Kansas Science + Technology Plan

2021

Endorsement from the chief research officers of Kansas research universities

Innovations in science and technology are critical for Kansans to provide basic services for healthy and vibrant communities and to create economic stability and growth. Kansas has several challenges, including environmental (extreme weather events), social (changing demographics across the state), and technological disruptions (automation and declining markets for traditional sectors). Kansas can and will meet the future needs of our citizens by creating an educated workforce, supporting research and innovation, partnering with our industries to translate discoveries for economic growth, and leveraging our central location and natural resources for an interconnected, global economy.

This Statewide Science & Technology Plan highlights how research at our state universities provides a critical link between the Kansas Board of Regents and the Kansas Department of Commerce strategic plans. Collectively, these plans create a clear path of education, research and innovation, and economic growth. As the Chief Research Officers at the University of Kansas, Kansas State University, and Wichita State University, we endorse this plan, and we are committed to supporting research and innovation across our state toward a sustainable and prosperous future.

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Endorsement from the Kansas Board of Regents EPSCoR Committee

The Established Program to Stimulate Competitive Research (EPSCoR) program has become the centerpiece of the federal government's efforts to ensure that all states and regions benefit from its science and engineering (S&E) research and education activities. States that historically receive a disproportionately low percentage of federal research dollars are eligible to apply for EPSCoR funds so that taxpayers in these states do not subsidize the research efforts of states that historically receive a large share of those dollars. The program also aims to improve the ability of EPSCoR-designated jurisdictions to compete for federal and private-sector research and development (R&D) funding. The experience gained from competing successfully in a merit-review process enables many scientists to compete more effectively in the regular research programs of federal agencies.

The state of Kansas annually provides matching funds for the EPSCoR program as well as the Institutional Development Awards (IDeA) program from the National Institutes of Health (NIH). The Kansas Legislature has assigned oversight responsibility for the state's matching funds to the Kansas Board of Regents, which, in 2011, established the EPSCoR Program Review Committee. The committee is charged with reviewing these proposals in light of Kansas R&D priorities and recommending suitable projects to the Board for state matching funds.

We endorse this Science + Technology Plan and will work within our capacities to support the R&D activities described herein.

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Executive summary

This document serves as the Science and Technology Plan for the state of Kansas. It outlines the state's R&D priorities and will be used by the Kansas Board of Regents (KBOR) to review EPSCoR proposals for matching-fund requests and to make investments that will increase research competitiveness in strategic areas within Kansas. This plan aligns with other statewide strategic plans (KBOR's Building a Future and the Kansas Department of Commerce's Framework for Growth) aimed at increasing the impact of higher education on Kansas families, businesses, and the economy.

We have identified six broad areas of strength in which the research infrastructure is sufficiently developed that the state can immediately capitalize on the science and technology to transcend economic cycles. With respect to each area, we offer a snapshot as well as an overview of the state's investment, research infrastructure, and economic impact. Although these are existing areas of strength, Kansas must continue to invest in these areas, both to remain competitive and to translate ongoing research into new industries. For science and technology fields in which the state has an encouraging but shorter history, we outline key research-infrastructure investments. These investments are needed to build the research capacity that will enable Kansas researchers to be highly competitive for federal R&D funding and to inject the Kansas economy with emerging economic markets.

Areas of strength

1. One Health: Intersection of human, animal & environmental health
2. Aviation & transportation
3. Agriculture & bioscience
4. Advanced manufacturing & polymer science
5. Energy & environment
6. Security

Areas of opportunity

7. Smart infrastructure & resilience
8. Precision agriculture
9. Digital transformation & automation
10. Harnessing genomics

We identified two additional foundational areas that require infrastructure investment to build science and technology research capacity broadly across multiple fields.

Foundational infrastructure needs

1. Rural broadband and connectivity
2. Data literacy, data storage, and open data access to enable research

Our vision is to elevate, stimulate, grow, and translate science and technology research in Kansas to improve the quality of life and economic resilience of its citizens.

To achieve this vision, our plan provides a clear set of recommendations for each actionable vision-statement element. These recommendations provide a consistent framework to guide the efforts of state offices with contributing roles in science and technology, KBOR institutions, businesses, and researchers. By building functional links and networks across Kansas agencies and KBOR institutions, Kansas can excel in science, technology, engineering, and mathematics, bringing innovation and economic opportunity to the state.

Overarching recommendation
Establish a statewide Science, Technology & Economic Prosperity Council that connects research initiatives at KBOR institutions to state initiatives.

Elevate the role of science and technology in improving the lives of Kansans and their communities.

Recommendations
- Create better communication networks between scientists, engineers, academics, and the state's stakeholders.
- Create a network and a record of community-engaged research in Kansas that demonstrate how Kansas scholars have partnered with communities.
- Tell the stories of how research discoveries have impacted Kansas communities.
- Foster partnerships with rural and urban stakeholders through social science research to change the culture of science and technology mistrust that can pervade both types of communities.

Stimulate discovery and innovation through education, partnerships, and infrastructure investments that build on current areas of strength and nurture emerging areas of opportunity.

Recommendations

- Cultivate in-state talent, beginning with K-12. State metrics indicate that Kansas is losing talent early.
- Recruit and retain a diverse research workforce.
- Foster diverse and interdisciplinary research teams by providing opportunities to network across disciplines and research institutions.
- Create joint initiatives across KBOR institutions that leverage individual strengths and resources.
- Collect industry and KBOR needs for research infrastructure improvements and work collaboratively to pursue federal, state, and private funding to meet them.

Grow the economy by applying new technologies and expanding access to information technology, resulting in vibrant and diverse economic development that brings tangible benefits to the citizens of Kansas and attracts new business to the state.

Recommendations

- Promote education, research, and infrastructure as keys to economic growth.
- Leverage university expertise and foster cooperation between the Department of Commerce and universities to retain, expand, and recruit research faculty and companies.
- Support efforts to expand equitable access to broadband — a foundational need for science and technology applications.

Translate research results to address societal challenges by encouraging the fabrication of patentable technologies through support from entrepreneurial incentives and university-entrepreneur-stakeholder communication and knowledge-sharing networks that encourage better-informed partnerships and policies.

Recommendations

- Develop state policies that provide entrepreneurial incentives, including proof-of-concept funds and financial support for small businesses.
- Expand innovation and research parks at KBOR universities.
- Create a statewide entrepreneurial ecosystem.
- Educate faculty, staff, and students on translating basic research discoveries into commercial enterprises.

Expanding on our vision

Our vision is to elevate, stimulate, grow, and translate science and technology research in Kansas to improve the quality of life and economic resilience of its citizens.

The quality of Kansas's institutions of higher learning places it in a special position — the state's three research universities each have specific strengths that allow them to rise above their peers. Outstanding research in fields such as cybersecurity, radar, pharmacy, and medicinal chemistry has garnered the University of Kansas a National Cancer Institute designation, as well as recognition as a National Center of Academic Excellence in both cyber defense education and cyber research. Kansas State University provides the state's hub for agricultural research and animal health with its four U.S. Agency for International Development Feed the Future labs and its recent designation as the site for the National Bio and Agro-Defense Facility (NBAF). Wichita State University boasts a long history of aviation excellence and is home to the National Institution of Aviation Research and the National Center for Aviation Training.

Areas of strength at Kansas' regional universities and Washburn University provide additional substance and regional impacts to the state's science and technology enterprise. Emporia State University is lauded for K–12 programs that foster diversity in careers in science, technology, engineering, and math (STEM). Pittsburg State University has an internationally recognized Kansas Polymer Research Center that provides a hub for vegetable-oil–based polymer research. Fort Hays State University is noted for its innovative efforts to create international links, especially with China. Washburn University is noted for its School of Law. Haskell Indian Nations University is recognized as a national center for Indian education, research, and cultural preservation, offering degree programs in elementary teacher education, American Indian studies, business administration, and environmental science.

Solving society's most challenging problems will require interdisciplinary efforts, which can be encouraged and supported through actions that state offices, KBOR institutions, businesses, and researchers take together. By building true links and networks among all Board of Regents institutions, Kansas can excel in STEM and bring innovation and economic opportunity to the state.

Alignment with statewide higher education and economic development strategic plans

This document aims to update the Kansas: Building an Environment for Science & Technology (B.E.S.T.) for Innovation plan, originally written in 2012, to align its vision and goals with statewide initiatives to increase the impact of higher education and grow the Kansas economy.

This Kansas Science and Technology Plan has been informed by two statewide strategic plans that were developed in 2020 and 2021. KBOR is the governing board of the state's six universities and the coordinating board for the state's 32 public higher education institutions (six state universities, one municipal university, 19 community colleges, and six technical colleges). KBOR adopted a new strategic plan, Building a Future, in June 2020 after two years of stakeholder engagement of students, businesses, and higher education institutions across the state. Building a Future makes key changes and enhancements of the previous plan Foresight 2020, which was in place for a decade. The new plan includes focused metrics and promising practices that are designed to positively impact Kansas families and businesses and to improve economic prosperity. The inclusion of these practices and the emphasis on societal benefits makes the Regents' plan unique nationally.

The second statewide strategic plan was produced by the Kansas Department of Commerce. In the last decade, the Kansas economy has struggled. The last comprehensive economic development strategy, the Redwood-Krider report, was published in 1986. Governor Laura Kelly directed the Kansas Department of Commerce to create a new strategy using a public process. During 2020, more than 2,000 Kansans were engaged to help guide the direction of the Framework for Growth. This strategy has four pillars: Talent, Innovation, Community Assets, and Policy. The plan also describes economic clusters that are geographically proximate companies and institutions in a field, which are targeted growth areas to improve productivity, foster innovation, and facilitate commercialization of new ideas.

