commitment to the research and entrepreneurial communities of the Midwest.

Success looks like a startup economy that is quantifiably able to add value in the commercial market to patents emerging from the strategic sectors that Invent2026 has identified. That would be demonstrated by more venture capital investment in the region, and an increased number of exits. Success could also be viewed as a larger number of dollars invested in R&D regionally, and expanded licensing from our laboratories to startup entrepreneurs.

Under this construct, calculating value would require a function of venture capital deal flow and acquisitions, as well as R&D investment, and licensing activity. In the coming years, Invent2026 will carefully monitor all three measures of value. To grow value, we have addressed the need to better transition technology, root our startup economy in our region's resources, invest in our people, and target national problems. However, there are two critical challenges of which solutions are elusive and perhaps outside the bounds of this document:

Risk averse and impatient capital management

Chris Olsen, partner at the Columbus, Ohio-based Drive Capital, a venture capital firm that has raised \$250 million fund to invest in Midwest-based startups, opined that the “raw ingredients for bold, ambitious new companies” in the Midwest are “more plentiful...than in Silicon Valley,” writing in an August 2016 op-ed for VentureBeat.^{lix}

Illinois dollars go in, few come back

According to data gathered by the Illinois National Guard, the State of Illinois receives 2.3 percent of Department of Defense expenditures, even as the state contributes 4.8 percent of all federal gross revenues. “When you look at the dollars we send to Washington, we’re ranked 50th out of 54 – I’m including the states and territories – in terms of what comes back versus what we put in,” Maj. Gen. Richard Hayes said. Just 0.8 percent of Illinois’ GDP is attributed to defense spending, according to research done by the Illinois Defense Industrial Adjustment (DIA) program, fourth lowest nationally.

California is the eighth largest economy in the world. The Midwest is the fifth. The Midwest is also bigger than Brazil, Russia, and India, each of which had recently caught many a venture capitalist's eye.

The Midwest receives 25 percent of all research dollars in America and graduates more computer science degrees than any other region or country on planet earth. There are gobs of tech exits at valuations just as large as other places, and yet, the Midwest receives just four percent of the annual venture dollars in America.

One of the goals of Invent2026 is to grow the number of venture capital deals originating from the Midwest, and involving Midwest-based startups. Logically, any solution to support increased venture capital deal flow would involve increasing the pool of regional venture capital. Of course it would. But the issue is much deeper and broader than simply the dearth of venture capital in the Midwest market. Capital managers in the Midwest seem to lack the willingness to embrace risk and the tactical patience needed to support a thriving startup economy.

By any measure the VC environment in the Midwest is improving, but there is still room to grow the venture market for entrepreneurs if the region is to sustain a competitive startup economy. Most observers would recognize the two go hand-in-hand. As noted in a May 2016 report from the Economic Innovation Institute: “The uneven geography of new business formation tracks very closely with that of access to capital – particularly venture and other forms of risk capital. Addressing the former challenge will surely involve tackling the latter. Without mitigating these disparities, the trend towards increasing concentration ... may even accelerate.”^{lx}

Data from the National Venture Capital Association illustrates that Chicago is a competitive, though not attractive, venture capital market. The San Francisco venture capital market in 2015 was far and away the most fertile in the United States, supporting 797 companies with more than \$21 billion in venture funding. The San Jose market, or Silicon Valley, registered the fourth-largest in 2015, supporting 321 companies with more than \$6.2 billion in venture financing.^{lxi}

Chicago ranked eleventh in venture financing in 2015, according to the National Venture Capital Association, supporting 81 companies with \$1.1 billion in venture funds. St. Louis and Minneapolis rank 18th and 19th in the NVCA venture financing rankings, though both markets are both about half the size of Chicago in measures of deal flow and volume of available venture capital.^{lxii}

Jim Schultz, himself a venture capitalist, noted the struggles for entrepreneurs in traversing the “Valley of Death,” or the dwindling pool of venture capital that entrepreneurs must compete for during the “B,” “C,” and “D” rounds of funding. Schultz recalled one fund that he managed that saw five of the

15 companies they had invested in flee the Midwest region once they reached later stages of funding. “They got caught in the ‘Valley of Death,’” Schultz said. “And it still exists, and it will continue to exist if we don’t have enough equity in the market to satisfy that early-stage sector.”

