TECHNOLOGY AND RESEARCH INITIATIVE FUND

FY 2019

ARIZONA BOARD OF REGENTS

ASU ◆ NAU ◆ UA

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TRIF EXECUTIVE SUMMARY

PROPOSITION 301 FUNDS TRIF

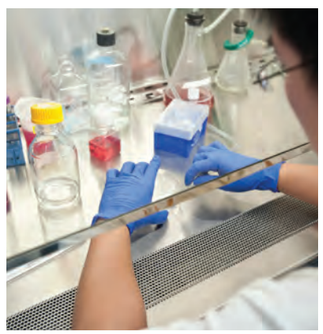
- Proposition 301 increased the state's sales tax to be dedicated to K-12, the community colleges and Arizona's public universities. Collection of the tax began on June 1, 2001. In 2018, the proposition was extended for another 20 years.
- Arizona law establishes the Technology and Research Initiative Fund (TRIF) using Proposition 301 sales tax revenue and gives the Arizona Board of Regents (ABOR) the responsibility to administer the fund.
- TRIF monies are continuously appropriated to ABOR and do not lapse at the end of the fiscal year.

TRIF BUDGET

- ABOR approves the TRIF budgets and project plans in five-year cycles. The fiscal year 2017-21 project plans were approved by the board in June 2016 using the sales-tax forecast from the Joint Legislative Budget Committee (JLBC). These project plans are available on the ABOR web site at: http://www.azregents.edu/reports-0
- In fiscal year 2018-19, TRIF received approximately $83.6 million in revenue. Total TRIF revenue received to date since the inception of the program in June 2001 is over $1.124 billion.
- The TRIF statute includes a 20 percent limitation on use of TRIF funds for capital projects expenditures.

2019 FINANCIALS

This year the actual sales tax receipts were $5,401,910 over budget projections. In September 2017, revised budget projections were approved by the board for the remaining four-year term of the program. Revised budgets are reflected in the financial and metrics sections of this report.



TRIF INITIATIVES

TRIF money is used to support initiatives and projects that meet one or more of the following categories established by the board.

Research investment areas:

- **Improving Health**
- **Water, Environmental, and Energy Solutions**
- **National Security Systems**
- **Space Exploration and Optical Solutions**

Workforce development investment area:

- **Higher Education Access for Workforce Development**

Pursuant to A.R.S. §15-1648(C), TRIF monies will be used to support initiatives and projects that meet one or more of the following criteria:

- **Promote university research, development and technology transfer related to the knowledge-based global economy.**
- **Expand access to baccalaureate or post-baccalaureate education for time-bound and place-bound students.**
- **Implement recommendations from the Governor's Task Force on Higher Education and/or the Arizona Partnership for the New Economy.**
- **Develop programs that will prepare students to contribute in high technology industries located in Arizona.**

These same criteria are used in considering tri-university awards of the Regents' Innovation Fund and grants.

TRIF REPORTING

- **A.R.S. §15-1648(D) requires the board to submit to the governor and Legislature by Sept. 1 of each year a report of prior year TRIF expenditures.**
- **The fiscal year 2019 TRIF report, along with previous reports, is available on the ABOR website.**
- **The board adopted TRIF five-year project plans detailing anticipated budgets and expected outcomes are also available on the ABOR website.**

ASU Arizona State University

ARIZONA STATE UNIVERSITY

Investment of Technology and Research Initiative Funds (TRIF) at Arizona State University advances research, entrepreneurship and economic development while fueling innovative solutions. These solutions provide a significant return on investment to the citizens of Arizona in the form of an accelerating economy, broad access to education and training, and better quality of life.

During the TRIF cycle of fiscal year 2017 through fiscal year 2021, ASU is investing in four focus areas:

- **Improving Health**
- **Water, Environmental and Energy Solutions**
- **National Security Systems**
- **Access and Workforce Development**

In the past year, ASU leveraged TRIF investment to attract $208 million in new funding from external sources. For example, the National Science Foundation renewed the NEWT Engineering Research Center for another five years, and the Global Security Initiative received two awards from the Defense Advanced Research Projects Agency totaling over $19 million. Across the four focus areas this year, TRIF-supported research engaged 1,275 undergraduates, 2,278 graduate students, and 401 post-doctoral appointees. In addition, TRIF research generates novel technology and new businesses. This year, 14 new startup companies were founded based on technology from TRIF-supported research and 58 new patents were issued.

Since 2002, ASU has leveraged TRIF investment in ways that are accelerating research, solutions and economic impact. ASU reached $618 million in research expenditures in fiscal year 2018, making it one of the fastest-growing research enterprises among U.S. institutions with more than $100 million in research expenditures. This work is translated into the marketplace where it has real impact. ASU now ranks No. 10 among all universities in the world for U.S. patents, ahead of Columbia University, the University of Washington and Duke University.

In recognition of this growth and impact, ASU was named the most innovative university in the country by U.S. News and World Report for the fourth consecutive year, based on surveys of university presidents and leaders. This innovation allows the university to educate and graduate more students while earning recognition for the increasing caliber of ASU's programs and graduates.

"A spirit of discovery, innovation and entrepreneurship permeates everything we do at ASU. It allows us to inspire and train students at scale. It identifies, addresses and solves societal and economic challenges locally, nationally and globally. Our transdisciplinary approach fosters a collaborative environment for research while nurturing cooperative, symbiotic relationships with public and private partners. With a commitment to inclusivity, diversity and to the development of lifelong master learners, ASU is truly an exemplar of a new national service university."

— Dr. Sethuraman "Panch" Panchanathan, Executive Vice President, ASU Knowledge Enterprise, and Chief Research and Innovation Officer

IMPROVING HEALTH

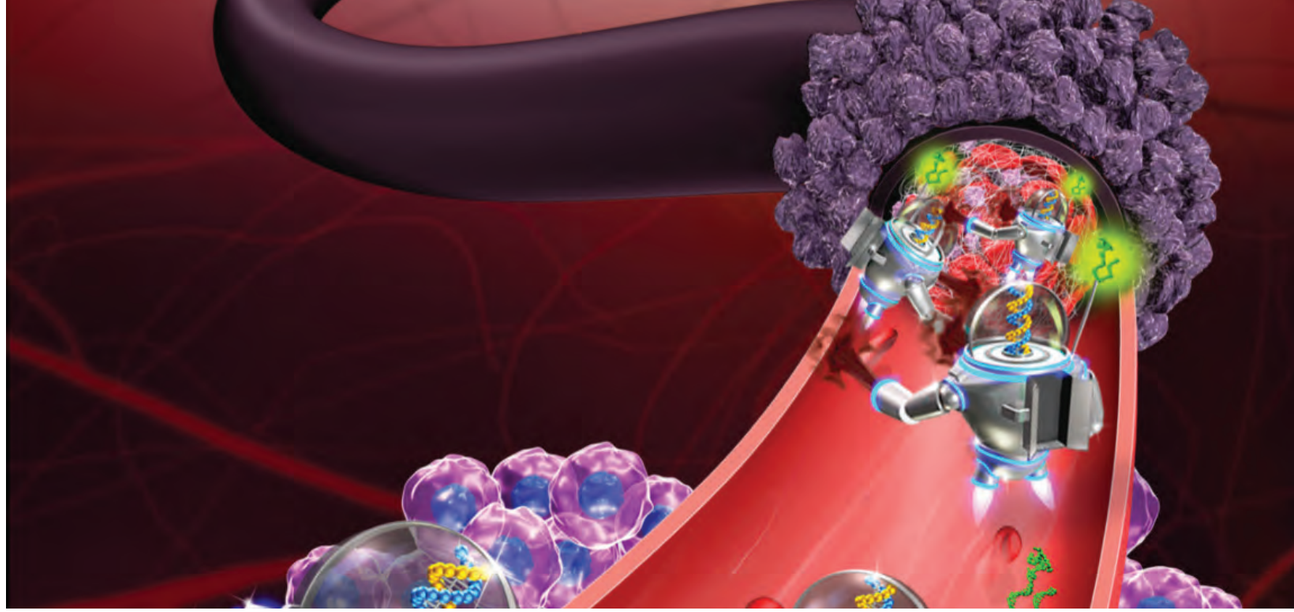
TRIF-supported researchers in Improving Health initiatives are addressing the complex and critical challenges of health and health care. This focus area fuses biomedicine, engineering and computing through innovative approaches in partnership with leading institutions such as Mayo Clinic.

Programs supported in the Improving Health focus area and associated goals:

- The Biodesign Institute addresses today's critical global challenges in health care, sustainability and security by developing solutions inspired by natural systems and translating those solutions into commercially viable products and clinical practices.
- Decision Theater (DT) engages researchers and leaders across the TRIF focus areas to visualize and identify solutions to complex problems. With locations in Tempe and Washington, D.C., DT facilities provide the latest expertise in collaborative computing and display technologies for data visualization, modeling and simulation.
- Research Computing provides high-performance computing resources across the TRIF focus areas. These resources are available to ASU researchers as well as industry and community partners, enabling the collection, management and analyses of vast and complex datasets.
- Complex Adaptive Systems (CAS) represents a unique framework for biomedicine. Initiatives led by CAS include the nonprofit National Biomarker Development Alliance (NBDA) which is developing standards for the discovery and effective use of biomarkers in medicine.

"The researchers at the Biodesign Institute play a key role in making important things happen — from creating the world's first mobile metabolism tracker, to developing a blood test for a more precise breast cancer diagnosis, to discovering a link between diet and autism. Their drive, intellect and energy are limitless when it comes to making Arizona and our world a better, safer and healthier place for all of us. The encouragement and support from Arizona leadership and citizens fuels our optimism and our opportunities."

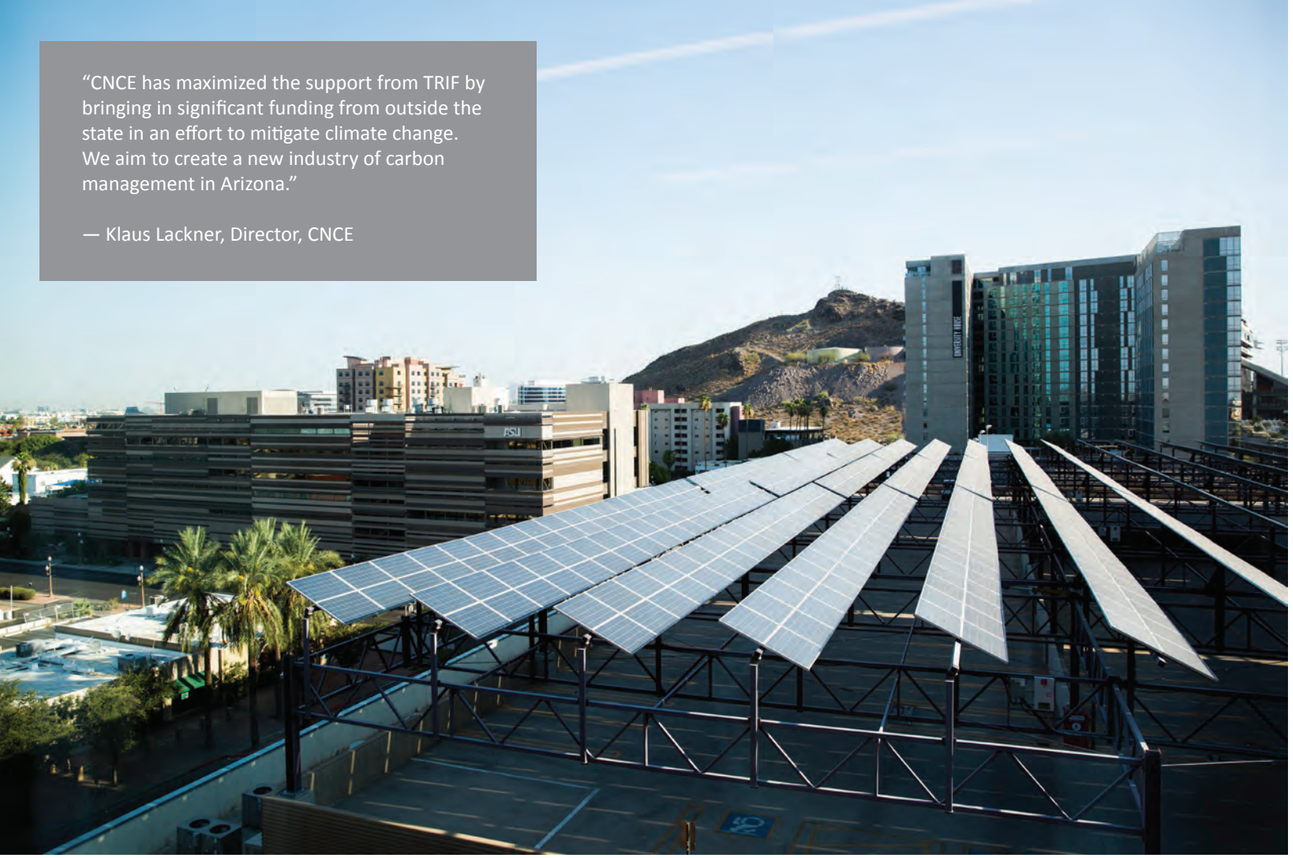
— Josh LaBaer, M.D., Director, Biodesign Institute



SUMMARY OF ACCOMPLISHMENTS

Researchers in the Improving Health area leveraged TRIF investment to secure over $105 million in sponsored awards to address critical health problems such as neurodegenerative diseases, cancer, autism and addiction.

- ASU researchers harnessed gut microbes as a promising treatment for autism symptoms in a study that was featured in The Economist, Smithsonian and Science News. At the start of the study, 83 percent of participants were rated as having "severe" autism. At the end of the study, only 17 percent were "severe," and 44 percent fell below the cutoff for mild autism spectrum disorder.
- The Biodesign Institute and the College of Nursing and Health Innovation received a $50 million gift from Charlene and J. Orin Edson in support of dementia research and education and training for nurses and caregivers. Scientists in the ASU-Banner Neurodegenerative Disease Research Center are keenly focused on finding answers to Alzheimer's disease, the fifth leading cause of death in Arizona. Recently, researchers in the center developed a blood test that can diagnose a genetic risk for Alzheimer's, as early as age 20.
- In June 2019, OncoMyx, the latest biotech spinout company from the Biodesign Institute, announced that it raised $25 million in new funding to help commercialize an innovative, viral-based therapy for the treatment of cancer. This is the largest amount of Series A funding raised for any ASU spinout to date.
- Additional companies proliferating from Biodesign research are growing and thriving as well. This year, the world's largest canine cancer vaccine clinical trial began, supported by and based on the technology of Biodesign spinout company Calviri, Inc. If the trial is successful, it may pave the way to new methods of preventing cancer in humans as well as dogs. Professor Hao Yan, who made headlines with his cancer-fighting robots constructed of DNA, started Biosciences, Inc. to speed his tech to market. Yan's innovative use of DNA also earned him a spot in Fast Company's Most Creative People of 2019.
- In fiscal year 2019, two ASU researchers were named new innovators by the National Institutes of Health, receiving large grants to accelerate their discoveries. Assistant Professor Nicholas Stephanopoulos received $2.2 million to improve synthetic protein properties in order to increase the effectiveness of biomedicines. Assistant Professor Rizal Hariadi received $1.6 million to improve the functionality of biomolecular systems, with the end goal of fighting malaria.
- Attracting attention throughout the world, ASU Biodesign researchers entered into a partnership with the City of Tempe to test a new system for helping communities manage challenges related to drug abuse by monitoring opioids and other substances in wastewater. According to Tempe officials, the immediate goal of this new partnership is to achieve an end to opioid-related deaths and overdoses.



"CNCE has maximized the support from TRIF by bringing in significant funding from outside the state in an effort to mitigate climate change. We aim to create a new industry of carbon management in Arizona."

— Klaus Lackner, Director, CNCE

WATER, ENVIRONMENTAL AND ENERGY SOLUTIONS

Research in the Water, Environmental and Energy Solutions focus area capitalizes on the key role that Arizona can play in the future of energy technology, education and commercial development.

Programs supported in the Water, Environmental and Energy Solutions focus area and associated goals:

- The Julie Ann Wrigley Global Institute of Sustainability (ASU Wrigley Institute) advances research, education and business practices for an urbanizing world. Its four cornerstones — education, research, business practices and global partnerships, and transformation — transcend disciplines, campuses and institutional boundaries.

- The Center for Negative Carbon Emissions (CNCE) develops carbon management technologies, such as direct air capture, to put the excess carbon in our atmosphere to work. Projects include converting carbon dioxide captured from the ambient air to liquid fuels and pulling oxygen out of carbon dioxide.

- The LightWorks® initiative envisions a resilient and equitable energy future supported by innovations in technology, policy, law and markets. LightWorks pulls light-inspired research at ASU under one strategic framework, leveraging the university's unique strengths in solar-electric energy, sustainable fuels and products, and energy and society.

- The Center for Bio-mediated and Bio-inspired Geotechnics (CBBG) and the NanoEnabled Water Treatment Technologies (NEWT) center are National Science Foundation-supported Engineering Research Centers. ASU leads CBBG and is a partner in NEWT. These centers advance engineering research and design to tackle imminent sustainability issues by developing applied solutions for transportation, water, power, sanitation, and residential and commercial development.

- Future H_2O is changing the narrative about water from one of scarcity to one of abundance and creating opportunity for change at scale for regional, national and global water systems.

SUMMARY OF ACCOMPLISHMENTS

- ASU has become a global pioneer in sustainability research, education and impact. In 2019, ASU was ranked No. 2 nationally in the Times Higher Education University Impact Rankings, which assess universities against the United Nations Sustainable Development Goals. Regents' Professor Bruce Rittmann of Biodesign was named a laureate of the prestigious Stockholm Water Prize — known as "the Nobel prize of water" — for his work employing microbiological-based technologies in water and wastewater treatment. ASU Wrigley Institute researcher Leah Gerber was a lead author on the first large-scale global assessment of biodiversity since 2005.