KBOR strategic plan, Building a Future (adopted June 2020)

KBOR's new strategic plan focuses efforts on how higher education offers Kansans the best opportunity to secure a prosperous future. The plan is organized around three pillars:

Pillar 1: Helping Kansas Families
Pillar 2: Supporting Kansas Businesses
Pillar 3: Advancing Economic Prosperity

Kansas higher education must be accessible to underrepresented student populations.

The strategic plan clearly links education, research, and economic development. "In addition to workforce training, the Kansas public higher education system supports businesses and entrepreneurs through innovation, research and partnerships that leverage the unique capabilities of the system to grow the state's economy."

Pillar 1 Helping Kansas Families focuses on **student access and success**. As Kansas becomes more diverse, public higher education must be accessible to underrepresented student populations. There are three key areas of enrollment gaps, which compare the overall demographics of Kansas to students enrolled at two- and four-year institutions:

- Hispanic students are underrepresented by 5.8 percentage points and

African American students by 4.0 percentage points.
- Pell-eligible students face enrollment gaps ranging from 5 to 9 percentage points.
- Rural students have enrollment gaps of 13.4 percentage points.
- Other minority demographics were not reported by KBOR.

As students complete their degree, the KBOR strategic plan aims to place graduates in successful careers with a sustaining wage, which is defined as greater than 250 percent of the federal poverty level. Building a Future will track the percentage of graduates and average wages by sector and will monitor equity gaps that exist in graduation rates between white, Hispanic, and African American students. Overall, practices and policies will be implemented to close equity gaps in both access and success.

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For *Pillar 2 Supporting Kansas Businesses,* the strategic plan emphasizes the role of universities and colleges in developing a **talent pipeline** that meets the demands of employers and the state's economy and provides **research and innovation capabilities for industry**. Under Foresight 2020, KBOR has partnered with the Kansas Legislature to address workforce needs, which resulted in three special initiatives: the Excel in Career Technical Education program, the University Engineering Initiative, and the Nursing Initiative. The Governor's Council on Education has also identified eight industries with a need for future workers that also provide a sustaining wage.

- The **Excel in Career Technical Education** (2012) provides state-financed college tuition for high school students in postsecondary education courses. In 2020, the 13,934 participating high school students took 109,226 credit hours and earned 1,631 postsecondary credentials. This was an increase of 3.5 times the baseline year.
- The **University Engineering Initiative** (2012) included an initial investment of $105 million by the Kansas Legislature over 10 years to ensure that three accredited engineering schools (K-State, KU, and Wichita State) increase engineering graduates to meet industry demand for new talent. The 2021 target goal was 1,365 annual undergraduate engineering degrees, and this goal was first surpassed in 2018. In 2020, these universities increased their bachelor's graduated to 1,698.
- The **Kansas Nursing Initiative** was developed to address the growing nursing shortage in the state. The initiative is an annual appropriation by the Kansas Legislature of $1.8 million to both public and private nursing programs.

To measure progress in Pillar 2, enrollment in these special initiatives will continue to be monitored. Each KBoR institution will also identify three to five programs that meet the needs for employers in their specific region, and enrollment in these programs will be monitored. The ultimate goal is to increase graduates in high-demand, sustaining-wage fields.

Target industries for talent pipeline

Advanced manufacturing
including aviation

Agriculture
including animal health

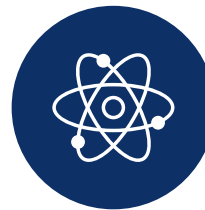**Architecture, construction, engineering**

Business and financial services

Computer science
including cybersecurity

Education

Energy

Health sciences

The ultimate goal is to increase graduates in high-demand, sustaining-wage fields.

The Building a Future plan also aims to support Kansas businesses by providing university expertise for innovation and research. The metric to track progress in this area is industry-sponsored research, which has become increasingly important in Kansas during the last decade. From 2014 to 2019, federal funding for research in Kansas at the three research institutions (K-State, KU, and Wichita State) increased by $37.2 million, while industry-sponsored research increased by $62.4 million. For Wichita State, industry-sponsored research accounted for 63.7% of sponsored research in 2019.

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For *Pillar 3 Advancing Economic Prosperity*, the role of public universities as **intentional partners in growing the Kansas economy** is a central focus.

Each public state university has developed programming to advance the economies of their communities and state, which are unique to the economic development capacity of each institution. Building a Future will measure the impact of these plans for at least two metrics: family sustaining jobs created and capital investment generated.

The Pillar also seeks to measure the monetary benefits of higher education for individuals and society. The Lumina Foundation has reported that 60 to 70% of graduates with associate or bachelor's degrees report excellent or very good health, which is 10 to 20% more than those with only a high school diploma. In addition, individuals with associate degrees or higher are more likely to volunteer and participate in community organizations.

The university core strengths for economic development were identified in the following eight areas. As of 2021, each university has formed a working group to develop five- and ten-year goals for this pillar.

University core strengths for economic development
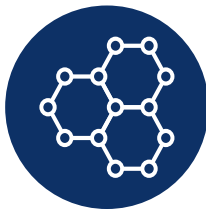
Aviation + advanced manufacturing

Biosecurity

Cybersecurity

Food + ag systems

Medical research

Polymers + advanced materials

Rural health

Small business development

Kansas Department of Commerce Framework for Growth (adopted February 2021)

The Framework for Growth identifies five tradable target sectors that the state should play a more active role in supporting and promoting:

1. Advanced manufacturing
2. Aerospace
3. Distribution, logistics + transportation
4. Food + agriculture
5. Professional + technical services

These clusters were prioritized based on the future growth projections, level of specialization (or comparative advantage) Kansas has in the sector, and the potential impact on the aspiration across employment growth, wage growth, and impacts on lagging regions.

The strategic plan outlines four pillars to provide the framework for growth: Talent, Innovation, Community assets, and Policy. The plan highlights the role of Kansas' public-school systems and higher education institutions in

supporting this framework. "Specifically, our Kansas Board of Regents schools will be critical in driving job growth and capital investment in Kansas through cutting-edge research and

Kansas Board of Regents schools will be critical in driving job growth and capital investment in Kansas through cutting-edge research and talent development.

talent development." The plan lists objectives and outcomes for each pillar, and several align with the KBOR strategic plan:

- **Talent:** Bridge the skills gap for in-demand and high-wage occupations in target sectors.

- **Innovation:** Foster a vibrant innovation ecosystem within and across economic regions; improve commercialization outcomes that drive innovation and job creation; support research and development of disruptive technologies that define future growth prospects; establish "front doors" at each state university to create easy access points for partnerships with the private sector to encourage new business and product development.

- **Community assets:** Empower our regions to develop the infrastructure that will help "future proof" their economies.

- **Policy:** Support the attractiveness of our innovation ecosystem by ensuring that incentives for innovation are constantly evaluated and updated, including updates to incentives for research and development activity.

Science + technology profile for Kansas

The National Center for Science & Engineering Statistics (NCSES) of the National Science Foundation releases periodic updates to its Science & Engineering State Profiles. Several key metrics from this data source, combined with metrics for STEM education from the National Science Board, the U.S. Department of Education, and Advanced Placement (AP) testing data, are discussed below.

Kansas ranks 50th in percentage of students taking high school AP courses and 40th in the number of STEM bachelor of science degrees. However, its rank improves to 31st at the graduate level for the number of science, engineering, and health (SEH) students. Kansas ranks 31st for individuals in the STEM workforce and 21st for the percentage of high-tech businesses. Indeed, Kansas businesses rank 20th in terms of the percent of business output devoted to R&D. Despite these metrics — which indicate significant capacity for research, innovation, and economic growth — Kansas ranks 49th in federal R&D as a share of state gross domestic product (GDP) and 42nd in federal obligations for science and engineering R&D.

A significant performance gap exists between Kansas's K-12 and undergraduate science and engineering metrics and graduate, research, and workforce metrics. Heightened focus and investment to increase STEM undergraduates will grow the talent pipeline for Kansas businesses. Furthermore, additional EPSCoR and IDeA research funding would help Kansas close the gap in federal R&D as a share of GDP.

Kansas STEM education + workforce	Value	Rank / 50 states
Population, 2019[1]	2,913,000	36
Civilian labor force, 2020[1]	1,497,000	33
8th grade math score, 2019 (% of students at or above proficiency)[2]	33%	26
Student taking AP courses in high school[3]	14%	50
STEM BS degrees, per 1,000 individuals[4]	21	40
SEH* graduate students in institutions granting research-based graduate degrees, 2019[1]	5,395	31
SEH doctorate recipients, 2019[1]	409	30
SEH postdoctoral appointees in institutions granting research-based graduate degrees, 2019[1]	300	32
Individuals in STEM workforce (% of workforce)[5]	4.26%	31
Employed SEH doctorate holders, 2017[1]	5,300	33

Kansas research + development	Value	Rank / 50 states
Total R+D performance, 2017[1]	$2,819,000,000	30
Federal obligations for science and engineering R+D, all agencies, 2018[1]	$232,807,000	42
Federal R+D (as % of GDP)[6]	0.13%	49
State government R+D expenditures, 2019[1]	$12,355,000	33
State R&D (per $1M of GDP) [6]	$71.36	30
Business R+D (as % of business output) [6]	1.77%	20

Kansas innovation	Value	Rank / 50 states
SBIR awards, 2019[1]	17	36
Utility patents issued to state residents, 2019[1]	788	31
High-tech business (as % of all businesses)[7]	8.65%	21

*SEH = science, engineering and health

Data citations

1. National Science Foundation Science & Engineering State Profiles, https://www.nsf.gov/statistics/states/.

2. Elementary School Testing Data: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2019 Mathematics Assessment.

3. AP test data: National report from https://research.collegeboard.org/programs/ap/data/participation/ap-2020

4. STEM Degrees: National Science Board. Science and Engineering Indicators: State Indicators. Alexandria, VA: National Science Foundation. https://ncses.nsf.gov/indicators/states/indicator/se-associates-degrees-per-1000-18-24-year-olds. Accessed June 18 2021

5. Workers in Stem Occupations: National Science Board. "Individuals in Science and Engineering Occupations as a Percentage of All Occupations." Science and Engineering Indicators: State Indicators. Alexandria, VA: National Science Foundation. https://ncses.nsf.gov/indicators/states/indicator/se-occupations-to-all-occupations. Accessed on June 18 2021.