The State of Illinois is about to add to the market. In January of 2016, Illinois Treasurer Mike Frerichs announced that he would be exercising his authority, given to his office under a law first proposed by then-State Senator Barack Obama, to invest up to one percent the state’s treasury money in venture funds.^{lxiii} The capital, amounting to about \$220 million, will be spread out over multiple venture funds, with the requirements that at least a portion be invested in Illinois-based companies. All funding decisions are otherwise made by the fund managers, not the state.

The lack of available venture capital is a challenge that deserves the undivided attention of Midwest leaders of research and policymakers. With pent-up demand for capital that has built over many years of underinvestment in infrastructure, coupled the end of global central banks’ efforts to inject liquidity into the financial markets, interest rates for capital are certain to increase over the long term.^{lxiv} That will make starting a business without venture capital even harder.

“The underbelly that has held us back”

A frequent barroom conversation among Chicago-based entrepreneurs involves this all-consuming question: Why hasn’t Chicago built a startup economy like the one found in the Bay Area or Boston? Typical answers center on the lack of venture capital, or the lack of skilled engineers willing to root themselves in Chicago. Dr. Seth Snyder, leader of Argonne’s water technology research, noted that the region is quite unforgiving to entrepreneurs who fail in a venture. “You might be out of work for 18 months,” Snyder said of entrepreneurs in Chicago who have been forced to close entrepreneurial ventures.

John Dallas, the chief executive officer of Hillview Partners and mentor to many of Chicago’s most successful entrepreneurs, has a different, and extremely provocative answer: “The psychology of this city, the sociology of this region.” The solution, Dallas argues, begins with untethering the city’s people from a “dependency” on patriarchal structures.

Dallas’ challenge can strike any proud Chicagoan as an insult, yet seemingly no member of the Invent2026 task force took offense. Is Chicago, by nature, a city with a risk-averse workforce more interested in celebrating itself than in doing the glamourless work concomitant to successful entrepreneurship? Is the culture of Chicago one that truly encourages ambitious young people to strike out on their own?

Fred Hoch, CEO of the Illinois Technology Association, argues the patriarchal structure of Chicago flows from one source. “For a long time...if City Hall couldn’t give an imprimatur of support, it wasn’t really worth doing,” Hoch said.

Ultimately what may be at issue is the ability of the Midwest startup economy to embrace entrepreneurs who may not have the seniority, or be “somebody somebody sent,” typically required to get an audience with potential collaborators and investors. That’s a big problem if the region wants to build a competitive startup economy. Alec Ross, in his book “The Industries of the Future,” noted the correlation between regional growth in startup economies and prevailing social norms. “Venture capitalists in Silicon Valley won’t hesitate to invest in twentysomethings,” Ross writes. “Increasingly, if a young entrepreneur is not willing to wait until his forties to be taken seriously, he leaves and starts his company in a more youth-friendly culture like London, Berlin, or Silicon Valley.”

This question of culture harkens on Brad Feld’s Boulder Thesis and his insistence that that startup economies be led by a distributed network of entrepreneurs, not one flowing from one external source. A 2014 Kauffman Foundation report strongly endorsed Feld’s thesis by, in part, examining the social media accounts of entrepreneurs.

“Entrepreneurs follow local entrepreneurs,” the report found, noting that entrepreneurs most frequently follow the social media accounts of “other entrepreneurs, entrepreneurial programs, and individuals affiliated with local entrepreneurship support organizations,” and not those of local elected officials. The Kauffman Foundation report also noted that the most influential social media accounts in local entrepreneurial economies were often those of other entrepreneurs within that local market. “Entrepreneurship is a local phenomenon,” the report said.