- ASU researchers earned six Department of Energy awards totaling $5.7 million, propelling the university to No. 1 for awards to advance photovoltaic research and development. A $2 million grant from the Office of Naval Research was awarded to ASU Wrigley Institute researcher Nathan Johnson for his solar-powered, electrical grid-in-a-box for use in remote areas. Locally, the institute's Sustainable Cities Network released the Greening Events Implementation Guide and the Low Impact Development Handbook for Maricopa County. The School of Sustainability increased opportunities for Arizonans to learn from leading sustainability practitioners and earn professional credentials.

- Carbon capture technology developed at CNCE is now being commercialized and deployed by Silicon Kingdom Holdings. The planned deployment of CNCE's technology — mechanical trees that passively collect CO_2 from the air for reuse — is expected to cost below $100 per metric ton at scale, making it the most commercially viable in the industry. Widespread deployment of the technology may prove vital to reaching standards set by the Paris Climate Agreement. TRIF support for CNCE has provided the foundation for developing research tools and graduate research on carbon management, which has led to additional industry support, such as from Shell, and helps steer investment dollars for carbon management to Arizona.

- A NEWT-enabled, woman-owned business was awarded multiple NASA small-business projects to develop new disinfecting technologies. NEWT has also deployed a mobile pilot plant to a local city to demonstrate new ways to treat pollutants that will soon be regulated, which have caused numerous cities to turn off water supplies. Based upon a proven record of success, NEWT was renewed by the National Science Foundation (NSF) for another five years.

- Future H_2O is engaging state agencies and Fortune 500 companies in Texas to help the state implement environmental flows per state law. With support from NSF, Future H_2O is partnering with the U.S. State Department to help Cambodia, Vietnam, Lao PDR and Thailand implement sustainable hydropower operations that sustain food production.

NATIONAL SECURITY SYSTEMS

ASU takes a multifaceted approach to security research, including innovative public-private partnerships. The National Security Systems focus area has created a portfolio of university research initiatives that partner with companies in the highly competitive security, defense and aerospace sectors. These efforts are creating new potential and markets for these industries in Arizona.

Programs supported in the National Security Systems focus area and associated goals:

- The Global Security Initiative (GSI) produces mission-relevant approaches and decision support tools to address some of the world's most vexing and complicated security challenges. The hub of ASU's security research, GSI leverages connections with the global defense, security, development and diplomacy communities to take new approaches toward the world's "wicked problems."

- The Space Technology and Science Initiative (NewSpace) leads the integration of academic and commercial space enterprises using ASU's core strengths in space science, engineering and education. NewSpace is creating academic-commercial partnerships that bring together the most brilliant minds in the space industry sector for an unprecedented collaborative effort.

- The Interplanetary Initiative creates interdisciplinary projects that approach critical questions about our space future that are neglected elsewhere. Projects advanced by the initiative use a structured project management approach, including planning outcomes and products from the start. In addition, all projects bring research into the classroom and track efforts in exploration learning.

SUMMARY OF ACCOMPLISHMENTS

TRIF support has enabled ASU to advance security research in key emerging areas such as cybersecurity, homeland security and aerospace.

- For instance, GSI's Center for Cybersecurity and Digital Forensics (CDF) has received over $19 million from DARPA to address cybersecurity risks by integrating human knowledge and automated cyber-reasoning systems. Working with PayPal, CDF is targeting phishing attacks, through which criminals pose as a legitimate company to steal login credentials. CDF and PayPal identified significant vulnerabilities in the anti-phishing ecosystem and worked with companies such as Google, Microsoft and Mozilla to address the problems they found.

- GSI's Center for Accelerating Operational Efficiency, a Department of Homeland Security Center of Excellence, worked with the Transportation Security Administration and Phoenix Sky Harbor Airport to develop more efficient TSA checkpoints.

- GSI's DARPA Working Group, which connects researchers with the Defense Advanced Research Projects Agency, helped to secure Young Faculty Awards totaling more than $2.3 million for three researchers. The funded projects seek to understand the intentions of hostile, autonomous swarms; develop robust tools to connect humanitarian organizations and governments; and create low-cost, energy-efficient sensing technologies to bolster national defense. GSI's efforts have propelled ASU to the No. 1 university for DARPA Young Faculty Awards received since 2014.

- A Tempe-based, GSI-incubated cybersecurity startup, CYR3CON, raised $1.5 million in seed funding in fiscal year 2019. CYR3CON combines artificial intelligence and social sciences to build stronger, more resilient defenses against cyberattacks.

- Through a NewSpace-led initiative, ASU was selected by the remote sensing satellite company Planet as its first institutional data partner for higher ed. This gives the ASU community access to Planet's satellite imaging data for research and educational purposes.

- ASU's Interplanetary Initiative's 13 research pilot projects relating to a positive human space future have garnered an incredible 14:1 return on investment from external funding sources. The initiative is now developing a new educational program designed for the fastest and most effective workplace preparation. In addition, 1,000 people from Arizona and beyond have attended the initiative's educational outreach events.

> "TRIF funds have enabled our steady growth in securing partnerships and external funding with local and national commercial space partners, and engagements will continue to scale as the commercial space industry continues to grow."
>
> — Dr. Jim Bell, Director, NewSpace

ACCESS AND WORKFORCE DEVELOPMENT

The Access and Workforce Development focus area addresses the need for training and education required to drive Arizona's economy. ASU research and programs supporting these efforts marry innovative thinking with cutting-edge applied technology.

Programs supported in the Access and Workforce Development focus area and associated goals:

- ASU Entrepreneurship + Innovation (E+I) provides educational opportunities, training and mentoring to students, faculty and the community. E+I connects the university's research and development capabilities, experience in innovation, and facilities to the broader community with an eye toward stimulating new ventures and improving economic outcomes.

- The Advanced Materials Initiative (AMI) enables the materials research community to accelerate the pace of innovation through strategic teaming, infrastructure development and operational analytics. It seeks to identify and nurture opportunities of high impact, especially those related to transportation, health, energy, sustainability, construction and space exploration.

- The Compact X-ray Free Electron Laser is slated to be the world's first tabletop X-ray laser, located in the lower level of Biodesign C. This new laser mimics the ability of linear accelerators, currently available in only five places in the world, at a much lower cost.

- The Flexible Electronics and Display Center (FEDC) is a global leader in flexible electronics manufacturing. This public-private partnership demonstrates ASU's manufacturing capabilities and provides a unique pilot line capability for U.S. industry. Together with the MacroTechnology Works (MTW) Initiative, ASU is advancing fundamentally new manufacturing capabilities for emerging transformational technologies and facilitating technology transfer and development with industry partners.

- SciHub brings together multidisciplinary teams of students, staff and faculty for integrated research, teaching, outreach and product development. The laboratory unites artists, engineers, scientists, medical professionals and others in their flagship innovation space on the Tempe campus to accelerate ideas to realization.

- A public-private partnership between ASU's Ira A. Fulton Schools of Engineering, governments and local industry is initiating a series of advanced research centers (ARCs) in areas that represent significant growth potential for ASU and greater Phoenix. WearTech is one of the ideas being advanced to help build a strong economic development ecosystem.

- ASU Core Research Facilities provide state-of-the-art equipment, specialized services, and expert consultation and training to aid internal and external researchers, agencies and industry partners to achieve research goals, prototype new technologies and solve problems.

"The SciHub program will build on President Crow's vision of the New American University by combining high-quality, interdisciplinary research and teaching with outreach to a broad community in Arizona."

— Nobel Laureate Frank Wilczek, Co-Director, SciHub

SUMMARY OF ACCOMPLISHMENTS

ASU is helping the Arizona economy thrive by developing a skilled workforce, advancing next-generation technologies and industries, and empowering entrepreneurs.

- E+I is reopening the 13,000 square foot makerspace in Chandler, which allows students, faculty, staff, alumni and the greater community to prototype, create and make new products. E+I also received a $6 million endowed gift from the J. Orin Edson Foundation to launch the Training and Development Network to serve ASU and the community. In fiscal year 2019, the network hosted 97 entrepreneurship training and development events, including workshops, training series and boot camps. E+I hosted an additional 96 community-facing events to provide training, support and technical assistance to local residents.

- AMI is aggressively pursuing development of new materials that can withstand extreme environments and advance next-generation electronic, sensing and computing devices. In fiscal year 2019, AMI launched the Center for Materials of the Universe to apply emergent computational capabilities to predicting the chemistry of exoplanets and to discover and develop new materials that withstand extreme environments in space and on Earth. Work at AMI has led to intellectual property and startups, including two women-led companies, Advent Diamond and Ryan Innovations.

- In its inaugural year, SciHub created an integrated, interdisciplinary research, teaching, outreach and product development lab. TRIF support enabled SciHub's Clubes de Ciencia Hub to engage 244 high school students in hands-on workshops developed by young scientists from prestigious universities and research institutions. Through SciHub's SCience and ENgineering Experience (SCENE) program, 53 high school students have worked in ASU labs to answer original research questions and compete in regional and national science competitions.

- The WearTECH consortium initiated and successfully completed a demonstration project on wearable technologies. A faculty-led spinout company partnered with a local business to explore opioid detection in wearable patches, which is now being developed into a commercial product.

- Scientists in ASU's Decision Theater worked with DCEdEx and the Arizona Board of Regents to develop two software applications to model the impacts of postsecondary education on the overall state economy and workforce trajectory. DT is also developing a decision-support tool to understand the existing labor force across the state of Arizona, its vulnerability to automation and its alignment with industries. At its facility in Washington, D.C., DT worked with the American Academy of Diplomacy to develop a scenario-based simulation that trains future ambassadors for pre-crisis situations and improves foreign relations.

- ASU Core Research Facilities assists companies with their research and development needs through equipment and services ranging from cleanrooms for semiconductor fabrication to DNA sequencing to advanced electron microscopes. Core facilities partnered with 167 external organizations in fiscal year 2019, including 71 from Arizona and eight Fortune 500 companies. In addition, the core facilities group trained more than 700 users on equipment and techniques.

HIGHLIGHTS

Year after year, ASU exceeds the goals set by ABOR for research growth and impact. Through interdisciplinary, solutions-focused research, ASU scientists and scholars are improving human and environmental well-being, advancing Arizona's economy and preparing the workforce of tomorrow.

ASU has leveraged TRIF investment to attract significant additional research funding from government agencies, donors and industry. Since TRIF began in 2002, ASU has more than quintupled its research enterprise, reaching $618 million in expenditures in fiscal year 2019. ASU has also been tremendously successful at bringing discoveries into the marketplace to advance the economy and improve quality of life. ASU now ranks No. 10 among universities worldwide for U.S. patents, up from No. 17 in 2018.

With support from TRIF, ASU is poised to accelerate this trajectory of success into the future. This spring, the Biodesign Institute received a $10 million philanthropic gift from Leo and Annette Beus to complete the Beus Compact X-ray Free Electron Laser Lab (CXFEL), now under construction in the new Biodesign Building C. Expected to be the world's first compact X-ray free electron laser, the CXFEL holds promise for advancing drug discovery, renewable energy, materials science, the semiconductor industry, and the preservation of art and archeology — at a fraction of the size and cost of existing linear accelerators.

TRIF investment is also enabling mutually beneficial partnerships with local and international organizations. In fiscal year 2019, ASU launched the MILO Institute in partnership with Lockheed Martin and GEOshare. The institute uses a consortium model to make space science missions affordable and accessible to space agencies and companies around the world. MILO's inaugural mission has generated so much interest that a second mission is already being planned.

ASU is pushing the boundaries of knowledge and finding creative solutions to pressing challenges. Building on the success of the Julie Ann Wrigley Global Institute of Sustainability and the nation's first School of Sustainability, ASU has launched the Global Futures Laboratory. Led by Professor Peter Schlosser, one of the world's leading earth scientists, the laboratory focuses on proactively designing a future in which all of Earth's inhabitants will thrive.

Global Futures Laboratory is an innovative conglomerate of activities with the sole mission of addressing complex problems that threaten our planet and our well-being. It is an exemplar of the mission and purpose of ASU — to ensure the long-term success and well-being of our students, our community, our state and our world.

NAU NORTHERN ARIZONA UNIVERSITY

NORTHERN ARIZONA UNIVERSITY

Northern Arizona University's capacity to invest in areas of strategic research growth significantly expanded in 2016 when the Arizona Board of Regents approved NAU's bold five-year plan for the fiscal year 2017-21 Technology and Research Initiative Fund. In the three years since, NAU's TRIF financial investments have had a meaningful impact throughout Arizona, producing economic benefits through scientific advancements, workforce training and access to higher education.

This year, NAU was awarded 10 new patents—representing a significant increase over fiscal year 2018. In addition, 40 new patent applications were filed, and 35 new invention disclosures were submitted.

Beyond their economic benefits, NAU's investments have also increased the university's capacity to form successful research partnerships, strengthened the capability to commercialize new technologies and capitalized on the intellectual talent of faculty to achieve the university's mission of enriching lives and creating opportunities for students as well as the communities NAU serves.

Through its five TRIF initiatives — Improving Health (iHealth), National Security Systems (NSS), Access and Workforce Development (AWD), Water, Environmental and Energy Solutions (WEES) and Space Exploration and Optical Solutions (SPACE) — NAU has consistently generated a positive return on those investments.

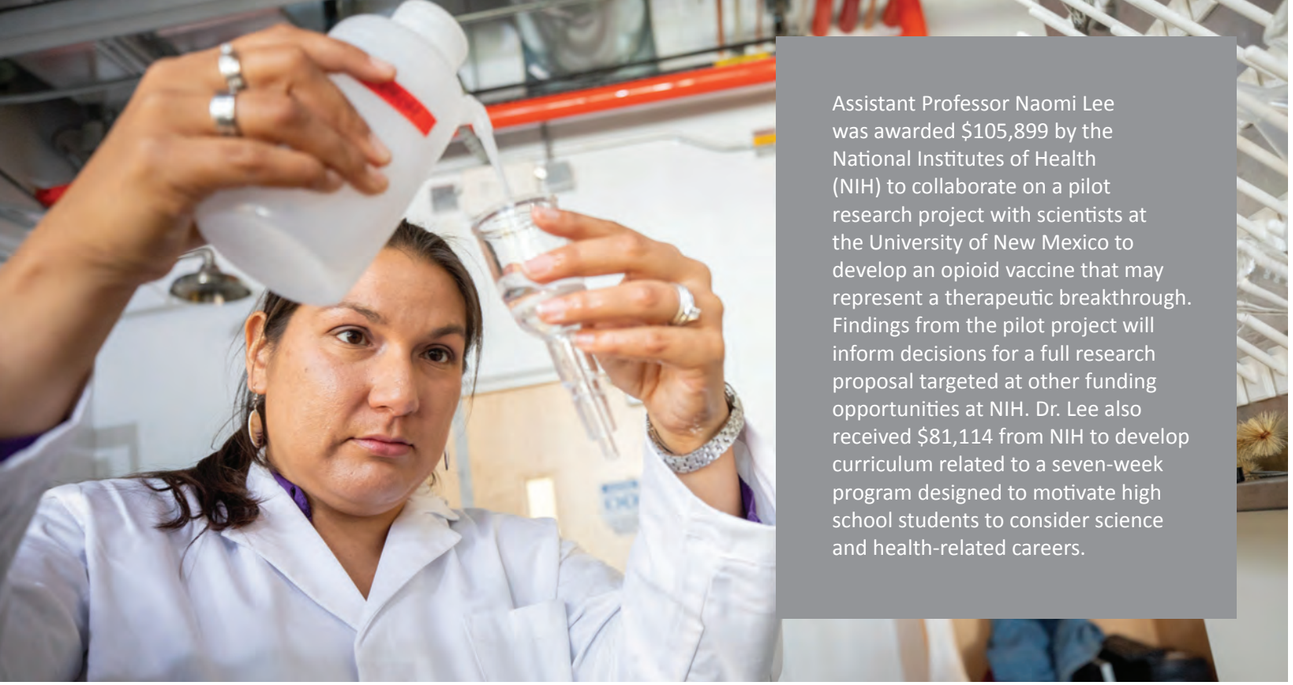
- The iHealth initiative has propelled NAU to innovate and discover in the lab, clinical settings and the public health arena in ways that elevate the university's translational research capabilities to new heights.
- The NSS initiative has driven investment in research-intensive hires and high-tech laboratories. As a result, NAU has already become a leader in the critical area of cybersecurity, developing new technologies to protect Arizona's businesses and consumers while spurring its economy. This discipline is a core national security priority that will affect all Arizonans in the years ahead, and NAU is committed to developing the highly qualified workforce needed to meet these challenges.
- AWD supports the state's economic growth through the development and delivery of degree and certificate programs that support workforce needs in high-demand areas such as health and teacher education, particularly focused on serving communities throughout Arizona.
- The WEES initiative, based on regional research that is one of NAU's historic strengths, has driven the university to explore and discover on a global scale, enhancing the university's leadership position in this discipline.
- The SPACE initiative capitalizes on recent recruitment of research-intensive faculty in the areas of astronomy and planetary science, while leveraging the wealth of astronomical resources found throughout Arizona at partner institutions, to prepare a workforce that will strengthen Arizona's stature as a worldwide leader in this rapidly growing area of research.

"Northern Arizona University's research is globally recognized and locally vital, impacting both Arizona's economy and quality of life. NAU's research addresses national needs and priorities while also supporting underserved populations in the region by increasing access to health care, quality education and social support services. NAU's researchers and research centers actively collaborate with state and community agencies, foundations, nonprofit organizations and initiatives, and a host of other partners to carry out their missions.

"The success of NAU's research enterprise has a direct and significant impact on the quality of Arizona's education system. Through our public service and outreach initiatives, we influence curricula in K-12 classrooms throughout the state, and because of the quality of our faculty — not only as educators but also as mentors and researchers — we provide meaningful hands-on experiences to undergraduate and graduate students that prepare them for careers of the future in our quickly changing world.