6. R&D Data by State: National Science Board. Science and Engineering Indicators: State Indicators. Alexandria, VA: National Science Foundation. https://ncses.nsf.gov/indicators/states/indicator/rd-performance-to-stateGDP. Accessed on June 18, 2021.

7. High-Tech Establishments: National Science Board. Science and Engineering Indicators: State Indicators. Alexandria, VA: National Science Foundation. https://ncses.nsf.gov/indicators/states/indicator/high-set-to-all-business-establishments. Accessed on June 18, 2021.

Research funding

KBOR's Building a Future strategic plan tracks how much of the research enterprise is supported by federal funding and how much is sponsored

Kansas universities are well positioned to continue expanding research activities.

by industry partners. The KBOR and Kansas Department of Commerce plans both rely on industry-sponsored research as key metrics for economic development, and a key goal of the federal EPSCoR programs is to increase federal R&D funding per capita.

Total R&D funding for the research universities in Kansas is reported each year in the Higher Education Research and Development (HERD) survey. From 2014 to 2019, federal R&D funding in Kansas increased by $37.2 million, and industrial R&D funding increased by $62.4 million. **Increases in R&D expenditures reflect the emphasis on innovation at KBOR universities and the increased research capacity established over the last decade.** Kansas universities are well positioned to continue expanding research activities.

2014

Institution	Federal R+D	Business R+D	Total R+D
University of Kansas	$165,442,000	$12,704,000	$301,534,000
Kansas State University	$67,438,000	$5,058,000	$184,945,000
Wichita State University	$10,424,000	$30,942,000	$58,859,000
All research universities	**$243,304,000**	**$48,704,000**	**$545,338,000**

2019

Institution	Federal R+D	Business R+D	Total R+D
University of Kansas	$169,694,000	$22,073,000	$352,643,000
Kansas State University	$81,269,000	$7,099,000	$218,622,000
Wichita State University	$29,634,000	$82,008,000	$128,795,000
All research universities	**$280,597,000**	**$111,180,000**	**$700,060,000**

It is important to celebrate the success of R&D expansion overall. However, the NCSES S&E state profile shows that Kansas's federal R&D lags behind state and business R&D (page 15). Kansas currently ranks 49th in federal R&D as a percentage of GDP. In this plan, we provide strategies to increase federal R&D in Kansas.

Kansas innovation profile

The Economic and Prosperity Pillar of KBOR's Building a Future strategic plan focuses on job creation and bringing capital/investment to Kansas. The KBOR universities have developed programs, often leveraging federal dollars, that provide entrepreneurial infrastructure support to assist faculty and researchers in translating their science- and technology-development efforts into products for the marketplace.

Developing entrepreneurs (people)

Entrepreneurship begins with people. Researchers are trained to conduct research and disseminate knowledge. Faculty and staff must be given the tools to also translate their discoveries into patents and startup companies. Students must be educated early in their academic careers to think about innovation and how an entrepreneurial spirit would allow them to pursue a startup or further their professional careers. Kansas universities are investing in this training.

K-State's Biosecurity Research Institute is the home of comprehensive infectious disease research to address threats to agriculture and public health.

Kansas State University

K-State Innovation Partners is committed to collaborating with universities, industries, and communities to deliver a streamlined mission of corporate engagement, technology commercialization, and economic development under one roof. Driven by innovation, this structure serves K-State, community partners, and industry in one comprehensive unit. K-State and the Manhattan community share a special relationship that has been nationally recognized for its highly collaborative partnership to advance the region's economic development. Knowledge-Based Economic Development (KBED) is a partnership between K-State and community entities designed to leverage the university's assets to attract, retain, and grow knowledge-based businesses in the region.

Left: Frontiers: KU Clinical & Translational Science Institute at the University of Kansas Medical Center.
Right: College of Innovation & Design at Wichita State University.

University of Kansas

KU's NIH-funded accelerator program, the Sustainable Heartland Accelerator Regional Partnership Hub (SHARPhub) provides education, networking, and mentoring opportunities to entrepreneurs across a five-state central region (Kansas, Oklahoma, Nebraska, North and South Dakota). In addition, the KU Medical Center is home to the Frontiers: KU Clinical & Translational Science Institute, which seeks improvements in healthcare and public health, stimulates new ideas, and supports the researchers of today and tomorrow. Supported by a five-year, $25 million grant from the National Center for Advancing Translational Sciences of the National Institutes of Health, Frontiers is part of the Clinical and Translational Science Awards Program, a national network of medical research institutions that work together to speed the research process from scientific discovery to patient care.

In addition to training faculty and researchers, the School of Business and the Institute for Policy & Social Research jointly lead the U.S. Economic Development Association-funded KU University Center that emphasizes entrepreneurship and provides a broad array of student-focused educational programming and business-support opportunities. In addition to these entrepreneurial, education-based programs, KU actively pursues industry partnerships to enhance research collaborations that solve industry problems, supporting and often accelerating industry growth.

Wichita State University

WSU is home to an NSF I-Corps Site and supports entrepreneurs across the state as they develop their business ideas to solve problems, support customers, and target market needs. In addition, WSU recently launched the College of Innovation and Design (CID), which provides students the requisite skills to create, develop, launch and repeat, either for their own ideas or for applying innovation skills within an existing organization.

Providing innovation space + support (infrastructure)

Novel research conducted in university settings is often licensed to companies, which may be startups or established companies. Universities can support commercialization and industrial R&D by providing incubator space and business support for researchers and entrepreneurs. Through local innovation parks, businesses are launched, and high-tech companies are recruited to communities to access the talent and resources unique to these technological and entrepreneurial ecosystems. Our universities have invested in this infrastructure.

Kansas State University

The K-State campus has Biological Safety Level 3 (BSL-3) agriculture laboratories, as well as NBAF, the National Bio and Agro-Defense Facility, a BSL-4 facility, directly adjacent to campus. These and other unique facilities at K-State create an environment focused on delivering innovations to improve global health, trade, and security through partnerships between academic units and industry.

K-State aggressively leverages its global preeminence to advance the university's land-grant mission and create novel pipelines of new direct jobs and direct investments coming into the state. The University has unparalleled expertise and facilities to address biotechnology, health security, and supply-chain challenges, as well as capabilities that can help entrepreneurs develop and launch diverse businesses.

The Edge Collaboration District, located along the north campus corridor, is a partnership between K-State and the Kansas State University Foundation to inspire industry collaboration. The Edge is where

Pat Roberts Hall houses the $54 million Biosecurity Research Institute, which helps to ensure a safe food supply and prevent major economic losses to the agriculture and food industries.

industry, research and talent come together to advance innovations that impact the economies of the region and the state. The Edge integrates cutting-edge research and talent, and its proximity to NBAF promotes development of partnerships that can leverage university, district, and NBAF resources. The Edge currently hosts more than 10 partners that are taking advantage of the research and talent collaborations.
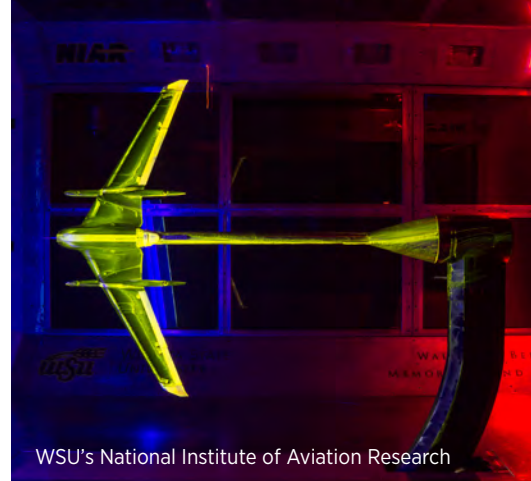
Pittsburg State University

KU Innovation Park

WSU's National Institute of Aviation Research

Pittsburgh State University

PSU's University Strategic Initiative (USI) unit is home to Enterprise PSU (formerly the Center for Innovation & Business Development) and the Kansas Polymer Research Center, which is internationally recognized for its chemistry and material-science work. In addition, the USI also hosts the Block 22 project, located in downtown Pittsburg, which provides business incubation, co-working space, student housing and event/education space. The USI's goal is to create a live-work-play environment that brings together university resources to assist external partners in the region.

University of Kansas

The KU Innovation Park (formerly known as the Bioscience & Technology Business Center, or BTBC) presents an unparalleled and transformative economic-development opportunity for Lawrence, Douglas County, and the state of Kansas. The park builds on more than 10 years of BTBC success and, at its core, will be a dense concentration of innovation-related buildings, infrastructure, services, and programming designed to support a broad mix of startup companies, private industry firms, government agencies, and KU research activity. The park, supported and strengthened by complementary mixed-use developments and amenities within and surrounding it, will attract and anchor innovative firms and highly skilled workers, diversifying and broadening the regional economic profile. More broadly, the KU Innovation Park is the embodiment of an entire community committed to innovation and economic development and represents a long-term strategic investment in its sustainability, resilience, and future growth. The park has supported more than 55 companies and state/federal agencies during the past 10 years. It has more than 40 current tenants and has created more than 400 jobs.