It would then follow that to gain an audience and change the culture within the Midwest’s startup economy, one would not want to approach Chicago’s City Hall but instead weave through the startup community’s distributed network.

VIII. THE PLAN

Entrepreneurship is America's greatest export. International economies still emerging from government control look to the United States for a replicable model of entrepreneurship. Let's provide that model. Invent2026 will join applied researchers and entrepreneurs, rooted in the Midwest region, to form a coalition, activated to solve national problems. Invent2026 does not rely on building an central location; it relies only on a strong distributed network, and a resolute focus on growing a startup economy in the sectors outlined above.

Invent2026 will die on the vine without a call to action, and "buy in" from the organizations represented in our discussions. In other words, the Invent2026 leadership team is aware that white papers, like the one you are reading, often fail to lead to any meaningful action.

Here is the plan to ensure that doesn't happen:

Build a coalition to identify grant opportunities from both private foundations and the federal government: Speaking with one voice, the organizations that are joined together in Invent2026 – representing applied researchers and entrepreneurs – will make clear our intention compete for grant opportunities with broad collaborations. As Dr. Jeff Binder made clear, federal agencies need authorities they "trust to manage the money." By joining together respected principals in applied research and showing a broad base of support that extend into centers of entrepreneurship, Invent2026 will demonstrate regional capacities and reliability to funding authorities. This coalition will marshal entrepreneurs to join us under the construct proposed by Vasco Bridges: find the best entrepreneurs, identify a problem, and go solve it.

Evaluate university technology transfer offices, and where appropriate, make recommendations to streamline and expand technology transfer and form potential collaborations with interested entrepreneurs: Dr. Elizabeth McNally of Northwestern's Feinberg School of Medicine observed that less than one percent of applied research with commercial applications are supported by technology transfer offices. This is an issue of capacity and perhaps a misalignment of incentives. It is not an issue of will or competence. Let's work with universities to ensure that the economic potential of their intellectual property portfolios are maximized.

Generate a plan to allow private-sector manufacturers to leverage Rock Island Arsenal for prototyping of designs: We need to save Rock Island Arsenal from closing. There is no reason, with the manufacturing facilities at Rock Island Arsenal, that applied researchers should be looking around the

Midwest for places that can prototype their designs. Let's work with all of the organizations that have participated in this review to generate a plan to integrate Rock Island Arsenal into the "world's largest maker space."

Strengthen mentor networks within regional startup economy: Steve Fifita, who before leading incubation efforts at DMDII spent seven years at Stanford University, observed a dearth of mentor relationships being built within the Chicago startup community, and noted that he "still [has] people in San Francisco that I consider mentors today" two time zones away. Invent2026 will build a network of successful entrepreneurs in the region to make available a pool of mentors who are willing to provide guidance over a multi-year period.

Expand summer internships in Chicago for college students in STEM-related programs: "Students [at the University of Illinois at Urbana-Champaign] go [to the Bay Area] for internships, and I will tell you, the majority of people who spend time there and have a good time, they have a job offer by the end of their junior-year summer," observed Dr. Andreas Cangellaris, dean of the University of Illinois' College of Engineering. "It's very difficult to change their minds and keep them in the Midwest after that." Invent2026 will work with the region's top universities and most promising startups to pair business and engineering students with summer internship opportunities *in Chicago*.

Continue to generate thought leadership in growing and strengthening the Midwest Innovation Corridor, rooted in applied research, focused on solving national problems: This is the first of a biennial document that will assess our regional assets and strategic strengths. Like in this document, the leaders who have generously participated in the Invent2026 Asset and Strategic Review drafting process will continue to advocate for expanding R&D and applied research, pro-startup public policies, and cross-sector collaboration to solve national problems right here in the Midwest. We invite you to join us.

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