"Funding from TRIF has enabled NAU to significantly increase its research productivity and garner recognition that is comparable to our peer universities and complements the research strength of our Arizona peers. We will continue to direct investment in our faculty and facilities to sustain and to grow further the level of impact that the state of Arizona expects."

– Rita Hartung Cheng, President



Assistant Professor Naomi Lee was awarded $105,899 by the National Institutes of Health (NIH) to collaborate on a pilot research project with scientists at the University of New Mexico to develop an opioid vaccine that may represent a therapeutic breakthrough. Findings from the pilot project will inform decisions for a full research proposal targeted at other funding opportunities at NIH. Dr. Lee also received $81,114 from NIH to develop curriculum related to a seven-week program designed to motivate high school students to consider science and health-related careers.

IMPROVING HEALTH

Northern Arizona University's investments in the iHealth initiative focus on three areas: bioengineering/ biotechnology, health research initiatives and pathogen genomics.

Bioengineering/Biotechnology: Investments in the NAU Center for Bioengineering Innovation (CBI) will catalyze discoveries that improve lives, foster economic growth in Arizona and beyond, and provide cutting-edge training in bioengineering research for undergraduate and graduate students who will join the biotechnology workforce. CBI's research focuses on a wide range of areas, including personal bionics and wearable robotics, rehabilitation, hearing improvement and materials, and devices for biocompatible implants and sensors.

Health Research Initiatives: NAU is expanding its capacity to produce nationally recognized translational health research and to make discoveries in personalized medicine, infectious disease control and clinical research around a wide range of chronic health conditions. In fiscal year 2017, NAU established the Center for Health Equity Research to address health care disparities of the state's underserved populations, including Native Americans, Hispanics and individuals in rural communities, and this initiative has resulted in millions of dollars in new grant funding.

Pathogen Genomics: Investments in NAU's world-renowned Pathogen and Microbiome Institute (PMI) have led to the creation of intellectual property and national recognition in biosecurity. This expansion and investment in PMI will lead to increased extramural research funding as well as startup companies formed to commercialize its discoveries. PMI's research focuses on the evolution, ecology and epidemiology of some of the most threatening disease-causing bacteria from hospital-acquired infections to anthrax, plague and biological warfare agents.

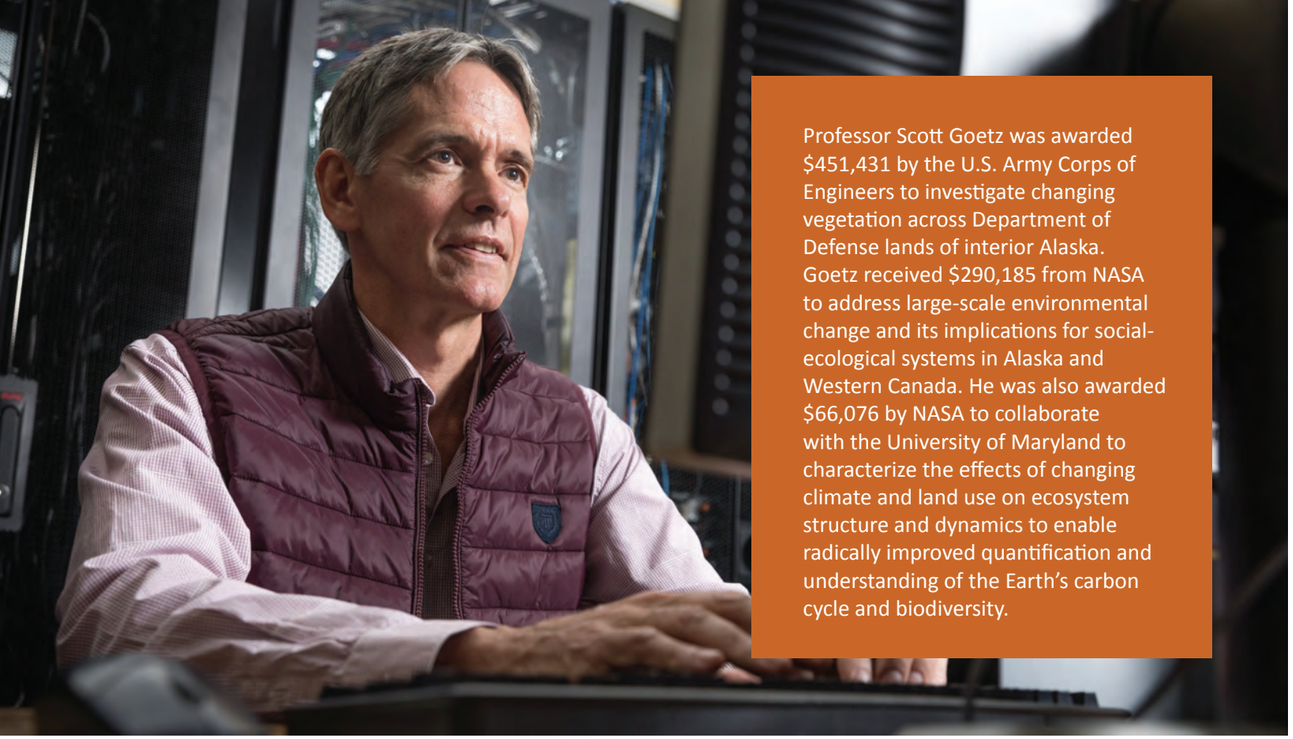
GOALS

- **Leverage NAU's existing research and intellectual assets to generate external funds.**
- **Create curricular innovations related to key workforce needs in the state and region.**
- **Catalyze an entrepreneurial spirit among university faculty and students.**
- **Build and strengthen partnerships with health care providers in Northern Arizona.**
- **Generate new biotechnology startup enterprises and jobs in the region.**

SUMMARY OF ACCOMPLISHMENTS

Northern Arizona University's TRIF investments under the Improving Health initiative range from basic, applied and translational research in human biology, bioengineering and microbiology/genomics, to clinical, community and behavioral health sciences. In fiscal year 2019, NAU established the Center for Materials Interfaces for Research and Applications (¡MIRA!), through which NAU can impact health, energy and the environment, improving lives and enhancing economic potential. By building valuable partnerships with local and regional healthcare providers, research institutions and tribal communities, NAU researchers continue to discover and invent new technologies that have a long-lasting impact on the health and well-being of the diverse populations of Arizona.

- NAU faculty who received TRIF funds through the Improving Health initiative received more than $11 million in external grant funds in fiscal year 2019.
- Regents' Professor Julie Baldwin, director of the Center for Health Equity Research, received $756,881 from the National Institutes of Health to conduct a formative assessment on oral health beliefs and practices of two Native American tribes.
- NAU was jointly awarded three U.S. patents, along with partner TGen, for assay technologies co-invented by Regents' Professor Paul Keim, executive director of PMI: Methods, Kits and Compositions for Detection of MRSA; Compositions and Methods for the Treatment of Fungal Infections; and Methods and Kits to Identify Klebsiella Strains.
- Professor David Wagner was awarded $500,000 by the Defense Threat Reduction Agency to study F. tularensis, which causes rabbit fever. Dr. Wagner also received three awards from the Centers for Disease Control and Prevention totaling $622,553 to conduct environmental sampling in Puerto Rico and the U.S. Virgin Islands in support of public health.
- Joseph Busch, associate director of PMI, is leading a study funded with $500,000 from the U.S. Department of Agriculture (USDA) to secure the sustainability of the U.S. cattle industry by developing genetic tools to prevent cattle fever; he was also awarded $100,000 by the USDA to provide assistance to the cattle industry in Texas.
- Assistant professor Zachary Lerner received $142,185 from the National Institutes of Health to improve walking ability in children with cerebral palsy through wearable assistance training. Dr. Lerner was also awarded $88,364 by the National Science Foundation to enhance neuromuscular participation.
- Assistant professor Emily Cope was awarded $100,000 by the Flinn Foundation for a study conducted in partnership with Mayo Clinic Arizona to determine whether prebiotic fiber supplementation leads to improved clinical asthma outcomes. She also received $60,000 from Cystic Fibrosis Research Inc. to facilitate a better understanding of the microbial ecology of the Cystic Fibrosis (CF) airway and will contribute significantly toward the development of new and more effective treatments for CF.
- The Flinn Foundation awarded professor Frank von Hippel $100,000 to investigate health disparities associated with fungicide exposure among migrant farmworkers and other residents of Yuma, Ariz.
- Assistant professor John Gibbs received $100,000 from Research Corporation to investigate how the shape of microscale self-propelled particles affects their collective dynamics.
- Associate professor Jeff Foster was awarded $60,248 by the U.S. Fish and Wildlife Service to investigate White Nose Syndrome in specific bat populations.
- Two patents were awarded to NAU for technologies co-invented by Regents' professor Kiisa Nishikawa, director of the Center for Bioengineering Innovation: the Actuator Control System and Related Methods and the Elastic Motor-Spring Actuator.
- NAU was awarded a U.S. patent for Ionic Liquids Sterilize and Prevent Biofilm Formation in Skin Wound Healing Devices, co-invented by associate professor of practice Robert Kellar, associate professor Andrew Koppisch and associate professor Nathan Nieto.
- In fiscal year 2019, TRIF funds were used to strengthen resources in NAU's core facilities serving health research communities, including the Imaging and Histology Core Facility and Environmental Genetics and Genomics Lab.



Professor Scott Goetz was awarded $451,431 by the U.S. Army Corps of Engineers to investigate changing vegetation across Department of Defense lands of interior Alaska. Goetz received $290,185 from NASA to address large-scale environmental change and its implications for social-ecological systems in Alaska and Western Canada. He was also awarded $66,076 by NASA to collaborate with the University of Maryland to characterize the effects of changing climate and land use on ecosystem structure and dynamics to enable radically improved quantification and understanding of the Earth's carbon cycle and biodiversity.

NATIONAL SECURITY SYSTEMS

According to the U.S. Department of Homeland Security, the country's economic vitality and national security depend on a stable, safe and resilient cyberspace. Under the fiscal year 2017-2021 Business Plan, Northern Arizona University's investments in the National Security initiative focus on cybersolutions, which are being delivered through NAU's School of Informatics, Computing and Cyber Systems (SICCS).

Cybersolutions address key challenges for secure computing. The most obvious challenge is the need for cybersecurity and encryption that cannot be easily defeated. Novel approaches will include both software designs and embedded encryption in hardware. Reconfigurable computing represents major challenges for cybersecurity due to a need for computing programs that are adaptable and often less secure, e.g., machine learning. Cyberphysical systems will require security to ensure that computers talking to other computers are not corrupted and harm entire systems of machine-to-machine communications. The same concern can be extended to remote sensing data and smart infrastructure systems such as smart cities, smart buildings and even smart cars.

GOALS

- **Develop new secure applications of computing and computer-systems design.**
- **Collaborate with technology-driven industry partners.**
- **Generate nationally recognized science and scholarship by integrating emerging research domains with NAU's areas of strength, including biological and environmental research.**
- **Emphasize scholarly productivity and extramural funding by creating a culture that centers on high expectations and high-impact interdisciplinary research.**
- **Provide cutting-edge training and learning opportunities to students by integrating research into existing curricular programs and building new programs that support 21st-century technological challenges.**

SUMMARY OF ACCOMPLISHMENTS

Northern Arizona University's National Security Systems initiative leverages research, discovery and training to develop and disseminate innovative and secure applications in informatics, computing and cyber systems. This will be accomplished largely through NAU's School of Informatics, Computing and Cyber Systems (SICCS), which was formed to meet the need for advanced interdisciplinary computational and data sciences, and to enable NAU to successfully compete for major external research grants in informatics, cyber systems development and cybersecurity.

- NAU faculty who received TRIF funds through the NSS initiative received more than $1 million in external grant awards in fiscal year 2019.
- Assistant professor Christopher Doughty was awarded $226,182 by NASA to address the role of animals in tropical forests by adding space-based forest structure measurements to an ecosystem model with complex animal ecology (the Madingley model). He also received $71,709 from NASA to determine whether 3D vegetation structure can be detected on Earth from a distance.
- Associate Professor Benjamin Ruddell received $255,908 from Arizona State University to develop a socio-technical framework for deploying adaptation strategies for interdependent power, water and transportation systems. He was also awarded $92,645 by the National Science Foundation to generate and test a conceptual framework centered on drying as a first-order control on stream ecosystems across genetic, population, community and trophic levels of biological organization.
- Professor Kevin Gurney received $182,609 from the National Institute of Standards and Technology to assist in the completion of the Hestia FFCO2 emissions data product for the northern Virginia to Pennsylvania urbanized corridor.
- Professor of Practice Bertrand Cambou was awarded $124,844 by the U.S. Air Force Research Laboratory to develop technology making blockchains resistant to cybersecurity attacks, potentially protecting strategic functions such as financial institutions, smart manufacturing, supply chain and inventory management. He also received $47,808 from CipherLoc for a cryptography project focused on securing communication through the use of true random numbers generators (TRNGs).
- NAU was awarded four patents for new technologies invented by Cambou:
  - Encoding Ternary Data for PUF Environments
  - Data Compiler for True Random Number Generation Related Methods
  - PUF Hardware Arrangement for Increased Throughput
  - PUF-Based Password Generation Scheme
- Assistant Professor Morgan Vigil-Hayes received $104,741 from the University of California Santa Barbara to collaborate on a project funded by the National Science Foundation to offer adaptive, smart Internet connectivity to rural populations, including Native American tribal members.
- NAU launched a new bachelor of data science degree program in fiscal year 2019, with many courses offered in fall 2019 through the Department of Mathematics and Statistics. Data science is the study of storing, accessing and manipulating data, visualizing and modeling relationships within data and drawing inference from data. Graduates from the program can pursue a wide range of careers, including marketing research and medical diagnostic techniques for companies such as internet and pharmaceutical, insurance and marketing companies as well as government agencies.

Professor Kiona Ogle received $156,766 from the National Science Foundation to develop, evaluate and establish a graduate training program for ecological and environmental informatics.

ACCESS AND WORKFORCE DEVELOPMENT

Northern Arizona University continues to build upon more than 30 years of success providing affordable, flexible degree completion programs across Arizona. NAU's TRIF initiative, Access and Workforce Development (AWD) supports statewide and online efforts to connect community members to degrees in the health sciences and education. By integrating instructional technology and advanced learning design, these programs meet both student and employers' needs in their communities throughout the state. A growing number of Arizona adults, many with some college credits, have achieved a higher education degree and career success through NAU's market-driven programs.

Health services and education remain high demand industries in Arizona, with health care having the highest overall gain in jobs. NAU continues to expand nursing program offerings to meet a variety of new and practicing nurse employment and advancement needs. Teacher education continues as a keystone of NAU's legacy, and this initiative supports programming throughout Arizona and online, including the Arizona Teachers Academy.

Providing outstanding support services toward student success and degree attainment are achieved through integrated, on-demand services, informed by the best practices in student retention and coaching, and through the application of adaptive learning technologies.

GOALS

- **Advanced training for high-demand health professions, including expanded concurrent programs with community colleges and a new competency-based nursing program.**
- **Continuing education and advanced degree offerings in teacher education, including the establishment of the NAU Teachers Academy.**
- **Expansion of student success and retention efforts through engaged academic coaching and advising for online and statewide students.**
- **Design and coordination of a coherent and comprehensive teaching and learning support structure for university-wide application.**
- **Applying e-Learning strategies to increase degree productivity; transform how faculty teach; improve how and how much students learn, while preparing students with life-long skills for learning through technology.**
- **Intentional course design for student success with a focus on blended delivery modes and application of adaptive learning technologies for individuation of learning.**

SUMMARY OF ACCOMPLISHMENTS

A key component of the mission and strategic plan of Northern Arizona University is to provide access to higher education and create opportunities for Arizonans, regardless of where they chose to learn. In addition to the residential campus in Flagstaff, NAU offers several programs online and across the state in partnership with local community colleges to meet workforce needs. As the needs of the Arizona workforce evolves, it is vital that access to higher education is flexible and affordable, and that the programs offered are relevant to the marketplace. Equally important is the ability for all students to receive the same high-quality services, regardless of their learning modality or location.

- Building from a solid foundation of concurrent enrollment in RN and BSN programs with 14 community colleges across Arizona, TRIF funds supported NAU's competency-based education (CBE) RN-BSN program and the launch of the new CBE MSN degree. These CBE programs create additional learning options for expanded professional mobility in healthcare. Nursing and other health professions will continue to have high labor market demand into the next decade with an expected growth of 38 percent. Health Care and Social Assistance remain in the top six segments of industry in Arizona by job volume, according to the Bureau of Labor Statistics.

- Established in response to the Arizona teacher shortage, the NAU Teachers Academy's Grow Your Own initiative offers tuition coverage, mentorship and professional development to full-time students earning their first bachelor's degree who agree to be full-time teachers in low-income Arizona schools for a period equivalent to the years they participated in the program. NAU's Teacher Academy partnership with community colleges and school districts statewide expanded from six statewide locations serving 60 students to eight statewide locations serving 100 additional students in fiscal year 2019, ending the spring 2019 term with 27 graduates from the first year cohort.

- The College of Education Educational Psychology program experienced an 18 percent growth in student headcount, with the largest gains — nearly triple the headcount from the year before — in the Masters of Education in School Counseling program. This program is offered at statewide locations in Phoenix and Tucson and is aligned to support the expansion of school counselors and meet the need to provide a qualified workforce for Arizona schools.

- E-Learning continues to work on the development of web-enhanced, blended, hybrid and fully-online (traditional and competency based) courses, with a renewed emphasis on course consistency, quality and student success.

- NAU continues to leverage its strengths in individualized learning and student support as the university provides access to Arizonans who choose to learn away from the main campus. Aligning services for non-traditional learners, such as expanded advising hours, access to Cline Library 24/7, writing support and career development have reinforced NAU's commitment to the success of all students, regardless of their learning modality. From workgroups with e-Learning to standardize and insure quality online courses, to service-focused initiatives to meet the needs of working adults, TRIF dollars provided not just academic programming for Arizona students, but also insured professional advising and support services for statewide and online students, including fieldwork placements for health professionals.