Wichita State University

WSU's Innovation Campus brings together research facilities, makerspaces, research centers, and students to support accelerating innovation to the marketplace. Home to nearly a dozen companies, the Innovation Campus also creates a rich research and learning environment with easy access to the National Institute of Aviation Research. NIAR provides tools and resources to validate and certify aviation designs. NIAR's test-lab facilities assist with design validation for materials, components, systems, and full airframes.

Recent investments in research capacity

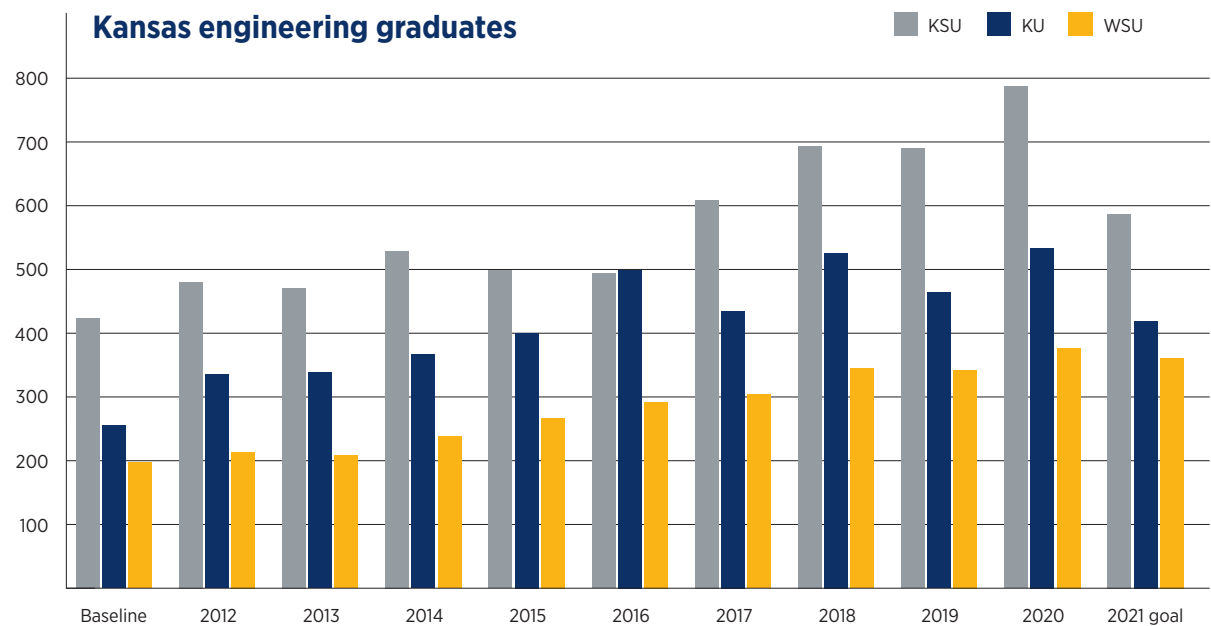*Kansas University Engineering Initiative*
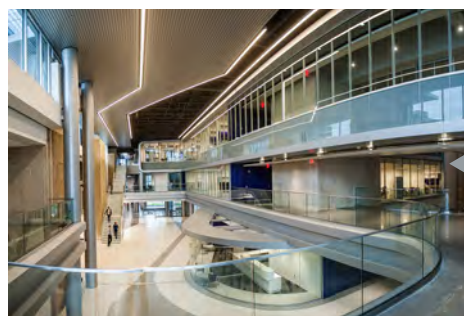
$105M
initial 10-year
investment in 2012

1,365
initial annual goal for
undergraduate degrees

1,698
revised goal after passing
original target in 2018

Kansas engineering graduates

Legend: KSU, KU, WSU

Year	KSU	KU	WSU
Baseline	425	255	200
2012	480	335	215
2013	470	340	210
2014	530	365	240
2015	500	400	265
2016	495	500	290
2017	610	435	305
2018	695	525	345
2019	690	465	340
2020	790	535	375
2021 goal	585	420	360

University engineering facilities

WSU
John Bardo Center
143K sq. ft.
2017

KSU
Engineering Hall
108K sq. ft.
2016

KU
LEEP2
110K sq. ft.
2015

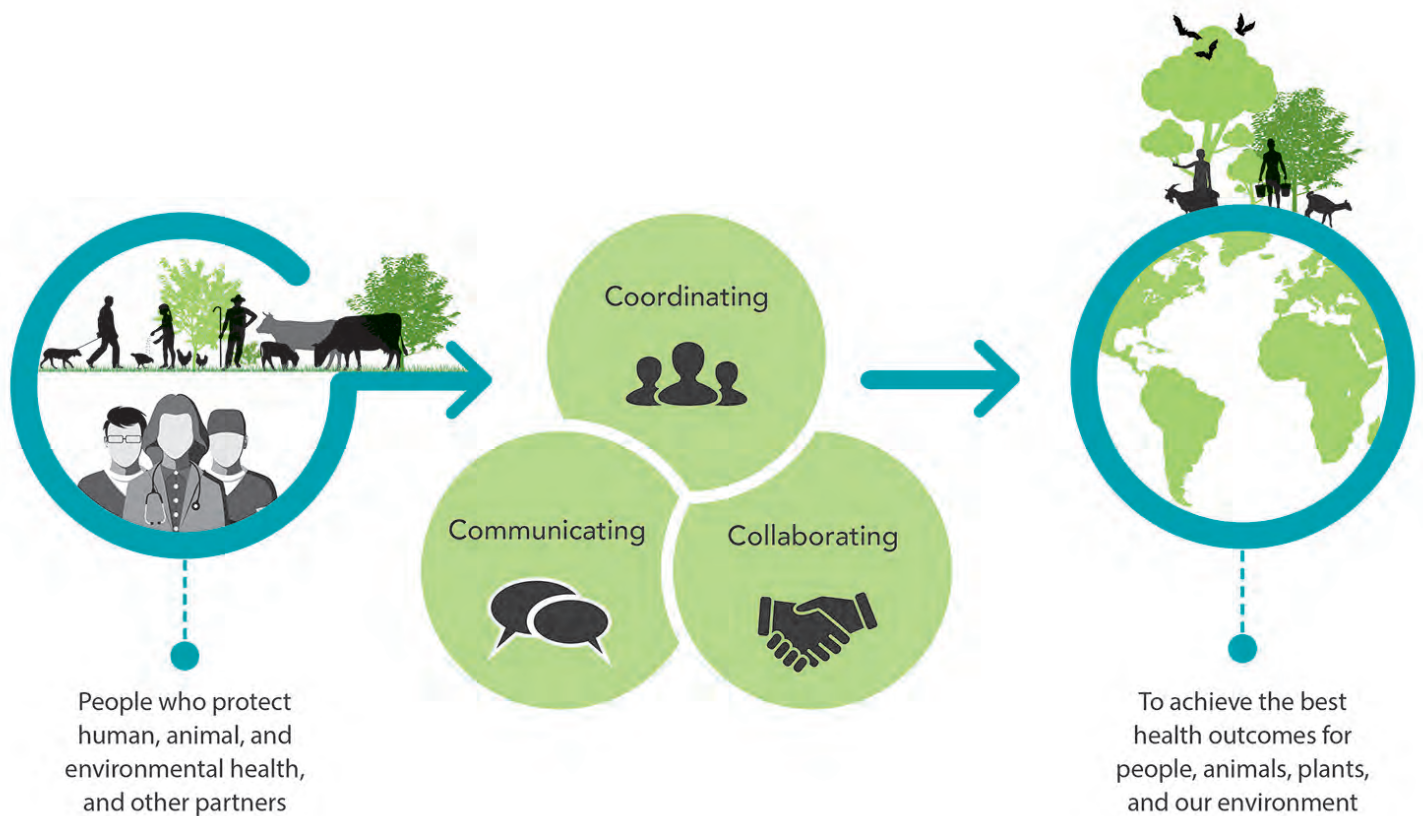# Areas of strength + established research infrastructure

Kansas's many areas of established research capacity and strengths provide a firm foundation for future science and technology development and innovation. In this section, we offer snapshots of the areas in which the state has a history of scientific expertise and infrastructure. This plan provides an overview of the state's investment, research infrastructure, and economic impact in each area and recommends how to sustainably build upon those inherent strengths to transcend economic cycles.

1. One Health: Intersection of human, animal + environmental health
2. Aviation + transportation
3. Agriculture + bioscience
4. Advanced manufacturing + polymer science
5. Energy + environment
6. Security

One Health:
Intersection of human, animal + environmental health

The One Health concept maintains that human health is closely connected to animal health and our shared environment. This concept has driven significant human healthcare innovations, underscoring the importance of understanding the intersection of human, environmental, and animal health. These innovations enhance workforce productivity and can provide the basis for research centers that draw federal recognition and funding as well as companies that enhance the state's economic base. In addition, healthcare industries understand and build off of the Kansas City area's animal-health corridor, which includes the National Bio and Agro-Defense Facility being built in Manhattan, Kansas. Food-animal and food-crop health are also critical for Kansas's agricultural economic well-being and, indeed, the nation's.

