

Arizona Higher Education Enterprise Technology and Research Initiative Fund (TRIF)

Five-Year Project Plan
July 1, 2016 through June 30, 2021



ARIZONA STATE UNIVERSITY

TECHNOLOGY AND RESEARCH INITIATIVE FUND (TRIF)

Business Plan – Fiscal Years FY17-21

1.1 Executive summary

TRIF investments at ASU are strategically allocated to fuel research-driven solutions that grow Arizona's economy and workforce and maximize the return on investment for the Arizona taxpayer. Our five TRIF initiatives:

Improving Health

National Security Systems

Water, Environmental and Energy Solutions

Access and Workforce Development: Entrepreneurship and Innovation

Access and Workforce Development: Advanced Manufacturing

represent a diverse portfolio of research-to-marketplace programs that promise significant benefits to the State of Arizona.

1.2 Outline of university mission/goals/values

ASU is a comprehensive public research university, measured not by whom we exclude, but rather by whom we include and how they succeed; advancing research and discovery of public value; and assuming fundamental responsibility for the economic, social, cultural and overall health of the communities it serves.

ASU has established the following goals for 2016 and beyond:

Demonstrate leadership in academic excellence and accessibility

- Maintain the fundamental principle of accessibility to all students qualified to study at a research university
- Maintain university accessibility to match Arizona's socioeconomic diversity
- Improve freshmen persistence to 90%
- Enhance university graduation rate to 75%-80% and 25,000 graduates
- Enhance quality while reducing the cost of a degree
- Enroll 100,000 online and distance education degree seeking students
- Enhance linkages with community colleges so as to expand

Establish national standing in academic quality and impact of colleges and schools in every field

- Attain national standing in academic quality for each college and school (top 5-10% for each college)
- Attain national standing in the learning value added to our graduates in each college and school
-

strategic alignment of research with challenges that need to be solved and of strong partnerships with leading national and global organizations. This brings additional revenue to the state and creates jobs at the university and at our local partners.

Technology transfer. Patents, licenses and options, and new startup companies represent the translation of research and innovation to the marketplace and workforce.

Industry engagement. By partnering with industry leaders, we leverage our knowledge enterprise for maximal marketplace impact.

Workforce contributions. University students who receive research training understand problem solving and are prepared for the high-tech industries driving our economy.

Educational outreach. ASU leads numerous outreach efforts to spark discovery, learning and entrepreneurship in K-12 students and community members.

Government agency/community engagement. Collaborations with government and community agencies connect our subject matter experts and innovative solutions with organizations working directly with populations in need.

1.4 Overall budget

ASU's proposed TRIF budget will remain concentrated on what are our largest and most well established TRIF funded initiatives, but will be expanded to include smaller investments in our two new Access and Workforce Development Initiatives in Entrepreneurship and Innovation, and Advanced Manufacturing.

Initiative Budgets	Projected FY 17	Projected FY 18	Projected FY 19	Projected FY 20	Projected FY 21
Improving Health	\$ 13,376,521	\$ 14,131,519	\$ 14,827,611	\$ 15,524,742	\$ 16,222,933
National Security Systems	\$ 3,561,613	\$ 3,769,612	\$ 3,977,610	\$ 4,185,609	\$ 4,393,608
Water Environmental and Energy Solutions	\$ 7,050,459	\$ 7,349,538	\$ 7,768,132	\$ 8,186,383	\$ 8,604,285
Access and Wrokforce Development					
Entrepreneurship & Innovation	\$ 1,369,851	\$ 1,449,851	\$ 1,529,850	\$ 1,609,850	\$ 1,689,849
Advanced Manufacturing	\$ 1,959,956	\$ 2,217,881	\$ 2,415,197	\$ 2,611,816	\$ 2,807,725
TOTAL	\$ 27,318,400	\$ 28,918,400	\$ 30,518,400	\$ 32,118,400	\$ 33,718,400

1.5 Marketing/communication overview

TRIF investment at ASU has enabled significant discovery, economic development and the attracting external funding awards. We communicate the impact of TRIF to audiences internal to ASU as well as those in the local community and throughout Arizona. The following key messages will be incorporated in ASU communications and presentations featuring TRIF-enabled research and impacts:

TRIF investments are strategically leveraged to support established research with a track record of success as well as emerging high-potential research areas.

The research and economic development enabled by TRIF has real impact on our community, our state and beyond.

TRIF investments support the training and education of students, and contributing to a highly skilled workforce that can fulfill the high-tech jobs being created in Arizona and attract new business and industry to the state.