Professor Han-Sup Han received $100,000 from PJ Woodlands LLC to assess the feasibility of operating a wood-plastic composite products production facility at Camp Navajo in Northern Arizona.

WATER, ENVIRONMENTAL AND ENERGY SOLUTIONS

Under the fiscal year 2017-2021 Business Plan, Northern Arizona University's investments in the WEES initiative focus on two areas: Adapting to a Changing Environment (environmental sciences) and Forest Health and Land Management (forest and land). These programs build on NAU's historical strengths in environmental and ecosystem sciences.

Investments in environmental sciences have created two research centers at NAU - the Center for Ecosystem Science and Society (Ecoss) and the Merriam Powell Center for Environmental Research (MPCER). Researchers in Ecoss study the interactions of biological communities to determine how they respond to and influence environmental change. Ecoss prioritizes the training of future scientists and disseminating information about their discoveries to the public. MPCER has been instrumental in advancing cross-disciplinary environmental research and training at NAU with a focus on the Colorado Plateau.

NAU's Forest and Land Management program invests in two research centers: the long-standing Ecological Restoration Institute (ERI) and Landscape Conservation Initiative (LCI). Investments in ERI support the development of solutions to the costly environmental problems of degraded forest health and unnatural wildfire. Losses of revenue from decreased tourism, short-term job losses and damage to water supplies and water quality are just a few of the economic impacts that ERI's work seeks to alleviate. Investments in LCI support applied biological research, collaborative planning and field-based educational experiences to forge new solutions to landscape-scale environmental challenges, bringing strong scientific support to public deliberation and land-management efforts across Arizona.

GOALS

- **Leverage NAU's existing research and intellectual assets to generate external funds.**
- **Create curricular innovations related to key workforce needs in the state and region.**
- **Catalyze an entrepreneurial spirit among university faculty and students.**
- **Build/strengthen partnerships with Arizona environmental and land-management groups.**
- **Generate new environmental business opportunities and jobs in the region.**

SUMMARY OF ACCOMPLISHMENTS

Northern Arizona University's investments under the TRIF WEES initiative have generated increased external funding and enhanced capacity for addressing complex issues in environmental variability and ecosystem science as well as forest restoration and land management. Because of this enhanced capacity, NAU researchers have been enabled to develop solutions to some of the unique environmental challenges of the southwestern United States.

- NAU faculty who received TRIF funds through the WEES initiative received more than $4 million in external grant awards in fiscal year 2019.
- Assistant Research Professor Kevin Grady received $360,000 from the U.S. Forest Service to improve conservation and management of forest resources in Puerto Rico and the U.S. Virgin Islands by expanding current knowledge of how tree species vary in ecosystem functioning during drought and in response to hurricanes. Grady was awarded $170,000 by the National Forest Foundation to restore an 11-mile stretch of the Salt River near the City of Phoenix by removing exotic plant species, planting over 500,000 native plants and developing educational and volunteer opportunities. He also received $139,935 from the Forest Service to collaborate on a new strategy for improving reforestation efforts on the Coconino National Forest.
- Regents' Professor Andrew Richardson received $168,926 from the Battelle Memorial Institute for a project funded by the National Science Foundation to continue support of a collaborative project between the National Ecological Observatory Network (NEON) and the PhenoCam network. He was also awarded $97,991 from UT-Battelle to assemble and analyze data sets on vegetation phenology at the Spruce and Peatland Responses under Changing Environments (SPRUCE) experimental site.

Professor Ted Schuur was awarded $511,140 by the National Science Foundation to investigate the potential impact of carbon release from Arctic permafrost.

SPACE EXPLORATION AND OPTICAL SOLUTIONS

Under the fiscal year 2017-2021 Business Plan, Northern Arizona University's investments in the SPACE initiative focus on three areas - solar system origins, Mars and exoplanets. These programs build on NAU's historical strengths in astronomy and planetary science, while leveraging Arizona's abundance of world-class telescopes, observatories and state-of-the-art imaging systems.

Solar system origins researchers study the formation and evolution of the solar system, detecting and characterizing the physical and chemical properties of rocky asteroids that could potentially impact the Earth. They are looking for the elusive "Planet X," a large and undiscovered planet in the most distant regions of the solar system. They are also studying objects in the Kuiper Belt, a vast region of comets and other icy objects beyond the orbit of Neptune.

Mars researchers use spacecraft data to study the geology of the Red Planet while hunting for water and life on its surface. Faculty members and their students direct the path and daily tasks of the NASA Curiosity Rover on the surface of Mars from the NAU campus; they also build flight instruments for spacecraft bound for Mars.

Exoplanets researchers study planets orbiting distant stars using telescopes and computer simulations to characterize their physical and chemical properties. The researchers' goal is to identify which of the thousands of known exoplanets are the best candidates to harbor life and are therefore worthy of further study.

GOALS

- **Double external research funding in astronomy and planetary science.**
- **Partner with Arizona companies to develop instrumentation for shoe-box sized spacecraft (CubeSats).**
- **Fly a CubeSat to an extraterrestrial object, such as an asteroid.**
- **Expand partnerships with private observatories such as Lowell Observatory, FRoST and ATLAS.**
- **Build and/or operate small telescopes such as FRoST and ATLAS to detect potentially hazardous near-Earth asteroids.**
- **Continue to operate and expand the capabilities of the Astrophysical Ice Laboratory on the NAU campus.**

Assistant Professor Ryan Behunin was awarded $90,000 by the University of California Santa Barbara for a project funded by the U.S. Department of Energy to develop a low-power, low-cost, compact technology to address future power and bandwidth scaling limitations resulting from exponential growth in Data Center Interconnect (DCI) traffic.

Assistant Professor Cristina Thomas was awarded $117,358 by the University of Tennessee to investigate volatiles on the surfaces of Near-Earth Objects (NEOs).

SUMMARY OF ACCOMPLISHMENTS

As the first International Dark Sky City, Flagstaff — at 7,000 feet above sea level — is a natural location for studying astronomy and planetary sciences. Through TRIF investment in the Exploring Planetary Systems research initiative, Northern Arizona University is developing unique and cutting-edge research and academic programs in solar system origins, Mars and exoplanet research. TRIF investment enables NAU to expand its partnerships with Lowell Observatory and the U.S. Naval Observatory, and provides access to highly sought-after telescopes such as the Discovery Channel Telescope, the Flagstaff Robotic Survey Telescope and the United Kingdom Infrared Telescope (UKIRT) in Hawaii under a partnership with the University of Arizona.

NAU researchers leverage TRIF support with external funding to discover new ways of exploring space, to contribute to a new understanding of our place in the universe and to seek opportunities to translate research into economically productive innovations with commercial applications.

- NAU faculty who received TRIF funds through the SPACE initiative received nearly $2 million in external grant awards in fiscal year 2019.
- Assistant Professor Mark Salvatore was awarded $197,152 by the National Science Foundation to examine microbial communities in Antarctica using high-resolution satellite data to better understand what controls the distribution and activity of life in harsh environments, with applications on Earth as well as on other planets.
- Assistant Professor Christopher Edwards received $159,809 from NASA to investigate how thermophysical data gathered in extreme environments on Earth can help identify habitable environments on Mars and other planets. He was also awarded $75,349 by Johns Hopkins University for a project funded by NASA to study the physical, spectroscopic and thermophysical properties of equatorial layered deposits on Mars.
- In fiscal year 2019, TRIF funds were used to strengthen partnerships with telescope facilities used by NAU astronomers and planetary scientists, including the Hawaii Telescope Partnership (UKIRT) with the UA and the Discovery Telescope Partnership with Lowell Observatory.

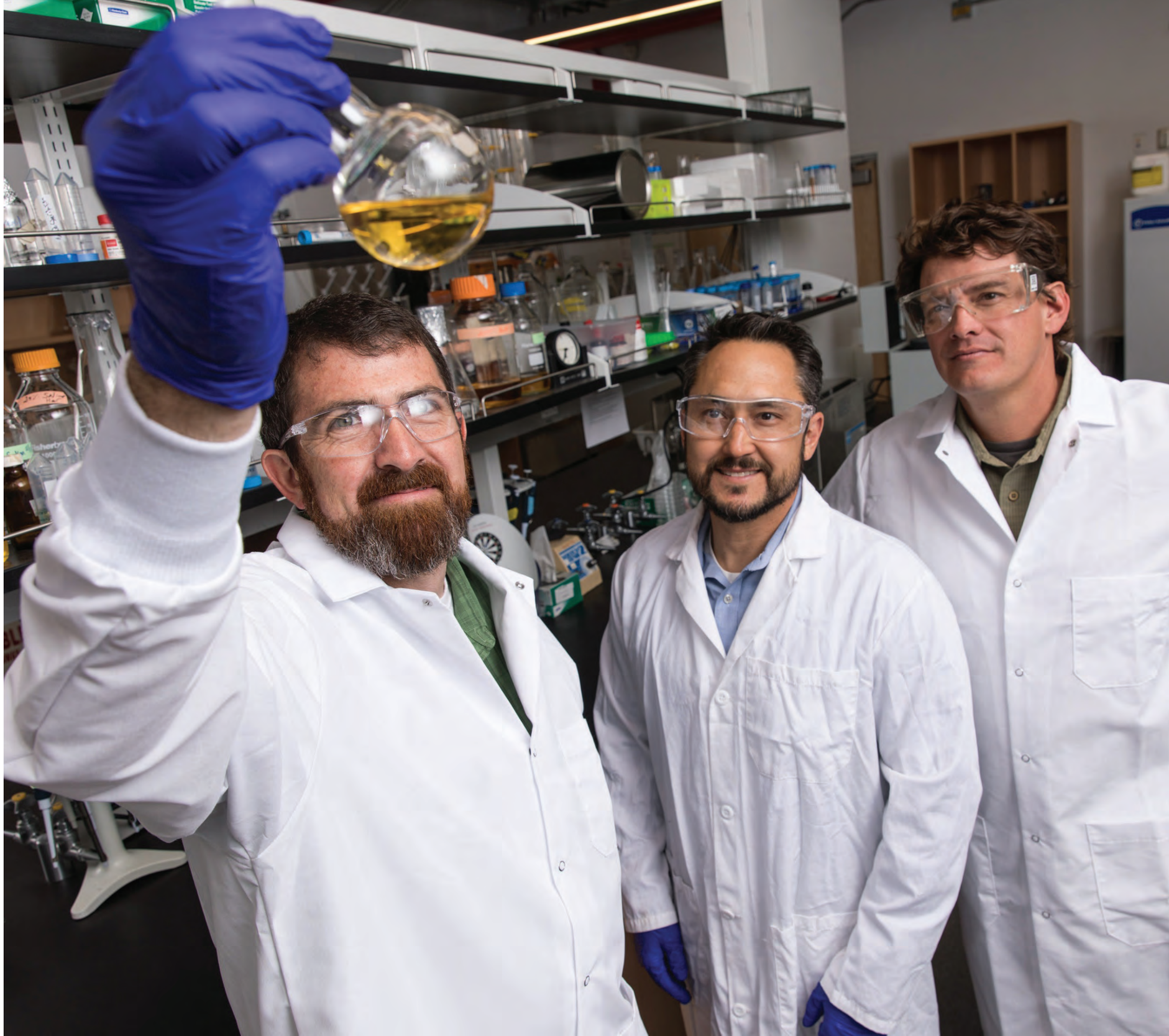
HIGHLIGHTS

At 7,000 feet and beyond, Northern Arizona University's researchers are elevating our quest for knowledge — now more than ever. NAU continues to generate impressive research outcomes, and TRIF funding is a strong mainstay, enabling NAU to make strategic investments that promise to sustain this growth well into the future.

TRIF funding has provided the foundation for NAU to attract new external research funding; increase the capability to develop inventions with high potential for technology transfer; and strategically invest in workforce development. These accomplishments enhance Arizona's research enterprise and reputation while addressing critical health care, defense and security, land and water management and space exploration issues facing the world today. Strategic investments in high-research faculty, research centers and new graduate programs have enabled NAU to make significant financial impact progress, generating technology transfer activity, including invention disclosures, patents issued, licenses and options.

TRIF resources have enhanced NAU's educational infrastructure and capability to prepare its students to be complex problem solvers addressing the workforce needs of today and an increasingly diversified workforce for the future. These investments develop new talent, as demonstrated by the increasing number of NAU graduates who are staying in Arizona to live and work after graduation, as well as attracting new talent to Arizona to study, teach and research.

NAU's TRIF initiative in Access and Workforce Development aligns with NAU's mission to serve the state of Arizona through accessible education delivery models. This initiative includes the integration of technology and advanced learning designs to increase student engagement across all of NAU's campuses. The primary focus of this effort is to provide educational alternatives to attending a residential campus in order to meet both student demands for a degree and workforce needs in local communities. NAU has advanced this effort through community campuses, in partnership with community colleges, online learning and the competency-based Personalized Learning program. Attaining 212 percent of the 2021 TRIF goal in this area is reflective of NAU's successful efforts. NAU graduated 1,318 nurses and teachers at locations other than Flagstaff, throughout Arizona and online in the 2018-19 academic year. These graduates meet critical workforce needs and represent the opportunity to transform education and health care in communities where they live and work.




NOW
THE UNIVERSITY OF ARIZONA

UNIVERSITY OF ARIZONA

As the largest research university in the state, with nearly $690 million in research expenditures, the University of Arizona is producing results that are creating impactful solutions to many global problems, preparing students for the workforce of tomorrow and contributing as one of the largest economic engines for Arizona.

The philosophy of UA's Technology and Research Initiative Fund (TRIF) program is to advance economic development opportunities and benefit Arizonans. The university does this by catalyzing research and development; supporting the infrastructure, facilities and computing that enables cutting-edge research and development; producing results that leverage UA's expertise; and attracting outside resources to the state.

The UA is combining that philosophy with the newly approved Strategic Plan, inspired by the Fourth Industrial Revolution – a time of augmented intelligence and the fusion of digital, physical and biological worlds. The UA's plan is bold and distinctive with 90+ initiatives organized under five pillars.

The UA participates in the following TRIF initiatives:

- **Improving Health:** Health care is changing, and the UA is at the forefront of the precision health movement — finding individual solutions to medical problems by taking into account individual variation in genes, environments and lifestyles. TRIF investments in Improving Health allow the BIO5 Institute — which aims to harness the power of its five disciplines (agriculture, engineering, medicine, pharmacy and science) — to connect and mobilize hundreds of world-class plant, animal and human bioscientists, engineers, physicians and computational researchers to develop creative solutions for complex challenges such as disease, hunger, water and food safety, and other environmental issues facing Arizona.

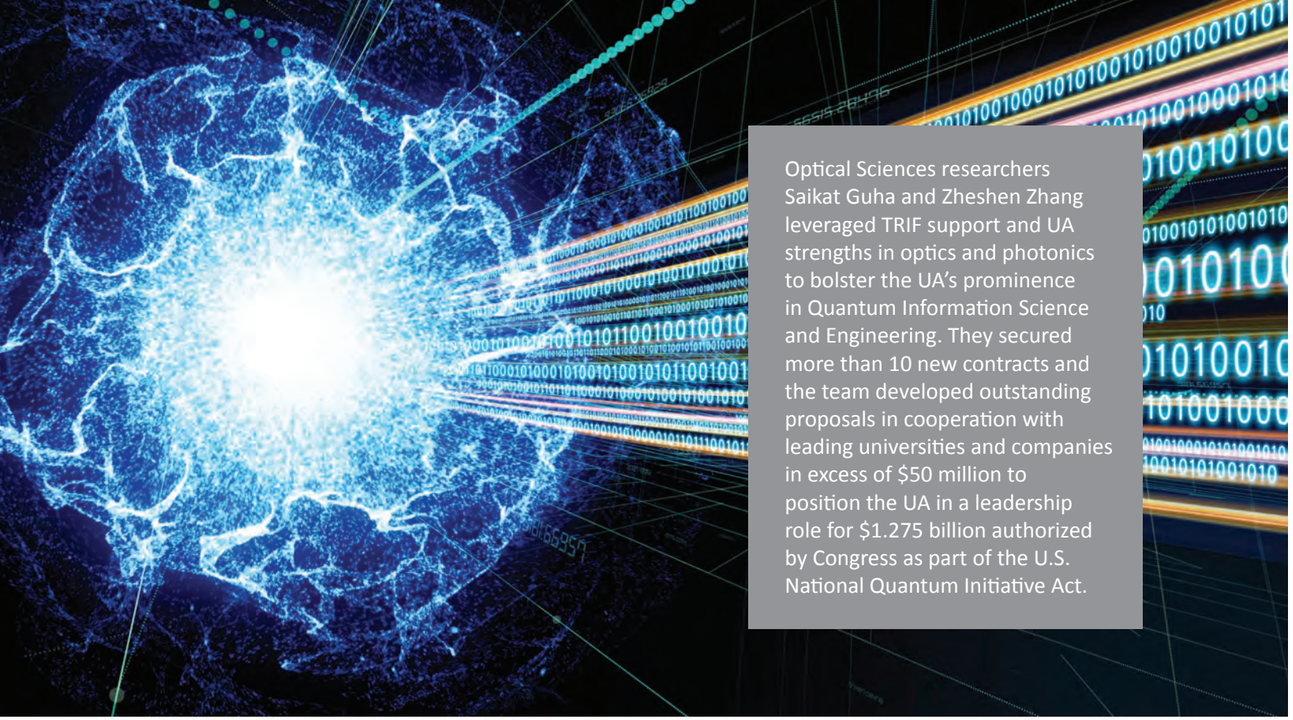
- **Water, Environmental and Energy Solutions:** The UA has been recognized as the world's No. 1 program in water resources by the Shanghai Academic Ranking of World Universities for the second consecutive year, recognizing outstanding leadership in water research. The WEES initiative invests TRIF dollars in cutting-edge food, energy and water research, cross-campus collaborations and innovative partnerships that promote fresh ideas, technologies and effective resource management practices necessary to help sustain a swelling global population. The UA's decision-support tools that integrate rainfall data into transportation and agricultural scenario planning as well as research on how groundwater pumping affects rivers, makes Arizona a safer and healthier place to live, now and in the future.