People who protect human, animal, and environmental health, and other partners

Coordinating

Communicating

Collaborating

To achieve the best health outcomes for people, animals, plants, and our environment

Source: Centers for Disease Control & Prevention

State + regional resources

- EPA Region 7 Headquarters in Kansas City
- USDA Economic Research Service Federal Headquarters in Kansas City
- U.S. Department of Homeland Security NBAF under construction in Manhattan
- Kansas Nursing Initiative (Kansas Legislature annual investment of $1.8 million to both public and private nursing programs)

Major research infrastructure

- KU Medical Center has 25 research institutes and centers and three campuses (Kansas City, Salina, and Wichita)
- KU's Cancer Center received National Cancer Institute Designation from the NIH.
- U.S. Department of Homeland Security Center for Emerging & Zoonotic Animal Diseases, launched in 2004, is a nationwide consortium of more than 29 university, government, and industry partners led by K-State
- Eight NIH-funded Centers of Biomedical Research Excellence (COBREs)
- Life Span Institute (KU) has served Kansas families and communities for 60 years

State economic impact

It is imperative that Kansas continues these successes, expands its medical research capabilities, and attracts more health-oriented businesses, all of which have positive impacts on economic growth and the health and prosperity of Kansans. Private companies and university startups have been created or have expanded near the research universities.

It is imperative that Kansas continues these successes, expands its medical research capabilities, and attracts more health-oriented businesses.

Aviation + transportation

America's transportation infrastructure is both a critical resource and a source of concern. A low population and large distances between population centers have made Kansas a preferred testing ground for transportation innovations, particularly in aviation. Kansas has been a leader in aerospace engineering and manufacturing for decades. Cessna, Beech, and Boeing have maintained production lines in the state since the 1940s and '50s. More recently, Kansas researchers have led efforts to design and use unmanned aerial systems (UAS). UAS-related research advances the understanding of structure-sensor interactions, investigates the effects of materials and environments on performance, and ultimately develops low-speed, low-altitude, and lightweight vehicles with increased autonomy. UAS expertise has become a critical tool for environmental-sensing and security radar applications.

Kansas researchers also focus on ground transportation and have maintained long-term research partnerships with the state and regional Departments of Transportation (DOT). These relationships have advanced physical infrastructure, driver and worker safety, and mobility of rural Kansans. The evolution and deployment of connected and autonomous vehicles (CAV) and the infrastructure to support these vehicles will transform the safety, economic, and personal-mobility opportunities that Kansas residents, businesses, and visitors experience. Kansas researchers will play a critical role in developing autonomous vehicles and the infrastructure to support them, including the requisite data and information-technology networks.

Top: Unique to the region, the KU's anechoic chamber supports R&D of remote-sensing technologies while also serving as a teaching laboratory. Bottom: Linda Harl, an aerospace engineering student at Wichita State University, manages the Aerospace Projects and Prototyping Lab in John Bardo Center, paid by the NASA in Kansas Jump Start program.

State + regional resources
- Wichita is an aircraft manufacturing hub
- Federal Aviation Administration Central Region office in Kansas City
- KDOT's FAA Drone Integration Pilot Program, one of 10 regional efforts conducting advanced UAS operations to yield sufficient data for rule-making that will result in access to new technologies for the nation
- KU, K-State, and WSU are three core partners in the FAA Center of Excellence for UAS Research, ASSURE (Alliance for System Safety of UAS through Research Excellence)
- KU is a member of the Midwest Transportation Center, one of 10 regional U.S. DOT regional centers

Major research infrastructure + programs
- National Institute for Aviation Research (NIAR) at WSU. NIAR is the largest university aviation R&D institution in the United States
- National Aeronautics & Space Administration (NASA) Space Grant Consortium (WSU)
- NASA Established Program to Stimulate Competitive Research (WSU)
- Transportation Centers (KU, K-State)
- Garrison Flight Research Laboratory (KU) provides resources for developing intelligent vehicle systems for the flight research of both piloted and unmanned air vehicles
- Infrastructure Research Institute (KU) performs research and develops methods, structures, and products to enhance infrastructure needs
- Applied Aviation Research Center (K-State)
- Center for Remote Sensing of Ice Sheets (CReSIS), an NSF-funded Science & Technology Center founded in 2005 at KU
- KU Electromagnetic Anechoic Chamber. Unique to the region, the CReSIS Anechoic Chamber supports R&D of remote-sensing technologies while also serving as a teaching laboratory. The anechoic chamber is available for external hire and provides a unique infrastructure for regional industry partners

Economic impact to the state

Further development of this research capacity will be critical for keeping Kansas aligned with the aerospace industry, specifically with shifts in the aerospace value chain, including guided missiles, space vehicles, aircraft engine parts, and UAS. In addition, many of the technologies explored at Kansas institutions apply to other fields, including the biomedical, wind energy, automotive, marine, space, and rail sectors. Supporting research around these technologies will help diversify the state's manufacturing capabilities and make Kansas's manufacturing sector more robust.

Agriculture + bioscience

From the moment food security became a matter of national concern, Kansas has been one of the nation's great resources, for both agricultural production and innovation. As agricultural research evolves into the realm of biotechnology, Kansas remains at the center of guaranteeing the health of America's food supply and the economic health of its produce and livestock providers.

Kansas's food and agriculture systems will align with the changing values and needs of consumers and other food and agriculture system stakeholders.

University researchers have developed strategies that will result in transformed, sustainable, and adaptable food and agriculture systems to create Kansas jobs and attract direct capital investment into the state. These strategies will result in innovations such as nontraditional grain (e.g., durum) and water-conserving crop (e.g. cotton, sorghum) solutions that stimulate value-added opportunities critical to economic development in Kansas. Kansas's food and agriculture systems will align with the changing values and needs of consumers and other food and agriculture system stakeholders.

State + regional resources
- USDA Federal Headquarters in Kansas City
- The Land Institute, a not-for-profit research institute in Salina working to develop sustainable food production methods

Major research infrastructure + programs
- Wheat Genetics Industry/University Cooperative Research Center (K-State)
- Four Feed the Future Innovation Labs (K-State)
- Global Food Systems Initiative (K-State)
- K-State Research & Extension network, with offices in all 105 Kansas counties
- Konza Prairie Biological Station (K-State)
- Kansas Biological Survey (KU)
- KU Field Station

Economic impact to the state
Agriculture is the leading economic engine in Kansas, directly driving 42% of the Kansas economy. Food processing and manufacturing, pet food and allied industries, and other value-added areas are growth areas for the state beyond the traditional sectors.

Researchers monitor test plots at the KU Field Station, a division of the Kansas Biological Survey at the University of Kansas. The Field Station's mission is to foster scholarly research, environmental education and science-based stewardship of natural resources.

Advanced manufacturing + polymer science

Development of advanced materials, including biomaterials and nanomaterials, is a critical building block of engineering applications in a variety of fields, from aerospace to bioscience. Our S&T plan builds upon existing strengths in materials development at Kansas universities. Several research centers are devoted to biobased polymer development, to replace petroleum-based materials, composite manufacturing and repair is critical for aviation technology.

Researchers at the Kansas Polymer Research Center at Pittsburg State University promote economic interests by delivering advanced technology and unique technical services in chemistry and material science with a specialization in polymer research.

Advanced manufacturing technology is rapidly changing with advances in 3D printing and digital manufacturing that use big data, cloud technology, advanced analytics, advanced robotics, and other digital tools. The Kansas Framework for Growth targets advanced manufacturing as a high-growth area in which Kansas is well-positioned to compete, but it acknowledges that workers will need suitable education to support these digital-manufacturing and automation endeavors.

Major research infrastructure + programs
- Center for Biobased Polymers by Design (K-State)
- Kansas Polymer Research Center (Pittsburg State)
- Technology Development Institute (K-State)
- National Center for Advanced Materials Performance at National Institute for Aviation Research (NIAR, WSU)
- WSU Smart Factory
- Supply Chain Management Graduate Program (KU)

Economic impact to the state
Wichita ranks #1 in manufacturing jobs as a percentage of all jobs for the 100 largest US metro areas. Kansas can leverage its universities' materials-science and advanced-manufacturing strengths to develop a diverse portfolio of materials development centers and to educate future workers for digital manufacturing applications.

Energy + environment

Two of the world's most challenging problems are the accelerating impacts of global climate change and the pressing need for clean water and energy to support the world's growing population. These challenges are closely interwoven in terms of cause and effect. Understanding these phenomena and their consequences is critical to managing natural resources, growing economies, enhancing human health, and improving quality of life. Solutions to these challenges can be obtained only by concerted, comprehensive research efforts to understand and address the looming issues of changes in climate and the need for sustainable food, energy, and water sources.