- **National Security Systems:** Harnessed by UA's Defense and Security Research Institute, researchers are finding effective and practical solutions in one of the most critical areas of research today — national security. The UA's National Security Systems initiative impacts a range of technology and research at the university — from optics to high-temperature materials to hypersonics.

- **Space Exploration and Optical Solutions:** The UA continues as an international research powerhouse in both space science and optics. Not only does the campus sit at the center of "Optics Valley" — a high concentration of optics companies and research in Southern Arizona - but it also has led space system development since the inception of the U.S. space program. Given these strengths, it's no surprise that SEOS is the most lucrative of the UA's TRIF initiatives, with an almost 8-fold return on investment. Strategies in this area will help the university continue to reach farther, faster, in this age of information and space exploration.

"TRIF funding enables the University of Arizona to advance knowledge and its applications by investing across our institution so that we not only stimulate the highest quality thought leadership, research and scholarship, but also allow our faculty, students and staff to translate knowledge into impact. We focus on challenges of the Fourth Industrial Revolution, fusing the digital, physical and biological worlds to benefit the people of Arizona. For example, TRIF funding has allowed our talented researchers to develop forecasting models that can warn motorists of impending weather-related hazards such as wind, heavy rains, and blowing dust. TRIF has also enabled research into the role of gender in Alzheimer's disease and the development of novel precision medicine interventions to prevent and potentially reverse the course of the disease in women and men. With the guidance of our clear pillars of value to Arizona, outlined in our recently approved Strategic Plan, we will continue to leverage our TRIF dollars to provide an even bigger impact to our state for generations to come."

- Dr. Elizabeth Cantwell, Senior Vice President, Research and Innovation



Optical Sciences researchers Saikat Guha and Zheshen Zhang leveraged TRIF support and UA strengths in optics and photonics to bolster the UA's prominence in Quantum Information Science and Engineering. They secured more than 10 new contracts and the team developed outstanding proposals in cooperation with leading universities and companies in excess of $50 million to position the UA in a leadership role for $1.275 billion authorized by Congress as part of the U.S. National Quantum Initiative Act.

SPACE EXPLORATION AND OPTICAL SOLUTIONS

The TRIF Space Exploration and Optical Solutions (SEOS) initiative seeks to expand educational opportunities for Arizona students in optics, astronomy and space sciences; incubate novel, high-impact research directions; and support regional economic development by leveraging the UA's world-renowned optics education and research resources.

TRIF funding in this area in the form of direct faculty hire support and seed grants has been critical to the UA's growing activity in Quantum Information Science and Engineering, where the quantum nature of light plays a critical role in quantum computing, networking and sensing. With the potential for rapid advances, the economic and national security implications of quantum technologies are truly game changing.

GOALS

- **Leveraging TRIF funds to obtain a ten-fold return on investment through increased external research funding to support more students.**
- **Identifying and supporting key optics, engineering and science faculty hires in areas aligned with the UA strategic plan and the needs of the state of Arizona.**
- **Creating new shared imaging and photonics infrastructure and facilities that broadly benefit the UA's research and education mission.**
- **Supporting Arizona workforce development directly through increased student fellowships and enhancing the UA's outreach to companies and underrepresented populations in Arizona to increase the number of trained minority students.**
- **Encouraging technology transfer, creating new Arizona startup companies and expanding innovation activities.**

SELECTED ACCOMPLISHMENTS

- The UA is advancing research growth in Quantum Information Science and Engineering (QISE). Researchers Saikat Guha and Zheshen Zhang from the James C. Wyant Colleges of Optical Sciences and the College of Engineering leveraged TRIF support and UA strengths in optics and photonics to lead collaborative efforts across campus, bolstering the UA's prominence in QISE, an internationally competitive focus. In fiscal year 2019, this team secured more than 10 new contracts with an annual UA expenditure totaling $2.5 million. In cooperation with the nation's leading universities and companies, the team also developed outstanding proposals in excess of $50 million to position the UA in a leadership role for the $1.275 billion that Congress authorized as part of the U.S. National Quantum Initiative Act. TRIF funds in this area also have supported three additional new faculty.

- UA is training a new generation of scientists and experts. UA researchers were awarded $3 million in NASA funding over three years to study the low-gravity surface environments of asteroids and provide students from underrepresented backgrounds the opportunity to design, build and operate CubeSats, or miniature satellites at the UA. The project was selected through NASA's Minority University Research and Education Project Institutional Research Opportunity, or MIRO, program. The UA, which was designated a Hispanic-Serving Institution in 2018, is one of eight institutions to receive a share of more than $8.2 million in cooperative agreements awarded through the MIRO program. Erik Asphaug, deputy principal investigator for the project, received TRIF funds as part of the Space Exploration and Optical Solutions initiative.

- UA innovations in space imaging and adaptive optics are being transformed into new applications. Results of work by Associate Professor Michael Hart are proliferating into applications that range from national security to interstellar space exploration. His research on adaptive laser beam steering through our turbulent atmosphere has become important in a number of contexts, including the efficacy of ground-based laser spacecraft propulsion as part of the Starshot project, funded by the Breakthrough Foundation. TRIF startup funds and instrumentation funding also enabled Hart to develop new methods to monitor the motion and behavior of artificial satellites in geosynchronous orbit.

- The UA's footprint in photonics is increasing. As an extension of the UA's TRIF-supported leadership and participation in Manufacturing USA's $600 million AIM Photonics program, Robert Norwood is leading a $2 million effort with an industry team in demonstrating advanced infrared imaging solutions that use integrated photonics to extract high-speed imaging data from cryogenic focal plane arrays used by the defense and intelligence community to view remote adversaries and targets through long distances in the atmosphere.

Professor Michael Hart and his research group work in novel adaptive optics and imaging systems capable of monitoring natural and artificial objects in space, and also the precise direction of optical beams. "TRIF support has given us the unique tools we needed to develop unprecedented capabilities that are enabling both to astronomy and national security applications," Hart said.

Landscape architecture graduate students Jon Choi and Jenny Moscato use WEES-supported Maker Space to build a Rural Hack Kit with sensors for soil moisture, light, temperature and humidity for environmental monitoring. They plan to take their new skills into professional design practice.

WATER, ENVIRONMENTAL AND ENERGY SOLUTIONS

University of Arizona research supported by TRIF in the Water, Environmental and Energy Solutions initiative is developing innovative, practical solutions for water, environmental and energy sustainability in Arizona. Research findings are applied globally, because many other semiarid regions face increasing natural resource demands as well as uncertainties related to drought and extreme events. Projects in this initiative are helping to secure adequate supplies of clean water for Arizona's economic vitality, optimize sustainable stewardship of Arizona's lands, create resiliency in the face of climate variability and advance Arizona's leadership in the renewable energy industry.

GOALS

- **Building on the UA's world-renowned expertise in water and climate variability and its emerging excellence in the renewable energy sector to enhance multidisciplinary collaboration for science, technology and resource management.**
- **Focusing on use-inspired research performed by multidisciplinary teams that will result in innovative, practical solutions for Arizona and beyond.**
- **Leveraging investment in strategic areas to increase public and private funding and commercialization of research results in tech and industry.**
- **Training a new generation of scientists, engineers and other professionals to meet state and national needs.**

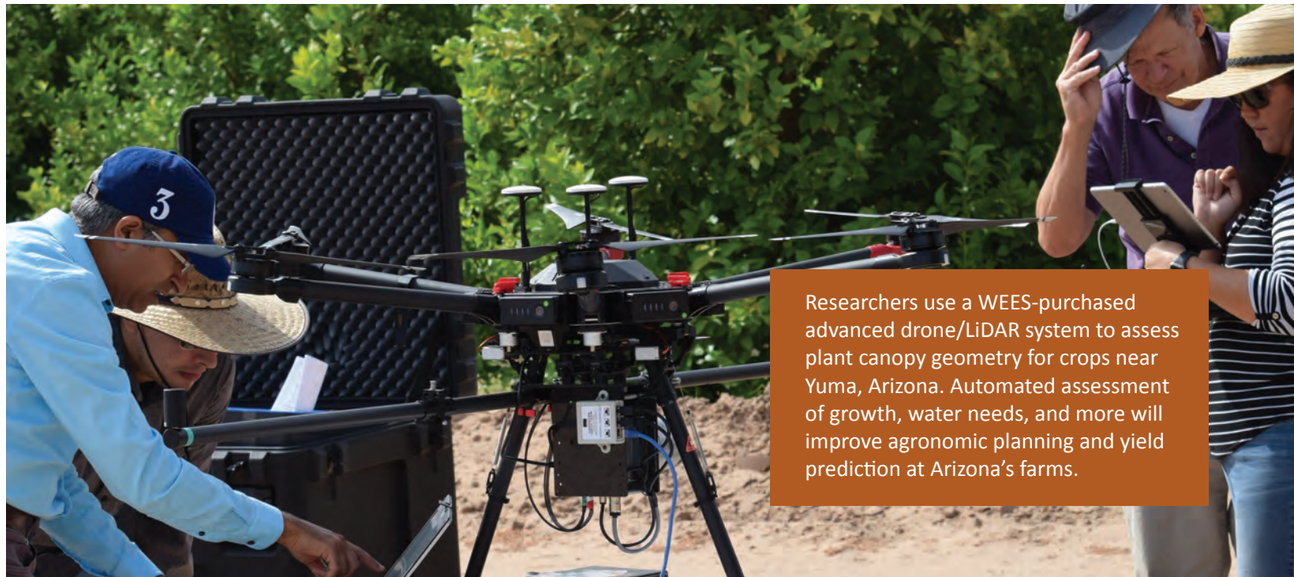
SELECTED ACCOMPLISHMENTS

- The UA is building resiliency in arid ecosystems. The majority of Arizona residents live in arid and semiarid portions of the state, and WEES investments are advancing innovative research to address their concerns as temperatures rise and precipitation becomes less predictable. William Kolby Smith is expanding Grass-Cast, which employs meteorological and satellite data to predict rangeland productivity and decrease uncertainties for management of natural resources and livestock as precipitation regimes change over time. Raina Maier, Julia Neilson, and their team are researching the arid soil microbiome to determine the impact of increased aridity on soil productivity in marginal arid ecosystems. Additionally, Luke McGuire and his students are seeking a better understanding of natural hazards in recently burned terrain by studying the contributing hydrologic and geologic factors. Better understanding of post-wildfire flooding and debris flows will help mitigate the costly consequences of these events.

- At the UA, science is employed to solve real-world problems. Municipalities, consultants and public agencies rely on data from the UA for projects vital to our state's public health and decision making. Chris Castro helped the Arizona Department of Transportation reduce vehicular accidents with an alert system that incorporates his models of weather-related hazards such as snow, heavy rain and blowing dust. Greg Hodgins at the Accelerator Mass Spectrometry Laboratory uses radiocarbon and other dating methods to better understand groundwater resources and pre-history. Hydrologists and archeologists around the state contract with his lab, which also provides data to the Arizona State Museum and the Montezuma Castle National Monument. In addition, the UA Arizona Laboratory for Emerging Contaminants provides critical data for public health decision making with its analyses of environmental contaminants such as lead, arsenic, TCE and PFAS (per- and poly-fluoroalkyl substances).

- The UA is supporting Arizona's mining industry. Isabel Barton's work to remotely identify clays and other minerals that pose problems for mining and mineral processing is enabling Arizona mining companies to mine more efficiently, more safely and with less water usage. Another UA researcher, Hongyue Jin, is collaborating with four national laboratories to assess the economic feasibility and commercialization potential of using novel technologies to extract rare earth elements from end-of-life products such as coal byproducts and hard disk drives.

- Tumamoc Hill, an 860-acre living laboratory with more than 1,000 daily recreational visitors, is home to a top collection of late Pleistocene megafauna paleofossils. WEES refurbishments ensure these fossils are preserved and remain a vibrant teaching and research tool. Water education also is critical for our future. Last year, Arizona Project WET held 53 days of professional teacher development, transferring knowledge to 62,068 students statewide. Additionally, more than 350 people from across the state attended the Water Resources Research Center's annual conference, Arizona Runs on Water: Scarcity, Challenges, and Community-based Solutions.



Researchers use a WEES-purchased advanced drone/LiDAR system to assess plant canopy geometry for crops near Yuma, Arizona. Automated assessment of growth, water needs, and more will improve agronomic planning and yield prediction at Arizona's farms.

IMPROVING HEALTH

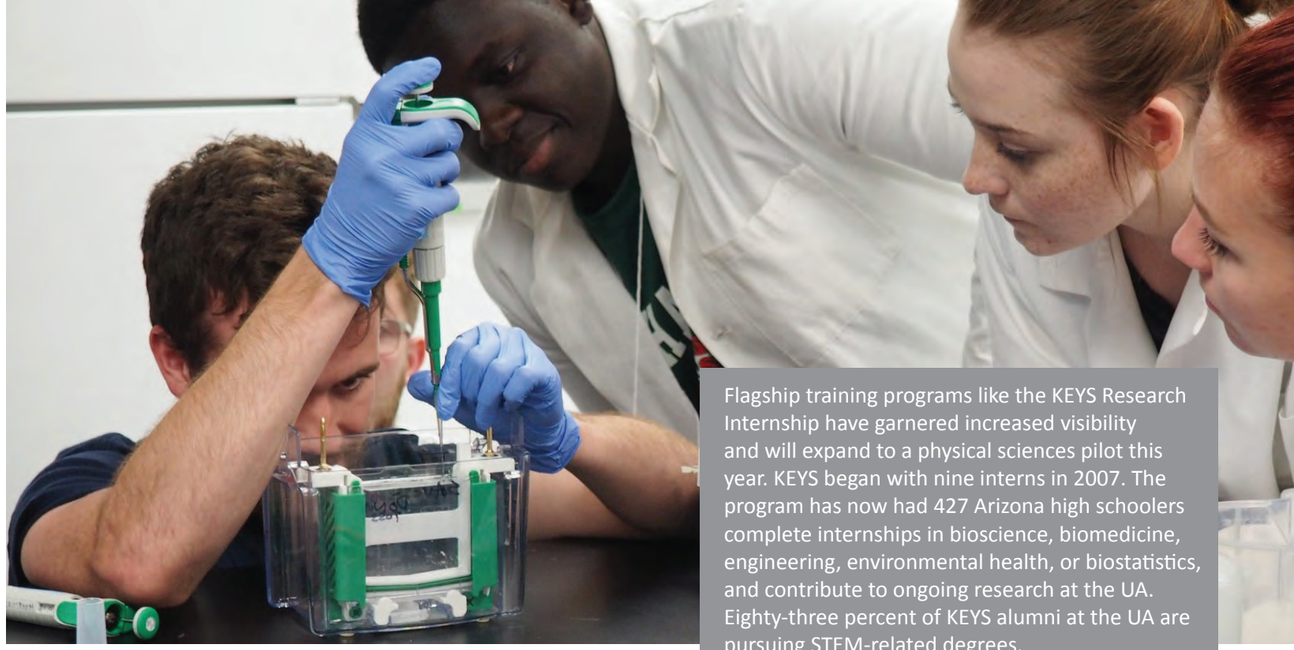
TRIF investments in Improving Health allow the BIO5 Institute to connect and mobilize hundreds of world-class plant, animal, and human bioscientists, engineers, physicians and computational researchers to develop creative solutions for complex challenges such as disease, hunger, water and food safety, and other health issues facing Arizona. This is done through a catalytic translational bio- and health-sciences research infrastructure, including collaborative institutes, centers and core facilities, as well as the advanced training of next generation scientists and physicians via UA's two medical schools. This interdisciplinary approach has resulted in improved food crops, innovative diagnostics and devices, disease prevention strategies and promising new therapies.

Improving Health areas for investment are carefully chosen to align with areas of state and national need and for which University of Arizona faculty already have significant expertise. This strategy catalyzes the capacity to expand impact and innovation, economic opportunity for the state and external funding opportunities.