Kansas has historic strengths in studying the state's ecology and natural resources. This focus on understanding grassland ecology led to the establishment in the 1970s of the Konza Prairie Biological Station, an 8,000-acre outdoor living laboratory funded in part by the National Science Foundation's Long Term Ecological Research (LTER) program. The state also houses the Kansas Applied Remote Sensing (KARS) program at the University of Kansas, which, with a commercial partner, conducts research on environmental and agricultural remote-sensing technology applications. KU is also the lead institution of the Center for Remote Sensing of Ice Sheets (CReSIS), a

Science and Technology Center established in 2005 by funding from the National Science Foundation to develop new technologies and computer models to measure and predict the response of sea-level change to the mass balance of ice sheets in Greenland and Antarctica. KU also houses both the Kansas Geo-
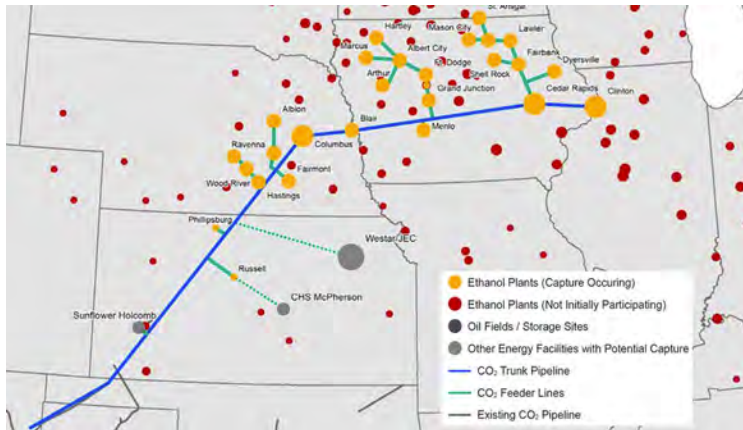
A scenario showing placement of potential pipelines used to transport CO2 from ethanol plants to enhanced oil recovery projects (gray dots). Initially, ethanol production capacities range from 40 to 350 million gallons per year (small to large orange and red dots). Source: State CO2-EOR Deployment Work Group. Data from DOE, Great Plains Institute and KGS

logical Survey and the Kansas Biological Survey, which provide open-access data for Kansas, including critical water-resource data, including the groundwater levels in 1,400+ High Plains Aquifer wells.

Kansas researchers have always supported the energy sector with research programs such as the Tertiary Oil Recovery Program. Ongoing work aims to develop renewable energy and to mitigate the environmental impacts of energy production. The Kansas Geological Survey has been investigating the state's subsurface geology and industrial infrastructure to determine the safety and viability of injecting carbon dioxide (CO_2) from industrial sources, such as ethanol

plants located on the map, into underground rock formations for long-term storage and to recover hard-to-reach oil. Carbon capture, utilization and storage (CCUS) is a process being developed to reduce the amount of CO_2 released into the atmosphere. Over the past 10 years, the KGS has led or played a key role in five large-scale CCUS projects funded by the U.S. Department of Energy. Working with private partners, the KGS has successfully injected CO_2 for enhanced oil recovery in the Wellington Field in Sumner County south of Wichita and the Hall-Gurney Field in Russell County. Kansas researchers are participating in all five CCUS focus areas: policy and law, data management, data analysis, economics, and outreach.

In projects funded by the National Science Foundation Established Program to Stimulate Competitive Research (EPSCoR), Kansas researchers are addressing environmental and energy issues with a fresh, integrative perspective. KU has partnered with West Virginia University to recover and reuse saline produced with oil production. Ongoing research also seeks to understand microbial ecology in water, plants, and soils, expanding the ecological expertise of Kansas to include next-generation sequencing tools.

Several funded research projects have strong components of information infrastructure, diversity (including a partnership with Haskell Indian Nations University in Lawrence), workforce development, and collaboration with out-of-state and international research institutions, which are vital to success.

State + regional resources
- Precipitation gradient across Kansas enables ecological research across several biomes
- EPA Region 7 Headquarters in Kansas City
- U.S. Geological Survey office in Lawrence

Major research infrastructure + programs
- Konza Prairie Biological Station, an 8,000-acre outdoor living laboratory funded in part by the National Science Foundation's Long Term Ecological Research (LTER) program
- Kansas Applied Remote Sensing (KARS) program (KU)
- Biodiversity Institute & Natural History Museum (KU)
- Center for Remote Sensing of Ice Sheets (CReSIS), a Science and Technology Center established in 2005 with National Science Foundation funding (KU)
- Center for Environmentally Beneficial Catalysis (CEBC), established in 2003 with funding from the National Science Foundation (KU)
- Kansas Geological Survey (KU)
- Kansas Biological Survey (KU)
- KU Integrated Carbonate Consortia (KICC) is focused on fundamental and applied carbonate research with industry relevance (KU)
- Haskell Environmental Research Studies Institute (KU-Haskell)

Economic impact to the state
This S&T plan recognizes the value of a strategy that incorporates all the state's resources, from the "grassroots" agricultural level in evaluating climate change in Kansas, to opportunities for the more efficient use of biofuel crops, to new technologies that co-produce higher-value products with energy as a significant economic driver for renewable energy adoption.

This S&T plan recognizes the value of a strategy that incorporates all the state's resources.

Rendering of National Bio and Agro-Defense Facility under construction in Manhattan.
Courtesy of NBAF Design Partnership

Security

New security breaches make the news on an almost-daily basis. These breaches affect our lives and have the potential for significant financial impact on the economy. The KS Department of Commerce has identified five sectors of growth in the Framework for Growth, each of which require a secure, assured, and resilient environment to be successful. The KBoR institutions are well suited to advance these areas.

KU has been nationally recognized for over 60 years in the development of advanced radar technology. Over the past decade KU has broadened this area by developing sensor and cybersecurity expertise aimed at detecting and mitigating threats for both the defense and commercial sectors. KU is one of six universities nationwide to receive a National Security Agency (NSA) Science of Security Lablet award. This award builds on designation by the NSA and the Department of Homeland Security as a National Center of Academic Excellence in both Cyber Defense Education (CAE-CDE) and Cyber Research (CAE-R). KU is one of only 40 institutions in the United States to have this dual designation.

In 2010, K-State was designated an NSA and DHS Center of Academic Excellence in Cyber Research (CAE-R) institution. It is also home to the Center for Information & Systems Assurance. The center catalyzes communication and collaboration across colleges and departments and encourages and guides transdisciplinarity. As a result of these activities, a diverse collection of faculty from computer science, electrical engineering, sociology, physics, and agronomy have all made significant contributions to K-State's many cybersecurity success stories.

KU and K-State are both part of the NSF CyberCorps: Scholarship for Service program, which trains security professionals. The program aims to meet federal, state, and local agencies' cybersecurity needs.

State + regional resources
- Kansas Intelligence Fusion Center
- 177th Information Aggressor Squadron at McConnell Air Force Base
- U.S. Army's Combined Arms Center, Fort Leavenworth
- U.S. Department of Homeland Security National Bio and Agro-Defense Facility (NBAF) being constructed in Manhattan

Major research infrastructure + programs
- K-State Center for Information & Systems Assurance (NSA/DHS CAE-R designation, NSF CyberCorps: Scholarship for Service)
- KU Information & Telecommunications Technology Center - Information Assurance Center (NSA Science of Security Lablet, NSA/DHS CAE-CDE and CAE-R designation, NSF CyberCorps: Scholarship for Service, Kansas Applied Research Laboratory)
- KU DIA Intelligence Community Center of Academic Excellence (IC-CAE)
- K-State Biosecurity Research Institute
- WSU is a team member of UT Austin's NSF AI Institute for Foundations of Machine Learning

Economic impact to the state
Kansas can lead the region and nation in security by leveraging KBOR universities' strengths and through R&D to provide technical solutions that enable a robust, resilient, and assured cyber environment. This expertise will provide a highly trained workforce that supports statewide industries and also serves as an asset for recruiting high-technology business to the region.

Kansas can lead the region and nation in security by leveraging KBOR universities' strengths and through R&D to provide technical solutions that enable a robust, resilient, and assured cyber environment.

Areas to advance research competitiveness, resilience + economic prosperity

Science and technology innovations are changing the Kansas economic landscape. With new technologies threatening to disrupt or replace traditional job markets, there is a real need to ensure that all communities across the state, including rural areas, can capitalize on innovations and have access to economic prosperity. At the same time, Kansas communities are challenged by an increase in extreme weather events, aging infrastructure, and access to healthcare and education. The global COVID-19 pandemic, along with 24 federally declared disasters within Kansas in the last 14 years, have revealed the critical need for Kansas communities to build resilience to major disruptions.

To advance research competitiveness and provide access to all Kansas communities, this S&T innovation plan recommends that Kansas invest in infrastructure to build research capacity, with a specific focus on four interdisciplinary areas for science and technology growth in the near future.

Infrastructure to build research capacity

Rural broadband + connectivity
Kansas can leverage the KBOR university strengths in cybersecurity and provide further development in connectivity and network research. Network connectivity, including rural broadband, is a critical enabler of research and research-program development and is also an important attraction to high-technology business development. Network connectivity is also essential for precision agriculture, telehealth, equitable access to economic growth for rural communities, and data-enabled smart-city infrastructure.

Data literacy, data storage + open-data access to enable research
The Kansas Geological Survey, Kansas Biological Survey, and KU's Biodiversity Institute provide open data sources that have enabled environmental, water-resource, and biodiversity research. As scientists work to harness big data for a multitude of applications, there is an urgent need to improve the infrastructure supporting the reuse of data. In a 2016 *Nature* publication, a diverse set of stakeholders — representing academia, industry, funding agencies, and scholarly

publishers — jointly endorsed a concise and measurable set of FAIR (findability, accessibility, interoperability, and reusability) Data principles to guide data producers and publishers. The FAIR principles aim to enhance the reusability of data holdings by individuals and machines, thus enabling machine-learning applications.

For Kansas research to have the maximum global impact, Kansas must invest in open-data initiatives, and investments should focus on three areas:

1. Training researchers in data literacy and FAIR principles, so that all data produced for one specific purpose is usable by others and can be leveraged widely.
2. Data storage that is safe, secure, and provides access beyond the life of a sponsored-research project.
3. Developing a workforce that can use open-access data and machine learning to harness the data revolution for Kansans.

Areas for growth

1. Smart infrastructure + resilience
2. Precision agriculture
3. Digital transformation + automation
4. Harnessing genomics
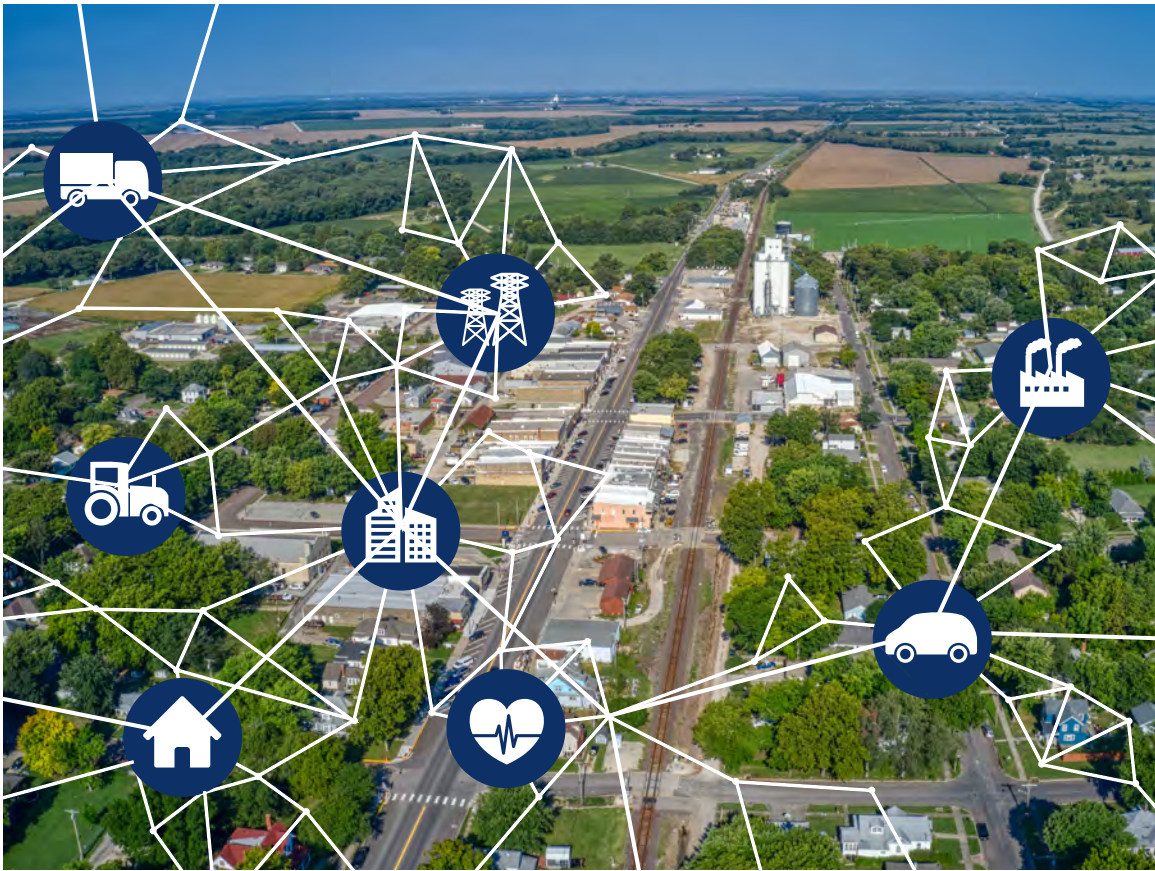
Smart infrastructure + resilience

The American Society of Civil Engineers has been sounding the alarm on the nation's aging physical infrastructure for decades, and recent power and water failures have demonstrated that critical infrastructure is increasingly susceptible to failure. In the last 14 years, 24 federally-declared disasters were declared in more than two-thirds of Kansas counties. Natural hazards — including floods, tornadoes, severe storms, winter storms, and drought — pose significant threats to Kansas communities that will only worsen with climate change. Community resilience depends on the performance of the built environment and on supporting social, economic, and public institutions, which are essential for community response and recovery after a hazard event. Community infrastructure systems, on which the economic and social well-being of any community depends, are susceptible to damage from these natural hazards. Damage to infrastructure has dispro-portionate impacts on social and economic losses, with particularly devastating and long-lasting effects on rural communities. Enhancing community resilience remains a national imperative, as reflected in recent significant financial investments in resilience enhancement at federal, state, and local levels as well as progress in disaster-related science and technology.

Kansas is uniquely positioned to capitalize on its expertise in cybersecurity and infrastructure to meet the needs of communities to rebuild aging infrastructure and to become more resilient to the changing climate.

Resilience science requires understanding pre-disaster capacities of the built, social, human, economic, financial, and political systems that are our communities. Resilience science requires interdisciplinary collaboration, sophisticated data science, and the ability to forecast or otherwise make predictions about future hazard events for risk-informed decision-making.

Beyond making current infrastructure more resilient, network connectivity and machine learning are transforming how new, "smart" infrastructure should be built. Smart infrastructure can be defined as a cyber-physical system that uses a data feedback loop to improve decision-making for a physical system. According to a recent analysis from Frost & Sullivan, global spending on smart-city technologies is expected to increase 22.7% by 2025. Cities and local governments are making investments now to improve infrastructure and resilience, while machine learning, data analytics, and network connectivity are completely transforming the technological landscape. Kansas is uniquely positioned to capitalize on its expertise in cybersecurity and infrastructure to meet the needs of communities to rebuild aging infrastructure and to become more resilient to the changing climate.

Economic impact to the state

Every $1 spent on pre-disaster mitigation saves up to $11 on post-disaster recovery, not including the additional quality of life maintained. Resilience- and risk-informed decision-making can be used to more optimally allocate financial resources where the greatest needs exist to prevent hazards from ever becoming disasters. Such resources could be used to maintain, repair, or retrofit physical infrastructure, or it can be used to build human capacity, both of which create more jobs in Kansas.

Precision agriculture

K-State is positioned to become the global hub for the development and deployment of digital agriculture and advanced analytic systems. As a land-grant institution, K-State has always been involved in agricultural biotech-nology, but feeding the global popula-tion increasingly requires a pivot to "evidence-based farming" driven by data, data analytics, and decision-making in near real time. Fluctuations in natural phenomena, evolving consumer preference, market implications of political decisions, and countless other production and market variables often overwhelm our ability to react. The resulting unpredictable and severe production and commercial shocks diminish commercial profitability, consumer confidence, and, ultimately, public health and safety.

Core advancements that transform agriculture from the current highly reactive, descriptive system to a transdisciplinary, predictive, solutions-based system are vital to empower the agriculture sector to make better-informed, more-responsive decisions. K-State's historical strengths across agricultural research, from biophysical to social sciences, are complemented by growing leadership in advanced analytics and partnerships with other KBOR institutions across the state.

We will leverage our existing computing capacity, artificial intelligence research, deep expertise in high-throughput phenotyping, advanced breeding techniques, and integrated cropping systems, as well as our geographic


Scientists at KU's Center for Remote Sensing of Ice Sheets are expanding the use of instrumentation into new areas, including agriculture.

advantage of a variety of microclimates distributed among our extensive network of regional research and extension centers. In addition, the state's UAS strengths support applica-tions to precision agriculture by providing a foundational tool that can be leveraged across the state's extensive farming acreage.

Economic impacts to the state
To maintain Kansas's traditional agricultural economic dominance in the face of a changing climate and the shrinking Ogallala aquifer, agriculture needs to go beyond its traditional emphases and become nimbler and more responsive to shifting conditions.
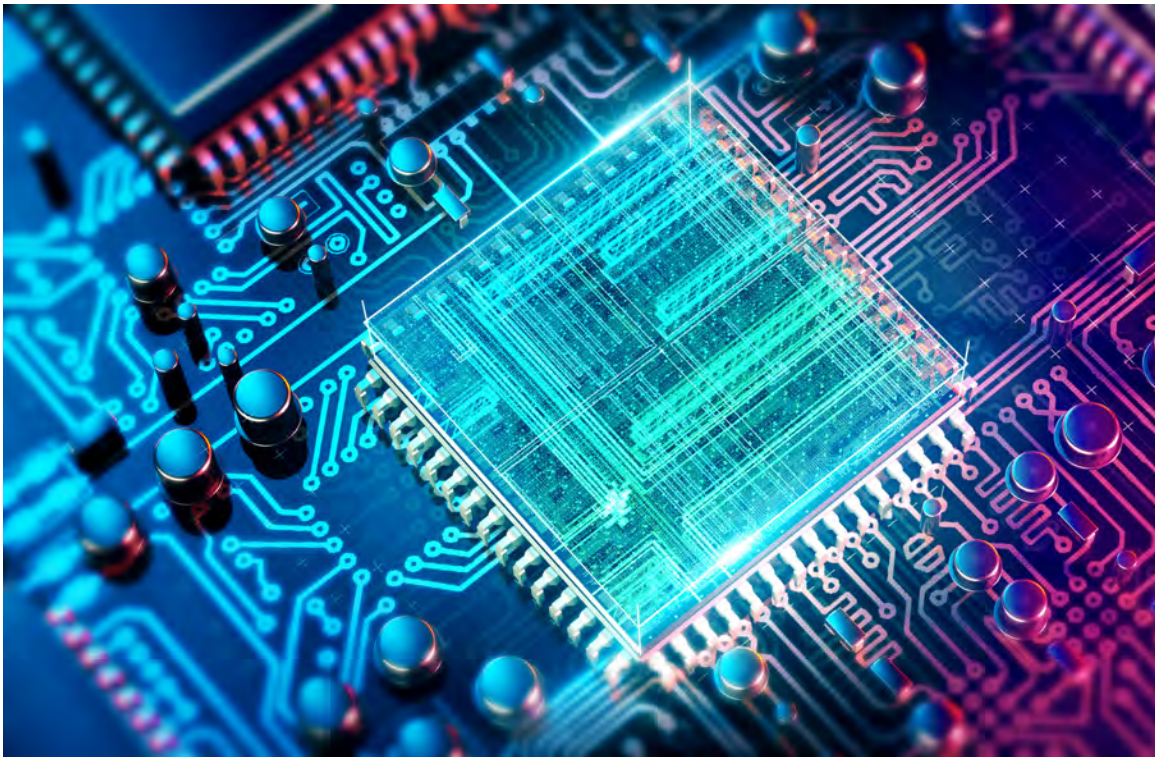
Digital transformation + automation

The pursuit of improved operational efficiency, cost reductions, and enhanced services to consumers is driving digital transformation and automation across all sectors of our economy. The COVID-19 pandemic and associated economic uncertainty has amplified the value of agility in business processes and decision-making. Widely considered as the foundation of the fourth industrial revolution, digital-transformation technologies that provide this agility include mobile and cloud computing, internet of things, and artificial intelligence. As both the global and Kansas economy is experiencing this fast-paced digital transformation, data science and data analytics will continue to play fundamental roles not only for economic growth and scientific progress, but also, and equally importantly, for informing good policy and for gathering public support.