GOALS

- **Fostering collaborative projects on novel treatments for asthma, cancer, valley fever, diabetes, sudden cardiac death, malnutrition, infectious disease, and Alzheimer's and other age-related brain diseases.**
- **Strengthening and expanding translational research by recruiting the best and brightest faculty to Arizona and supporting projects that will advance the development of new medicines, devices, diagnostics, and nutritional and therapeutic strategies.**
- **Engaging and training future generations of scientists by maintaining successful outreach and internship programs to promote experiential learning and STEM literacy in the state.**
- **Expanding shared resources in computational biology, imaging, high throughput screening, genomics, proteomics and cell analysis across all life science disciplines to expedite large-scale, team science grants that will boost federal research funding, serve as a resource for local industry and create new services and companies in Arizona.**
- **Promoting an entrepreneurial culture in which scientists work across disciplines to accelerate commercial translation of research breakthroughs.**

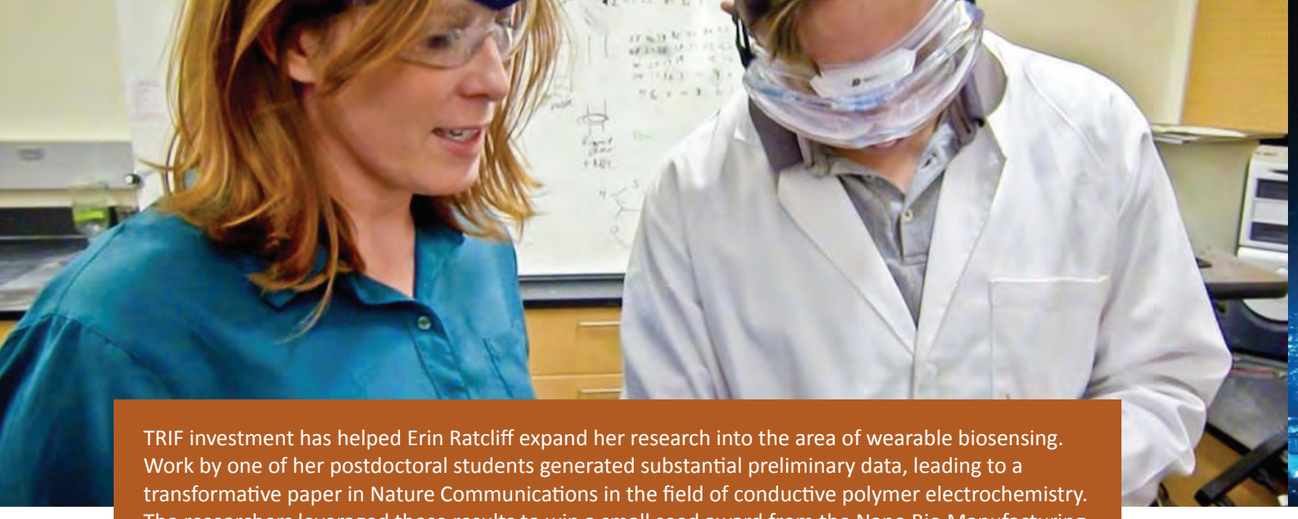
An interdisciplinary research team led by Melissa Herbst-Kralovetz completed a first-of-its-kind study that could aid in the treatment, diagnosis, and prevention of cervical cancer by identifying cervicovaginal metabolic signatures, or "fingerprints," that distinguish patients with HPV, pre-cancerous cervical conditions and cancer.



Flagship training programs like the KEYS Research Internship have garnered increased visibility and will expand to a physical sciences pilot this year. KEYS began with nine interns in 2007. The program has now had 427 Arizona high schoolers complete internships in bioscience, biomedicine, engineering, environmental health, or biostatistics, and contribute to ongoing research at the UA. Eighty-three percent of KEYS alumni at the UA are pursuing STEM-related degrees.

SELECTED ACCOMPLISHMENTS

- The UA is helping to prevent and cure disease in our state's most vulnerable. A research team led by Roberta Diaz Brinton received a $5.9 million grant to study the role of gender in Alzheimer's disease and develop precision medicine interventions to prevent and potentially reverse the course of the disease in women and men.
- The univeristy is enabling novel solutions to health and environmental challenges. People living in dry climates worldwide experience the problems wrought by dry air and blowing dust, which affects everything from respiratory health to cars and other machinery. To address the problem, a research team led by inventor Minkyu Kim has developed an environmentally safe biocompatible polymer blend that, when added to water used for dust control, keeps the ground damp for more than two months, even when exposed to the open desert air. This product is being commercialized through Clean Earth Tech as a new way to control dust in arid environments and places such as mines, construction sites and subway tunnels.
- Leading hands-on education and workforce development programs through the UA prepares students to thrive in a rapidly changing world. Flagship training programs like the KEYS Research Internship have garnered increased visibility and expanded to a physical sciences pilot in fiscal year 2019. KEYS began with nine interns in 2007. Now, 427 Arizona high schoolers — at least half of whom are from backgrounds traditionally underrepresented in science careers — have completed KEYS internships in bioscience, biomedicine, engineering, environmental health or biostatistics and have contributed to ongoing research projects across the UA. Many KEYS interns decide to continue their studies as undergraduates at one of Arizona's public universities: 72 percent have chosen to stay in the state for college, with the majority of those attending the UA. Eighty-three percent of KEYS alumni at the UA are pursuing STEM-related degrees.
- Discoveries are supported through commercialization at the university. To lower the need for invasive procedures, researchers Bernard Futscher and Lukas Vrba have combined the latest discoveries in epigenetics with new methods in informatics to create a new breed of "liquid biopsy" — a blood test for screening, detecting and monitoring most major cancers. The researchers also have launched the startup DesertDx to bring the invention to doctors and their patients.
- An interdisciplinary research team led by Melissa Herbst-Kralovetz has completed a first-of-its-kind study that could aid in the treatment, diagnosis and prevention of cervical cancer by identifying cervicovaginal metabolic signatures, or "fingerprints," that distinguish patients with HPV, pre-cancerous cervical conditions and cancer.



TRIF investment has helped Erin Ratcliff expand her research into the area of wearable biosensing. Work by one of her postdoctoral students generated substantial preliminary data, leading to a transformative paper in Nature Communications in the field of conductive polymer electrochemistry. The researchers leveraged those results to win a small seed award from the Nano Bio Manufacturing Consortium to develop a simulation for predictive design of wearable sweat sensors.

Daniel C. Kilper has been instrumental in supporting research into fiber optics that will enable future smart city technologies and 5G wireless networks. Working as part of a five-university consortium, the UA team members developed and prototyped the fiber optic test platform for COSMOS, the most advanced smart city network testbed in the world. The COSMOS testbed will help researchers explore truly game-changing technologies.

NATIONAL SECURITY SYSTEMS

With TRIF funding for the National Security Systems (NSS) initiative, the University of Arizona is leveraging its expertise to bring new resources and opportunities to the state. The university's tradition in space research, leadership role in precision health care and optics, and expanding collaborations with the defense and aerospace industries position the UA for continuing growth in this area.

These NSS efforts have been facilitated through the UA's Defense and Security Research Institute (DSRI) and are expected to grow as the university transitions DSRI to the University of Arizona Applied Research Corp., or UA-ARC. The new nonprofit corporation will harness existing and emerging UA research strengths, including optics, hypersonics, quantum information science, artificial intelligence and machine learning, cybersecurity, aerospace, and medicine to solve some of the most complex problems facing the nation.

UA-ARC is structured to meet stringent federal requirements for defense, security and intelligence projects, including nonprofit reporting requirements and cost accounting, security and other regulatory requirements not mandated for current research projects at the UA.

In fiscal year 2019, NSS had a number of notable successes, including advancements in developing astronomical instruments specifically optimized for satellite characterization, understanding how quantum mechanics can change everyday life, and developing and characterizing new printable electronic materials and next-generation flexible electronic devices.

GOALS

- **Increasing external U.S. Department of Defense and private-sector research and development funding to scale capacity.**
- **Strengthening and expanding defense- and security-related research by recruiting the best and brightest faculty to Arizona and supporting projects that will advance the development of new technologies and products to aid in securing national interest.**
- **Supporting workforce development directly through student research teaming experiences in partnership with defense agencies, the UA and industry.**
- **Setting the stage for innovation and commercialization of research results by spawning invention disclosures that will support future licensing and spinout companies.**

SELECTED ACCOMPLISHMENTS

- Working as part of a five-university consortium, a UA team developed and prototyped the fiber-optic test platform for COSMOS, the most advanced smart city network testbed in the world. Primarily funded through the National Science Foundation, the COSMOS testbed will help researchers explore truly game-changing technologies that will rely on low-latency and high-bandwidth networks not available commercially today. One such technology that the UA team is pursuing through TRIF funding is a ubiquitous edge-cloud computing environment that takes the cost and complexity out of computing, making it more accessible for all.
- The UA is bolstering National Security Systems capacity to meet a global need. Man-made, non-functioning objects — space debris — litter Earth's orbit, posing an economic and scientific threat, as they could collide with operational satellites and interfere with space missions and astronomical observations. Aaron Rosengren's research applies dynamical systems theory to space situational awareness and space-traffic management to define perennial ad-hoc practices and policies to make space a sustainable resource. Closer to Earth's surface, Mohammed Shafae, is developing tools and techniques to increase the resiliency of critical manufacturers against the threat of attacks, preserving their ability to securely produce high-quality products.
- TRIF investment has helped the UA increase research opportunities. Erin Ratcliff has expanded her research into the area of wearable biosensing. Work by one of her postdoctorate students, who received funding from the NSS initiative in 2017, generated substantial preliminary data, leading to a transformative paper in Nature Communications in the field of conductive polymer electrochemistry. The researchers leveraged those results to win a small seed award from the Nano Bio Manufacturing Consortium ($100,000/one year) to develop a simulation for predictive design of wearable sweat sensors. The team is proposing a new project this year to the same consortium for $750,000/18 months, which will employ four graduate students and lead to prototype development of sweat sensors. Work by another researcher, Douglas Loy, to advance 3-D printing has resulted in associations and relationships with leaders in additive manufacturing in academia and industry, including Honeywell, Stratasys, PADT, General Electric, Northrup Grumman and Boeing. The relationship with Honeywell also has resulted in the UA becoming a member of additive manufacturing organizations that will help with new program development.
- TRIF funds are providing the opportunity for students to gain real-world experience and preliminary data required for larger federal and industrial grant proposals that include a student-engagement component. The most current TRIF-enabled support is a $10,000 Faculty Seed Grant, which enabled three graduate students to travel to the Stanford Synchrotron Radiation Light source to do structural measurements of printed organic semiconductors. Results were used in a pending proposal to the Department of Energy Basic Energy Science and an upcoming proposal to the NSF. If successful, each of these federal efforts will result in sufficient funds for two graduate students. Additionally, the proposed NSF grant includes an outreach component to develop a new Summer Engineering Academy topic: Arizona Renewable Energy Camp, a one-week summer camp experience for underrepresented minority high school students. Student recruitment will target Flowing Wells High School in Tucson and students who matriculate to the UA will have the opportunity to do undergraduate research in the principal investigator's laboratory.

HIGHLIGHTS

The University of Arizona has made substantial progress toward 2021 goals. With overall Technology and Research Initiative Fund expenditures of $29.4 million, the UA's calculated financial impact (sponsored awards, gifts and other sources and royalty income) of these investments was $209 million, well over the expected projections of $165 million.

Technology transfer activity also beat projections. Fiscal year 2019 patents issued were well above budget – up about 600 percent. Invention disclosures were approximately 20 percent above expectations, and the number of university startups were almost double the projections.

The mission of the UA's Technology and Research Initiative Fund will continue to deliver economic value and public benefit to the state of Arizona and the university will use the funds in concert with the blueprint of the recently passed UA Strategic Plan. The framework is inspired by the Fourth Industrial Revolution, or 4IR – a time of augmented intelligence and the fusion of digital, physical and biological worlds. The UA embraces the duty and privilege to serve the needs of the state and its citizenry as this new era unfolds.

The approach promises to develop adaptive learners who will lead meaningful lives and improve society in a 4IR economy; invest in discovery, research and innovation to tackle the world's toughest challenges; leverage Arizona's unique assets and diversity as a competitive advantage; and continue to build the UA's role as an integral member of local and global communities.

The strategy is based on five strategic pillars:

- The Wildcat Journey: Driving student success for a rapidly changing world.
- Grand Challenges: Tackling critical problems at the edges of human endeavor.
- The Arizona Advantage: Advancing our land grant mission to drive social, cultural and economic impact.
- UA Global: Engaging the world.
- Institutional Excellence: Ensuring UA lives its values and innovative culture to enable an efficient, high-performing academic and administrative enterprise.

The UA has a history of maximizing the dollars it receives through the TRIF initiative. The university will continue that trend as an economic engine for the state by creating strategic partnerships with industry, communities and stakeholders both in the U.S. and overseas to advance the research and development enterprise, speed innovation and deliver public benefit.

As the UA unfolds the strategic plan, the university will work to combine recently established values – integrity, exploration, inclusion, adaptation, determination and compassion – to provide even more impact with TRIF funding. This will help fulfill the UA's vision: creating a world where human potential is realized and we're all working together to create solutions to big problems so that life in our communities, in Arizona and our planet can thrive.

ARIZONA BOARD OF
REGENTS
ASU ◆ NAU ◆ UA

ARIZONA BOARD OF REGENTS

TRIF FUNDS ADVANCE ARIZONA

The Technology and Research Initiative Fund (TRIF) allocates funds to the board in support of projects that advance Arizona's public universities in accordance with Arizona law and board guidelines. Each project funded through TRIF is intended to further goals outlined in the board's strategic plan while strengthening oversight of research at Arizona's public universities and contributing to Arizona's workforce development.

ABOR TRIF funds support initiatives in the general areas of data resources and technological support, STEM and innovation projects, and the Regents' Innovation Fund.

TRIF FUNDS FACULTY EXPERTISE AND BUSINESS INTELLIGENCE DATABASES

Included in the data, resources and technological support category are investments in the National Student Clearinghouse and K-12 pipeline student-data systems. A portion of TRIF funding provides access to expertise from faculty at Arizona's public universities through the Elsevier Pure Experts searchable database, a tool that is sorts topics into areas such as research units, journal articles, patent descriptions and business plans. In addition, TRIF funding was used for Arizona State University's Decision Theater to aid in developing an attainment visualization and forecasting model.

Funding also supports the board office's business intelligence and database projects, which use Tableau's software and server to compile, analyze and visualize data. In addition, Tableau supports university researchers' efforts to report and visualize data across the university system. These projects allow the board office to respond to regent, policymaker and other stakeholder requests for data and analysis regarding higher education and the K-12 pipeline

STEM AND INNOVATION PROJECTS SUPPORT SCITECH, INNOVATION OPEN

ABOR TRIF funds continue to support the Arizona Technology Council's SciTech Festival. The SciTech Institute is building a strong, robust ecosystem that fosters lifelong STEM literacy and positions Arizona to align with the White House's National Science & Technology Council Committee on STEM education's five-year STEM education strategic plan.

The Arizona SciTech Festival hosted over 2,000 events in 80 cities and towns throughout Arizona, engaging 560,000-plus visitors. The festivals provide opportunities for children, families and the public to directly interface with STEM professionals and learn about future careers.

ASU's Innovation Open is a multi-round competition that supports student ventures from across the United States in driving technology innovation and entrepreneurship. Teams are challenged to design innovative technologies that leverage the Internet of Things and help address the world's most complex problems. Students compete for a grand prize of $100,000 (provided by Avnet) to continue development of ventures powered by new hardware technologies.

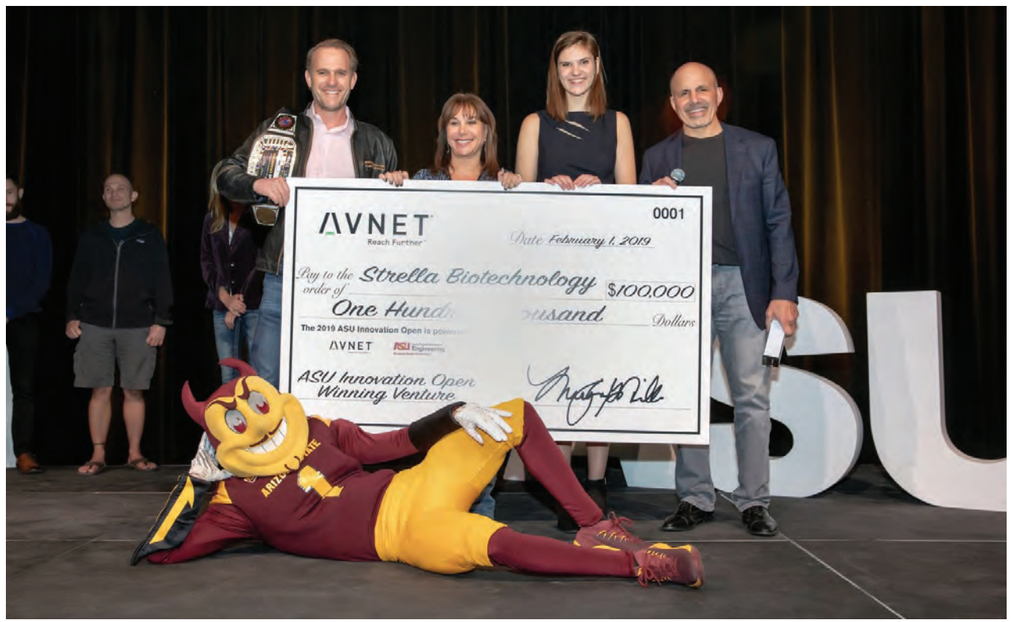
REGENTS' INNOVATION FUND

Regents' Innovation Fund (RIF) grants are instrumental in supporting research at Arizona's public universities and contribute to collaborative efforts among the universities as well as with community partners. During the June 2018 board meeting, the regents approved funding for three RIF projects designed and submitted through a tri-university collaborative effort:

- **Seed Funding for an Innovative Three-University Near Earth Object (NEO) Space Mission:** Near Earth Objects (NEOs) are small solar system bodies — asteroids, comets — whose orbits bring them close to the Earth's orbit. Robotic exploration of NEOs is a very cost-effective way to understand the origin and evolution of the solar system. Together, the three universities will develop innovative new ways for designing and operating space missions for science, technology and commercial benefits. The project will deliver a work plan for managing the mission science committee; define nominal instrument requirements and establish the nominal list of NEO targets; calculate the probabilities of interesting targets being available for study during the mission lifetime; and define component(s) of the mission that the three universities will jointly propose to deliver to the mission.

- **Statewide Collaborative Regenerative Medicine Research and Training Facility:** This project will lead to the establishment of the first comprehensive regenerative-medicine base training and research facility in Arizona. The facility will: equip students and research scientists with specialized knowledge and skills; support fundamental and translational research that would function as a conduit and test bed for other researchers; provide researchers access to stem-cell based therapies from the laboratory to the clinic; and engage and excite the community about the innovative stem cell research being conducted.

- **Advanced 2-D Materials and Organic Molecules for Quantum Photonic Processing:** This is a tri-university effort designed to enable the next steps in the creation of extremely secure "unhackable" communications systems, for both optical fiber-based telecommunication and point-to-point optical communications, which are directly applicable to defense applications. The team will focus on demonstrating a photonics quantum chip to leverage full computational power allowed by quantum mechanics and support on-demand generation and processing of a broad class of non-classical light.