To help diversify and grow the economy — while providing an important platform for creating new academic and applied programs for students — WSU is moving forward on a facility to house the National Institute for Digital Transformation (NIDT) as part of the university's convergence sciences initiative. A major building block for this effort was supported by the WSU Board of Trustees, who agreed to allocate $532,000 a year for the term of the bonds that will fund the development of an approximately 30,000-square-foot building on the

Innovation Campus. Research and partnerships created in this facility will be focused around the convergence of faculty and students from departments across the university to support development of research in a broad range of economic sectors, including high-tech, health, manufacturing, defense, and logistics, while also supporting the aviation and aerospace industries.

WSU will leverage its existing data-science research and education activities along with extensive expertise in cyber-physical and cyber-social systems, human-centric engineering, cyber security, and data privacy, artificial intelligence, agricultural economics and public policy to create a sustainable ecosystem for digital transformation of those same diverse economic sectors.

Economic impact to the state
To increase Kansas's economic productivity and enhance critical infrastructure resilience, government and industry sectors need to be agile and pursue coordinated digital transformations to propel the state towards a prosperous future. These advances can form the foundation for "smart communities" and "smart cities" across Kansas while creating a fertile economic environment for new industries and for retaining highly qualified Kansas professionals in Kansas jobs.

To increase Kansas's economic productivity and enhance critical infrastructure resilience, government and industry sectors need to be agile and pursue coordinated digital transformations to propel the state towards a prosperous future.

Harnessing genomics

Genomics is pervasive in contemporary STEM fields and is both a rich field of study and a tool used to understand phenomena. Agronomists and agriculturalists use genomics to study soil, crop, and livestock productivity. Engineers use genomics to track pathogens such as SARS-CoV-2 in our communities, optimize treatment systems (e.g., wastewater treatment, bioremediation), protect our water supply, and design biomaterials and artificial tissues. Anthropologists use genomics to study people and their lifestyles, and to protect our water supply. Biomedical scientists use genomics to understand microbial adaptation to antibiotics, the proliferation of cancer cells, changes associated with Alzheimer's disease, and much more. Genomics tools are transforming pharmacy and medicine through pharmacogenomics and personalized medicine, which is enabled by individual genetic testing. Basic science research, focused on understanding how genomes function, has improved our understanding of life on earth, but also provides the building blocks for new approaches to the applied fields discussed above. Thus, the interdisciplinary field of genomics promises to improve infrastructure through smarter uses of microbial diversity, to improve crop yields through traditional and engineering approaches, to improve pathogen surveillance to help prevent future pandemics, to improve patient care and disease outcomes, and to improve our understanding of how life on earth evolves, functions, and interacts.

Genomics is a funding priority at the DOE, USDA, NSF, and NIH. Large shares of federal funding go to research projects that use genomics. KBOR campuses (KU Lawrence, KU Medical Center, K-State, WSU) have complementary and emerging strengths in these fields, with recent investments in high-throughput sequencing and high-performance computing cores. We will continue to integrate computational science, engineering, statistics, and biology to achieve major advances in fields related to genomics to better serve Kansans. These advances will be evident in our infrastructure, food security, and public health.

Major research infrastructure + programs
- Genome sequencing facilities (KU, KU Medical Center, and K-State)
- Ecological Genomics Institute (K-State)
- Kansas Lipidomics Research Center (K-State)
- Wheat Genetics Resource Center (K-State)
- High-performance computing cores (K-State, KU, WSU)

Economic impact to the state

Kansas is a leading agricultural state in a time when demand, technology, and climate is changing. Genomics will help keep Kansas at the forefront of agricultural productivity. It will also allow Kansas to modernize infrastructure and personalize health care in innovative and cost-effective ways.

Genomics will help keep Kansas at the forefront of agricultural productivity [and] allow Kansas to modernize infrastructure and personalize health care in innovative and cost-effective ways.

2021 recommendations

Our vision is to elevate, stimulate, grow, and translate science and technology research in Kansas to improve the quality of life and economic resilience of its citizens.

To achieve this vision, our plan provides a clear set of recommendations for each actionable vision-statement element. These recommendations provide a consistent framework to guide the efforts of state offices with contributing roles in science and technology, KBOR institutions, businesses, and researchers. By building functional links and networks across Kansas agencies and KBOR institutions, Kansas can excel in science, technology, engineering, and mathematics, bringing innovation and economic opportunity to the state.

Overarching recommendation
Establish a statewide Science, Technology & Economic Prosperity Council that connects research initiatives at KBOR institutions to state initiatives.

Elevate the role of science and technology in improving the lives of Kansans and their communities.

Recommendations
- Create better communication networks between scientists, engineers, academics, and the state's stakeholders.
- Create a network and a record of community-engaged research in Kansas that demonstrate how Kansas scholars have partnered with communities.
- Tell the stories of how research discoveries have impacted Kansas communities.
- Foster partnerships with rural and urban stakeholders through social science research to change the culture of science and technology mistrust that can pervade both types of communities.

Stimulate discovery and innovation through education, partnerships, and infrastructure investments that build on current areas of strength and nurture emerging areas of opportunity.

Recommendations

- Cultivate in-state talent, beginning with K-12. State metrics indicate that Kansas is losing talent early.
- Recruit and retain a diverse research workforce.
- Foster diverse and interdisciplinary research teams by providing opportunities to network across disciplines and research institutions.
- Create joint initiatives across KBOR institutions that leverage individual strengths and resources.
- Collect industry and KBOR needs for research infrastructure improvements and work collaboratively to pursue federal, state, and private funding to meet them.

Grow the economy by applying new technologies and expanding access to information technology, resulting in vibrant and diverse economic development that brings tangible benefits to the citizens of Kansas and attracts new businesses to the state.

Recommendations

- Promote education, research, and infrastructure as keys to economic growth.
- Leverage university expertise and foster cooperation between the Department of Commerce and universities to retain, expand, and recruit research faculty and companies.
- Support efforts to expand equitable access to broadband — a foundational need for science and technology applications.

Translate research results to address societal challenges by encouraging the fabrication of patentable technologies through support from entrepreneurial incentives and university-entrepreneur-stakeholder communication and knowledge-sharing networks that encourage better-informed partnerships and policies.

Recommendations

- Develop state policies that provide entrepreneurial incentives, including proof-of-concept funds and financial support for small businesses.
- Expand innovation and research parks at KBOR universities.
- Create a statewide entrepreneurial ecosystem.
- Educate faculty, staff, and students on translating basic research discoveries into commercial enterprises.

Conclusion

In 1992, Kansas became eligible to participate in EPSCoR, a National Science Foundation program designed to help states that receive a lower percentage of federal dollars for research to build research infrastructure. Today, Kansas ranks 31st for individuals in the STEM workforce, and Kansas businesses rank 20th in terms of the percentage of business output devoted to R&D. Despite these metrics, which indicate significant capacity for research, innovation, and economic growth, Kansas ranks 49th in terms of federal R&D as a share of state gross domestic product (GDP) and 42nd in terms of federal obligations for science and engineering R&D.

Over the years, Kansas NSF EPSCoR has provided seed funding for prototype projects that led to an NSF Engineering Research Center, the Center for Environmentally Beneficial Catalysis, and an NSF Science and Technology Center, the Center for Remote Sensing of Ice Sheets. State matching funds for EPSCoR projects have been leveraged from 10- to almost 100-fold in some cases. These awards stimulated the development of multidisciplinary and multi-institutional centers and institutes of excellence. These successes have shown that the national EPSCoR strategy, when coupled with state funding and support, can build research capacity and stimulate federal research funding. In this plan, we have summarized six areas of R&D strength, along with the research infrastructure and economic impact these research areas have. Research and innovation are key drivers for economic growth, and the state of Kansas must be committed to increasing federal research funding as a critical strategy for economic resilience.

Along with six areas of existing strength, this plan outlines critical infrastructure needs and four areas of opportunity in science and technology research. We provide 17 specific recommendations for how the state of Kansas, its universities, businesses, and science and technology workforce can work collaboratively to elevate, stimulate, grow, and translate research. Ultimately, research in these areas will improve the quality of life and economic resilience of Kansas citizens — a worthy undertaking, indeed.

Kansas Science + Technology Plan

2021