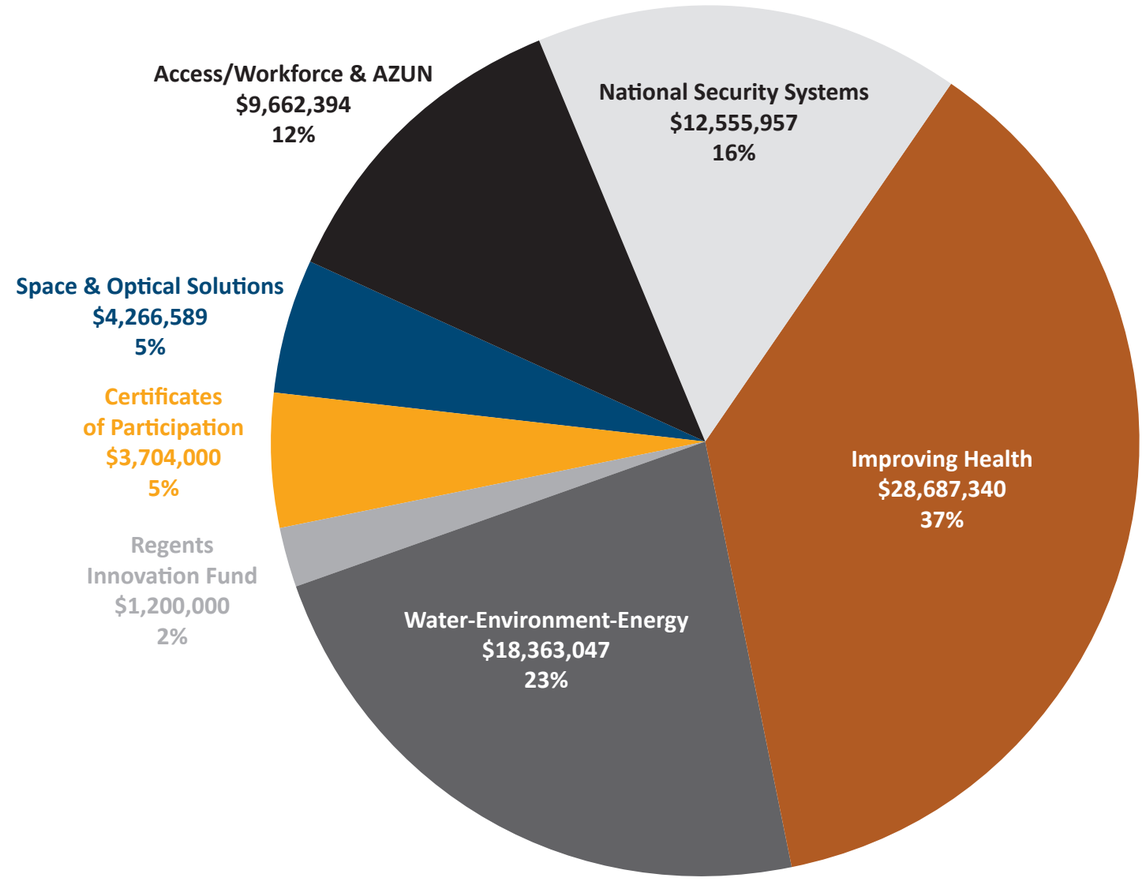


FINANCIALS & METRICS

FY 2017 - 2021
ARIZONA UNIVERSITY SYSTEM
TECHOLOGY AND RESEARCH INITIATIVE FUND

	FY 2017 ACTUAL	*FY 2018 ACTUAL*	*FY 2019 ACTUAL*	*FY 2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
REVENUE						
Carry Forward	4,322,940	8,684,576	10,634,673	10,634,674	8,434,183	-
TRIF Revenue	72,797,470	77,211,240	83,610,510	78,208,460	81,806,000	85,569,000
TOTAL REVENUE	**$ 77,120,410**	**$ 85,895,816**	**$ 94,245,183**	**$ 88,843,134**	**$ 90,240,183**	**$ 85,569,000**
EXPENDITURES						
OPERATING	56,555,913	61,995,953	66,671,410	70,929,221	66,820,123	72,170,400
CAPITAL	8,088,491	9,896,688	8,830,438	10,165,157	11,281,877	9,694,600
ASU Polytechnic/West COPs	3,707,500	3,704,000	3,704,000	3,704,000	3,704,000	3,704,000
TOTAL CAPITAL	**11,795,991**	**13,600,688**	**12,534,438**	**13,869,157**	**14,985,877**	**13,398,600**
TOTAL EXPENDITURES	**$ 68,351,904**	**$ 75,596,641**	**$ 79,205,848**	**$ 84,798,378**	**$ 81,806,000**	**$ 85,569,000**
SUMMARY BY PROGRAM AREA						
Improving Health	$ 26,074,280	$ 29,424,142	$ 28,687,340	$ 27,614,557	$ 29,212,812	$ 29,368,089
Water, Environment, Energy Solutions	11,646,602	14,911,510	18,363,047	18,499,214	17,668,180	20,139,762
National Security Systems	9,566,065	9,852,316	12,555,957	14,389,314	13,749,295	12,331,426
Space Exploration and Optical Solutions	5,850,345	7,172,981	4,266,589	8,390,520	6,721,289	9,042,423
Access & Workforce Development	7,656,193	8,054,570	9,152,394	8,084,964	8,235,424	8,463,300
Regents Innovation Fund	1,200,000	1,000,000	1,200,000	1,200,000	1,000,000	1,000,000
ASU Poly/ASU West COPs	3,707,500	3,704,000	3,704,000	3,704,000	3,704,000	3,704,000
AZUN	500,000	505,000	510,000	510,000	515,000	520,000
ABOR Other	2,150,919	514,620	623,578	2,233,800	1,000,000	1,000,000
PROGRAM AREA TOTAL	**68,351,904**	**75,139,139**	**79,062,905**	**84,626,369**	**81,806,000**	**85,569,000**
TOTAL EXPENDITURES	**$ 68,351,904**	**$ 75,139,139**	**$ 79,062,905**	**$ 84,626,369**	**$ 81,806,000**	**$ 85,569,000**

FY 2018
ACTUAL TRIF EXPENDITURES



Arizona State University

FY 2017 - 2021
ARIZONA STATE UNIVERSITY
TECHOLOGY AND RESEARCH INITIATIVE FUND

	FY 2017 ACTUAL	*FY 2018 ACTUAL*	*FY 2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
REVENUE						
Carryforward		$ 555,600	$ 335,500	$ 335,500	$ 207,204	
TRIF Revenue	30,543,500	32,306,900	34,866,604	32,705,700	34,144,800	35,650,000
TOTAL REVENUE	**$ 30,543,500**	**$ 32,862,500**	**$ 35,202,104**	**$ 33,041,200**	**$ 34,352,004**	**$ 35,650,000**
EXPENDITURES						
OPERATING	24,876,300	25,658,500	27,744,500	25,837,200	26,940,800	28,446,000
CAPITAL	1,404,100	3,500,000	3,546,400	3,500,000	3,500,000	3,500,000
ASU Poly/ASU West COPs	3,707,500	3,704,000	3,704,000	3,704,000	3,704,000	3,704,000
TOTAL CAPITAL	**5,111,600**	**7,204,000**	**7,250,400**	**7,204,000**	**7,204,000**	**7,204,000**
TOTAL EXPENDITURES	**$ 29,987,900**	**$ 32,862,500**	**$ 34,994,900**	**$ 33,041,200**	**$ 34,144,800**	**$ 35,650,000**
SUMMARY BY INITIATIVE						
Improving Health	$ 13,541,800	$ 14,744,400	$ 14,964,300	$ 13,767,200	$ 14,382,300	$ 14,991,400
Water, Environment and Energy Solutions	6,572,000	6,071,800	7,533,200	7,573,300	7,911,700	8,246,800
National Security Systems	3,671,700	3,942,300	3,450,400	3,884,400	4,057,900	4,229,800
Access & Workforce Development						
Entrepreneurship & Innovation	614,200	732,500	1,328,800	1,470,900	1,536,600	1,601,700
Advanced Manufacturing	1,880,700	3,332,000	4,014,200	2,641,500	2,759,500	2,876,400
TOTAL	26,280,400	28,823,000	31,290,900	29,337,300	30,648,000	31,946,100
ASU Poly/ASU West COPS	3,707,500	3,704,000	3,704,000	3,704,000	3,704,000	3,704,000
TOTAL EXPENDITURES	**$ 29,987,900**	**$ 32,527,000**	**$ 34,994,900**	**$ 33,041,300**	**$ 34,352,000**	**$ 35,650,100**

ARIZONA STATE UNIVERSITY
TECHOLOGY AND RESEARCH INITIATIVE FUND
IMPROVING HEALTH

PERFORMANCE ANALYSIS	*FY 2017 ACTUAL*	*FY 2018 ACTUAL*	*FY 2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
TRIF EXPENDITURES						
Total	$ 13,541,800	$ 14,744,400	$ 14,964,300	$ 13,767,200	$ 14,382,300	$ 14,991,400
FINANCIAL IMPACT OF TRIF INVESTMENT						
Sponsored Awards	$ 82,409,681	$ 92,909,977	$ 102,240,048	$ 100,750,000	$ 110,750,000	$ 124,000,000
Gifts & Other Sources	723,874	1,399,722	1,890,337	1,160,000	1,190,000	1,220,000
Royalty Income	157,454	196,261	371,958	800,000	800,000	800,000
TOTAL	**83,291,009**	**94,505,960**	**104,502,343**	**102,710,000**	**112,740,000**	**126,020,000**
TECHNOLOGY TRANSFER ACTIVITY						
Invention Disclosures Transacted	81	97	86	57	59	60
US Patents Issued	31	32	27	6	7	7
Licenses and Options Executed	37	15	14	18	20	22
Startup Companies	5	5	5	2	3	3
WORKFORCE CONTRIBUTION						
Academic and Postdoctoral Appointees	145	145	154	126	133	143
Graduate Students	542	630	749	394	416	445
Undergraduate Students	267	230	264	289	306	328

ARIZONA STATE UNIVERSITY
TECHOLOGY AND RESEARCH INITIATIVE FUND
NATIONAL SECURITY SYSTEMS

PERFORMANCE ANALYSIS	*FY 2017 ACTUAL*	*FY 2018 ACTUAL*	*FY 2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
TRIF EXPENDITURES						
Total	$ 3,671,700	$ 3,942,300	$ 3,450,400	$ 3,884,400	$ 4,057,900	$ 4,229,800
FINANCIAL IMPACT OF TRIF INVESTMENT						
Sponsored Awards	$ 39,063,761	$ 33,292,653	$ 48,532,922	$ 48,000,000	$ 53,000,000	$ 60,000,000
Gifts & Other Sources	-	-				
Royalty Income	-	76,305	14,898	50,000	50,000	50,000
TOTAL	**39,063,761**	**33,368,958**	**48,547,820**	**48,050,000**	**53,050,000**	**60,050,000**
TECHNOLOGY TRANSFER ACTIVITY						
Invention Disclosures Transacted	35	52	40	25	27	30
US Patents Issued	9	9	11	3	3	4
Licenses and Options Executed	4	8	2	4	5	5
Startup Companies	4	2	2	0	0	0
WORKFORCE CONTRIBUTION						
Academic and Postdoctoral Appointees	43	50	79	32	34	36
Graduate Students	338	366	479	265	281	303
Undergraduate Students	190	176	247	134	142	153

ARIZONA STATE UNIVERSITY
TECHOLOGY AND RESEARCH INITIATIVE FUND
WATER, ENVIRONMENTAL, ENERGY SOLUTIONS

PERFORMANCE ANALYSIS	*FY 2017 ACTUAL*	*FY 2018 ACTUAL*	*FY 2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
TRIF EXPENDITURES						
Total	$ 6,572,000	$ 6,071,800	$ 7,533,200	$ 7,573,300	$ 7,911,700	$ 8,246,800
FINANCIAL IMPACT OF TRIF INVESTMENT						
Sponsored Awards	$ 27,874,447	$ 26,139,847	$ 28,545,795	$ 28,500,000	$ 30,100,000	$ 34,000,000
Gifts & Other Sources	4,248,699	3,196,485	1,213,249	4,510,000	4,650,000	4,790,000
Royalty Income	2,000	2,000	117,016	100,000	100,000	100,000
TOTAL	**32,125,146**	**29,338,332**	**29,876,060**	**33,110,000**	**34,850,000**	**38,890,000**
TECHNOLOGY TRANSFER ACTIVITY						
Invention Disclosures Transacted	22	13	24	12	13	13
US Patents Issued	3	13	27	2	2	3
Licenses and Options Executed	3	5	3	5	5	5
Startup Companies	1	2	2	0	0	0
WORKFORCE CONTRIBUTION						
Academic and Postdoctoral Appointees	60	35	80	32	33	36
Graduate Students	210	147	400	166	171	183
Undergraduate Students	241	104	190	200	206	221

ARIZONA STATE UNIVERSITY
TECHOLOGY AND RESEARCH INITIATIVE FUND
ACCESS & WORKFORCE DEVELOPMENT:
ADVANCED MANUFACTURING

PERFORMANCE ANALYSIS	*FY 2017 ACTUAL*	*FY 2018 ACTUAL*	*FY 2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
TRIF EXPENDITURES						
Total	$ 1,880,700	$ 3,332,000	$ 4,014,200	$ 2,641,500	$ 2,759,500	$ 2,876,400
FINANCIAL IMPACT OF TRIF INVESTMENT						
Sponsored Awards	$ 13,047,918	$ 22,677,335	$ 18,810,146	$ 18,750,000	$ 21,250,000	$ 25,000,000
Gifts & Other Sources	112,652	138,791	158,936	100,000	100,000	100,000
Royalty Income	16,000	91,800	75,000	50,000	50,000	50,000
TOTAL	**13,176,570**	**22,907,926**	**19,044,082**	**18,900,000**	**21,400,000**	**25,150,000**
TECHNOLOGY TRANSFER ACTIVITY						
Invention Disclosures Transacted	27	44	28	9	10	12
US Patents Issued	5	18	26	1	2	2
Licenses and Options Executed	8	4	2	3	3	4
Startup Companies	3	2	3	1	1	1
WORKFORCE CONTRIBUTION						
Academic and Postdoctoral Appointees	33	25	59	12	13	14
Graduate Students	155	98	323	57	62	69
Undergraduate Students	75	27	89	64	69	77

ARIZONA STATE UNIVERSITY
TECHOLOGY AND RESEARCH INITIATIVE FUND
ACCESS & WORKFORCE DEVELOPMENT:
ENTREPRENEURSHIP & INNOVATION

PERFORMANCE ANALYSIS	*FY 2017 ACTUAL*	*FY 2018 ACTUAL*	*FY 2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
TRIF EXPENDITURES						
Total	$ 614,200	$ 732,500	$ 1,328,800	$ 1,470,900	$ 1,536,600	$ 1,601,700
FINANCIAL IMPACT OF TRIF INVESTMENT						
Sponsored Awards	$ 2,960,137	$ 4,021,094	$ 5,527,000	$ 3,500,000	$ 4,100,000	$ 5,000,000
Gifts & Other Sources						
Royalty Income						
TOTAL	**2,960,137**	**4,021,094**	**5,527,000**	**3,500,000**	**4,100,000**	**5,000,000**
TECHNOLOGY TRANSFER ACTIVITY						
Invention Disclosures Transacted						
US Patents Issued						
Licenses and Options Executed						
Startup Companies	26	22	18	22	23	24
WORKFORCE CONTRIBUTION						
Academic and Postdoctoral Appointees	1	0	6	0	0	0
Graduate Students	99	173	143	28	29	30
Undergraduate Students	246	346	342	138	145	152

NAU NORTHERN ARIZONA UNIVERSITY

FY 2017 - 2021
NORTHERN ARIZONA UNIVERSITY
TECHOLOGY AND RESEARCH INITIATIVE FUND

	FY 2017 ACTUAL	*FY 2018 ACTUAL*	*FY2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
REVENUE						
Carryforward	$ 1,281,965	$ 1,815,739	$ 3,681,174	$ 3,681,174	$ 6,397,949	
TRIF Revenue	13,417,994	13,957,380	$ 15,581,302	14,500,920	15,220,400	15,973,000
TOTAL REVENUE	**$ 14,699,959**	**$ 15,773,119**	**$ 19,262,476**	**$ 18,182,094**	**$ 21,618,349**	**$ 15,973,000**
EXPENDITURES						
OPERATING	11,089,829	11,619,310	11,780,490	12,035,763	12,328,523	12,778,400
CAPITAL	1,794,391	816,688	1,084,038	2,465,157	2,891,877	3,194,600
TOTAL EXPENDITURES	**$ 12,884,220**	**$ 12,435,998**	**$ 12,864,528**	**$ 14,500,920**	**$ 15,220,400**	**$ 15,973,000**
SUMMARY BY INITIATIVE						
Improving Health	$ 1,987,146	$ 2,287,367	$ 2,498,001	$ 2,778,248	$ 2,660,594	$ 2,876,838
Water, Environment and Energy Solutions	1,547,695	3,336,334	3,275,370	2,059,984	2,127,794	3,311,473
National Security Systems	3,305,425	2,068,714	1,765,557	2,388,299	3,330,615	837,660
Space Exploration & Optical Solutions	382,661	248,513	1,006,205	2,791,825	2,618,073	4,441,829
Access & Workforce Development	5,161,293	3,990,070	3,809,394	3,972,564	3,968,324	3,985,200
TOTAL	12,384,220	11,930,998	12,354,528	13,990,920	14,705,400	15,453,000
AZUN	500,000	505,000	510,000	510,000	515,000	520,000
TOTAL EXPENDITURES	**$ 12,884,220**	**$ 12,435,998**	**$ 12,864,528**	**$ 14,500,920**	**$ 15,220,400**	**$ 15,973,000**

NORTHERN ARIZONA UNIVERSITY
TECHOLOGY AND RESEARCH INITIATIVE FUND
IMPROVING HEALTH

PERFORMANCE ANALYSIS	*FY 2017 ACTUAL*	*FY 2018 ACTUAL*	*FY2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
TRIF EXPENDITURES						
Total	$ 1,658,683	$ 2,287,367	$ 2,498,001	$ 2,778,248	$ 2,660,594	$ 2,876,838
FINANCIAL IMPACT OF TRIF INVESTMENT						
Sponsored Awards	$ 9,823,529	$ 11,421,671	$ 11,799,528	$ 2,326,065	$ 2,878,568	$ 3,868,878
Gifts & Other Sources	200,000	200,000	-	116,303	143,928	193,444
Royalty Income	24,070	10,000	10,000	-	-	35,156
TOTAL	**10,047,599**	**11,631,671**	**11,809,528**	**2,442,368**	**3,022,496**	**4,097,478**
TECHNOLOGY TRANSFER ACTIVITY						
Invention Disclosures Transacted	27	19	18	23	26	29
US Patents Issued	3	5	6	1	1	1
Licenses and Options Executed	2	0	3	0	0	1
Startup Companies	1	0	0	0	1	0
WORKFORCE CONTRIBUTION						
Academic and Postdoctoral Appointees	13	10	26	5	5	4
Graduate Students	29	45	52	25	30	35
Undergraduate Students	75	129	125	50	50	50

NORTHERN ARIZONA UNIVERSITY
TECHOLOGY AND RESEARCH INITIATIVE FUND
WATER, ENVIRONMENTAL, ENERGY SOLUTIONS

PERFORMANCE ANALYSIS	*FY 2017 ACTUAL*	*FY 2018 ACTUAL*	*FY2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
TRIF EXPENDITURES						
Total	$ 1,547,695	$ 3,336,334	$ 3,275,370	$ 2,059,984	$ 2,127,794	$ 3,311,473
FINANCIAL IMPACT OF TRIF INVESTMENT						
Sponsored Awards	$ 11,241,109	$ 8,262,452	$ 4,490,896	$ 2,304,498	$ 4,108,358	$ 3,374,568
Gifts & Other Sources	0	-	-	115,225	205,418	168,728
Royalty Income	0	-	-	23,438	-	-
TOTAL	**11,241,109**	**8,262,452**	**4,490,896**	**2,443,161**	**4,313,776**	**3,543,296**
TECHNOLOGY TRANSFER ACTIVITY						
Invention Disclosures Transacted	5	11	2	10	12	12
US Patents Issued	2	2	0	2	2	2
Licenses and Options Executed	0	0	0	1	0	0
Startup Companies	0	0	0	0	0	0
WORKFORCE CONTRIBUTION						
Academic and Postdoctoral Appointees	17	20	30	5	5	4
Graduate Students	50	63	77	25	30	35
Undergraduate Students	136	127	124	200	200	200

NORTHERN ARIZONA UNIVERSITY
TECHOLOGY AND RESEARCH INITIATIVE FUND
NATIONAL SECURITY SYSTEMS

PERFORMANCE ANALYSIS	*FY 2017 ACTUAL*	*FY 2018 ACTUAL*	*FY2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
TRIF EXPENDITURES						
Total	$ 3,305,425	$ 2,068,714	$ 1,765,557	$ 2,388,299	$ 3,330,615	$ 837,660
FINANCIAL IMPACT OF TRIF INVESTMENT						
Sponsored Awards	$ 5,493,136	$ 1,193,274	$ 1,306,649	$ 4,355,925	$ 1,811,342	$ 1,330,197
Gifts & Other Sources	-	-	-	217,796	90,567	66,510
Royalty Income	6,000	30,500	500	23,438	46,875	35,156
TOTAL	**5,499,136**	**1,223,774**	**1,307,149**	**4,597,159**	**1,948,784**	**1,431,863**
TECHNOLOGY TRANSFER ACTIVITY						
Invention Disclosures Transacted	9	14	13	5	6	7
US Patents Issued	0	2	4	1	2	2
Licenses and Options Executed	1	1	1	1	2	1
Startup Companies	0	0	0	1	0	1
WORKFORCE CONTRIBUTION						
Academic and Postdoctoral Appointees	5	2	3	5	5	4
Graduate Students	3	4	8	10	10	15
Undergraduate Students	10	17	14	20	25	25

NORTHERN ARIZONA UNIVERSITY
TECHOLOGY AND RESEARCH INITIATIVE FUND
SPACE EXPLORATION AND OPTICAL SOLUTIONS

PERFORMANCE ANALYSIS	*FY 2017 ACTUAL*	*FY 2018 ACTUAL*	*FY2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
TRIF EXPENDITURES						
Total	$ 382,661	$ 248,513	$ 1,006,205	$ 2,791,825	$ 2,618,073	$ 4,441,829
FINANCIAL IMPACT OF TRIF INVESTMENT						
Sponsored Awards	$ 1,256,431	$ 882,075	$ 1,907,771	$ 2,343,311	$ 2,969,534	$ 3,836,157
Gifts & Other Sources	0	-	-	117,166	148,477	191,808
Royalty Income	0	-	-		23,438	35,156
TOTAL	**1,256,431**	**882,075**	**1,907,771**	**2,460,477**	**3,141,449**	**4,063,121**
TECHNOLOGY TRANSFER ACTIVITY						
Invention Disclosures Transacted	0	0	2	1	2	2
US Patents Issued	0	0	0	0	2	2
Licenses and Options Executed	0	0	0	0	1	1
Startup Companies	0	0	0	0	0	0
WORKFORCE CONTRIBUTION						
Academic and Postdoctoral Appointees	1	0	7	5	5	4
Graduate Students	3	3	7	10	10	15
Undergraduate Students	2	7	7	50	50	50

NORTHERN ARIZONA UNIVERSITY
TECHOLOGY AND RESEARCH INITIATIVE FUND
ACCESS & WORKFORCE DEVELOPMENT

PERFORMANCE ANALYSIS	*FY 2017 ACTUAL*	*FY 2018 ACTUAL*	*FY2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
TRIF EXPENDITURES						
AWD	$ 5,161,293	$ 3,990,070	$ 3,809,394	$ 3,972,564	$ 3,968,324	$ 3,985,200
AZUN	$ 500,000	$ 505,000	$ 510,000	$ 510,000	$ 515,000	$ 520,000
Total	$ 5,661,293	$ 4,495,070	$ 4,319,394	$ 4,482,564	$ 4,483,324	$ 4,505,200
FINANCIAL IMPACT OF TRIF INVESTMENT						
Annual Impact of Graduates on Economy[1]	$ 15,990,000	$ 15,626,000	$ 14,235,000	$ 15,210,000	$ 15,678,000	$ 16,146,000
Degree/Certificate Programs Offered [2]	92	84	89	79	81	83
Business/Nonprofit Collaborations [3]	211	374	522	190	205	220
Number of Students Served by A/WD [4]	4,482	4,405	4,220	4,840	5,324	5,856
TOTAL	**$ 15,990,000**	**$ 15,626,000**	**$ 14,235,000**	**$ 15,210,000**	**$ 15,678,000**	**$ 16,146,000**
WORKFORCE CONTRIBUTION						
Web/Hybrid/Enhanced Courses Developed[5]	191	287	243	170	180	190
Faculty Developing Courses[6]	405	304	312	430	460	490
Increase in Student Technology Literacy[7]	4,310	4,555	4,425	4,550	4,675	4,800
Individual Faculty Trained in Teaching Technologies[8]	376	307	316	300	325	350
Faculty Support Incidents Resolved Technologies[9]	13,590	11,734	12,721	17,500	17,775	18,000
Faculty using Adaptive Courseware	16	32	36	15	25	40

[1] Estimated based on U. S. Census Bureau Data for annual increase in earnings by a baccalaureate-trained worker compared to high school degree
[2] Number of degrees supported by A/WD funding
[3] Organizations (business, industry, nonprofits, school districts) with formal/informal relationships with NAU related to TRIF A/WD activities
[4] Number of students completing a course with significant or advanced technical fluency skills.
[5] Includes Web, hybrid, IT-enhanced, redesigns and quality review process compliance.
[6] Number of faculty participating in course development, design and redesign.
[7] Number of students completing a course with significant or advanced technical fluency skills.
[8] Number of faculty completing core eLearning training.
[9] The number of faculty eLearning help desk problems resolved


THE UNIVERSITY
OF ARIZONA

FY 2017 - 2021
UNIVERSITY OF ARIZONA
TECHOLOGY AND RESEARCH INITIATIVE FUND

	FY 2017 ACTUAL	*FY 2018 ACTUAL*	*FY2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
REVENUE						
Carryforward	-	4,707,123	4,648,508	4,648,508	6,431,213	
TRIF Revenue	26,835,988	28,602,907	31,162,604	29,001,840	30,440,800	31,946,000
TOTAL	$ 26,835,988	$ 33,310,030	$ 35,811,112	$ 33,650,348	$ 36,872,013	$ 31,946,000
EXPENDITURES						
OPERATING	17,238,866	23,081,521	25,179,899	29,450,348	25,550,800	28,946,000
CAPITAL	4,890,000	5,580,000	4,200,000	4,200,000	4,890,000	3,000,000
TOTAL	**$ 22,128,865**	**$ 28,661,521**	**$ 29,379,899**	**$ 33,650,348**	**$ 30,440,800**	**$ 31,946,000**
SUMMARY BY INITIATIVE						
Improving Health	$ 10,545,334	$ 12,392,375	$ 11,225,039	$ 11,069,109	$ 12,267,218	$ 11,499,951
Space Exploration & Optical Solutions	5,467,685	6,924,468	7,554,476	9,265,930	7,682,186	8,581,489
Water, Environmental, Energy Solutions	3,526,907	5,503,376	7,340,000	8,116,615	6,388,180	7,263,966
National Security Systems	2,588,940	3,841,302	3,260,384	5,198,695	4,103,216	4,600,594
TOTAL	**$ 22,128,865**	**$ 28,661,521**	**$ 29,379,899**	**$ 33,650,348**	**$ 30,440,800**	**$ 31,946,000**

UNIVERSITY OF ARIZONA
TECHOLOGY AND RESEARCH INITIATIVE FUND
IMPROVING HEALTH

PERFORMANCE ANALYSIS	*FY 2017 ACTUAL*	*FY 2018 ACTUAL*	*FY2019 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
TRIF EXPENDITURES						
Total	10,545,334	12,392,375	11,225,039	11,069,109	12,267,218	11,499,951
FINANCIAL IMPACT OF TRIF INVESTMENT						
Sponsored Awards	74,499,075	89,142,292	78,544,924	64,896,000	67,491,840	70,191,514
Gifts & Other Sources	117,545	465,399	804,222	648,960	674,918	701,915
Royalty Income	16,000	200	55,000	54,080	56,243	58,493
TOTAL	**74,632,620**	**89,607,891**	**79,404,146**	**65,599,040**	**68,223,002**	**70,951,922**
TECHNOLOGY TRANSFER ACTIVITY						
Invention Disclosures Transacted	55	38	35	45	50	55
US Patents Issued	7	2	21	2	4	5
Licenses and Options Executed	6	8	9	11	12	13
Startup Companies	1	4	1	1	2	2
WORKFORCE CONTRIBUTION						
Postdoctoral Appointees	160	184	218	110	116	122
Graduate Students	439	479	643	331	347	365
Undergraduate Students	741	539	659	353	370	389

UNIVERSITY OF ARIZONA
TECHOLOGY AND RESEARCH INITIATIVE FUND
WATER, ENVIRONMENTAL AND ENERGY SOLUTIONS

PERFORMANCE ANALYSIS	FY 2017 ACTUAL	FY 2018 ACTUAL	FY2019 ACTUAL	FY2019 BUDGET	FY 2020 BUDGET	FY 2021 BUDGET
TRIF EXPENDITURES						
Total	$ 3,526,907	$ 5,503,376	$ 7,340,000	$ 8,116,615	$ 6,388,180	$ 7,263,966
FINANCIAL IMPACT OF TRIF INVESTMENT						
Sponsored Awards	28,190,149	34,978,098	37,230,355	33,529,600	34,870,784	36,265,615
Gifts & Other Sources	6,978,663	31,228,311	2,470,875	3,677,440	3,824,538	3,977,519
Royalty Income	8,250	5,145	3,785	811,200	843,648	877,394
TOTAL	**$ 35,177,062**	**$ 66,211,554**	**$ 39,705,015**	**$ 38,018,240**	**$ 39,538,970**	**$ 41,120,528**
TECHNOLOGY TRANSFER ACTIVITY						
Invention Disclosures Transacted	18	16	12	23	25	27
US Patents Issued	3	1	0	2	4	5
Licenses and Options Executed	4	2	4	7	8	9
Startup Companies	1	0	0	1	1	1
WORKFORCE CONTRIBUTION						
Postdoctoral Appointees	16	29	55	94	98	103
Graduate Students	152	175	182	298	313	328
Undergraduate Students	74	109	123	121	127	134

UNIVERSITY OF ARIZONA
TECHOLOGY AND RESEARCH INITIATIVE FUND
SPACE EXPLORATION AND OPTICAL SOUTIONS

PERFORMANCE ANALYSIS	FY 2017 ACTUAL	FY 2018 ACTUAL	FY2019 ACTUAL	FY2019 BUDGET	FY 2020 BUDGET	FY 2021 BUDGET
TRIF EXPENDITURES						
Total	$ 5,467,685	$ 6,924,468	$ 7,554,476	$ 9,265,930	$ 7,682,186	$ 8,581,489
FINANCIAL IMPACT OF TRIF INVESTMENT						
Sponsored Awards	67,398,490	93,922,125	86,349,520	64,896,000	67,491,840	70,191,514
Gifts & Other Sources	525,123	597,340	488,660	11,000,000	1,000,000	1,000,000
Royalty Income	1,256,754	1,438,529	1,932,029	129,792	134,984	140,383
TOTAL	**$ 69,180,367**	**$ 95,957,994**	**$ 88,770,209**	**$ 76,025,792**	**$ 68,626,824**	**$ 71,331,897**
TECHNOLOGY TRANSFER ACTIVITY						
Invention Disclosures Transacted	50	62	69	45	50	55
US Patents Issued	14	11	17	2	4	5
Licenses and Options Executed	21	26	18	18	20	22
Startup Companies	5	6	4	1	2	2
WORKFORCE CONTRIBUTION						
Postdoctoral Appointees	2	20	25	17	17	18
Graduate Students	55	115	114	44	46	49
Undergraduate Students	29	47	57	9	9	10

UNIVERSITY OF ARIZONA
TECHOLOGY AND RESEARCH INITIATIVE FUND
NATIONAL SECURITY SYSTEMS

PERFORMANCE ANALYSIS	*FY 2017 ACTUAL*	*FY 2018 ACTUAL*	*FY19 ACTUAL*	*FY2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
TRIF EXPENDITURES						
Total	$ 2,588,940	$ 3,841,302	$ 3,260,384	$ 5,198,695	$ 4,103,216	$ 4,600,594
FINANCIAL IMPACT OF TRIF INVESTMENT						
Sponsored Awards	1,066,471	1,281,873	1,343,532	4,000,000	8,000,000	10,000,000
Gifts & Other Sources	0	0	0	125,000	150,000	175,000
Royalty Income	0	0	0	0	0	0
TOTAL	**$ 1,066,471**	**$ 1,281,873**	**$ 1,343,532**	**$ 4,125,000**	**$ 8,150,000**	**$ 10,175,000**
TECHNOLOGY TRANSFER ACTIVITY						
Invention Disclosures Transacted	0	6	8	0	3	5
US Patents Issued	0	0	0	0	0	0
Licenses and Options Executed	0	0	0	0	0	0
Startup Companies	0	0	0	0	0	0
WORKFORCE CONTRIBUTION						
Postdoctoral Appointees	5	10	10	5	6	6
Graduate Students	12	38	37	11	11	12
Undergraduate Students	10	49	13	11	11	12

ARIZONA BOARD OF
REGENTS
ASU ◆ NAU ◆ UA

FY 2017-2021
ARIZONA BOARD OF REGENTS
TECHNOLOGY AND RESEARCH INIATIVE FUND

	FY 2017 ACTUAL	*FY 2018 ACTUAL*	*FY 2019 ACTUAL*	*FY 2019 BUDGET*	*FY 2020 BUDGET*	*FY 2021 BUDGET*
REVENUE						
Carry Forward	$ 3,040,975	$ 1,606,114	$ 1,969,491	$ 1,969,492	$ 2,002,970	
TRIF Revenue	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
TOTAL REVENUE	**$ 5,040,975**	**$ 3,606,114**	**$ 3,969,491**	**$ 3,969,492**	**$ 4,002,970**	**$ 2,000,000**
EXPENDITURES						
OPERATING	83,944	122,002	142,943	172,110	140,000	150,000
GRANTS/PROJECTS	3,266,975	1,514,620	1,823,578	3,433,800	1,860,000	1,850,000
TOTAL EXPENDITURES	**$ 3,350,919**	**$ 1,636,622**	**$ 1,966,521**	**$ 3,605,910**	**$ 2,000,000**	**$ 2,000,000**
SUMMARY BY INITIATIVE						
Regents' Innovation Fund Grants	$ 1,200,000	$ 1,000,000	$ 1,200,000	$ 1,200,000	$ 1,000,000	$ 1,000,000
Data/Resources/Technology	200,919	464,620	573,578	683,800	900,000	900,000
STEM/Innovation Projects	50,000	50,000	50,000	50,000	100,000	100,000
Over realized funds to universities	1,900,000	-	-	1,500,000		
TOTAL EXPENDITURES	**$ 3,350,919**	**$ 1,514,620**	**$ 1,823,578**	**$ 3,433,800**	**$ 2,000,000**	**$ 2,000,000**