ASU's Office of Knowledge Enterprise Development (OKED) has a dedicated marketing and communication team with a mission of communicating the impact of ASU's research, innovation, entrepreneurship and economic development. The team works with partners throughout the university to implement marketing plans for key initiatives including those enabled through TRIF investment. ASU anticipates working closely with ABOR to ensure that we contribute materially to the public relations and media strategy surrounding this program.

1.6 University administration of TRIF

TRIF is administered through OKED with the following leadership:

Sethuraman "Panch" Panchanathan, executive vice president and chief research and innovation officer

Elizabeth Cantwell, vice president of research development

Tamara Deuser, associate vice president and chief of staff

During the proposed FY2017 – FY2021 cycle, ASU will invest TRIF funds in five strategic initiatives. Each initiative is anchored by a flagship unit and may have supporting programs and facilities:

Improving Health

Anchored by The Biodesign Institute led by Joshua LaBaer
Supporting programs and facilities: Center for Healthy Outcomes in Aging, College of Health Solutions, Complex Adaptive Systems, Research Computing, DNASU and the Genomics Facility.

National Security Systems

Anchored by the Global Security Initiative led by Nadya Bliss

Supporting programs and facilities: LightWorks, Food Systems Transformation Initiative, ASU Leadership Academy, the Decision Theater, and chemical and environmental characterization and synthesis facilities

Access and Workforce Development: Entrepreneurship and Innovation

Anchored by Entrepreneurship and Innovation (E+I) led by Ji Mi Choi

Access and Workforce Development: Advanced Manufacturing

Anchored by the Flexible Electronics and Display Center led by Nicholas Colaneri

Supporting programs and facilities: Center for Entrepreneurship, Generator Labs, Global Resolve, WP Carey Center for Entrepreneurship, Startup Mill, ASU NanoFab and Materials characterization and synthesis facilities

2 Improving Health

2.1 Investment description/rationale/justification

Improving Health has been the largest TRIF funded initiative at ASU for more than a decade. During this time, ASU successfully used TRIF funding not only to support substantial scientific advancements, but also to attract significant funding to the State, deliver cutting edge education and research training to our students and to successfully commercialize our research discoveries to create jobs in Arizona.

Since 2002, ASU has been the fourth fastest growing biosciences research enterprise among US universities that conducted more than \$40M in biosciences research annually. Moreover, ASU was the fastest growing biosciences research enterprise among universities without a medical school. While the national growth in university biosciences research since 2002 has totaled 77%, ASU's biosciences research funding grew by more than 220% from \$4

on novel health diagnostic research conducted at ASU's Biodesign Institute with seed funding from TRIF. The research led to the creation of new technology that was patented, licensed and is the foundation of the spinout company. Since establishing the company in 2012, the HealthTell founders have grown their business to support more than 30 employees almost all of which work in their Chandler Arizona offices. The company has surpassed \$3M in revenues and recently raised more than \$25 million from investors to further expand their business. HealthTell has also integrated into the region's biosciences economic ecosystem, and now has partnerships with several institutions including the Barrow Neurological Institute and Dignity Health.

TRIF funding has been a critical resource in supporting ASU's ascendancy in biosciences research, in our ability to provide top tier educational opportunities and financial support to students, and in moving our scientific breakthroughs into the marketplace - bolstering the Arizona economy and improving the health and wellness of its citizens. For the proposed additional period of TRIF Funding, ASU will maintain Improving Health as its largest TRIF investment. Biosciences is and will continue to be the largest discipline for higher education research and development funding, accounting for more than half of all US university research expenditures, and continued TRIF support in this strategically important field will allow ASU to continue to increase its share of competitively awarded biosciences research funding.

As in the previous TRIF funding cycles, ASU's Improving Health Initiative focuses on the Biodesign Institute. Created on the premise that scientists can overcome complex societal challenges by re-imagining the "design rules" found in nature, the Biodesign Institute embodies ASU's New American University design aspirations to conduct use-inspired research, fuse intellectual disciplines and value entrepreneurship – principles that are increasingly important to federal agency, business and nonprofit sponsors.

The planned TRIF investments at the Biodesign Institute will focus on specific resource needs including:

- Seed funding for scientific pursuits and collaborations to facilitate scientifically impactful projects

- Building and maintaining core facilities, shared instrumentation and infrastructure to accelerate research outcomes

To advance its research mission, the Biodesign Institute has established 15 interdisciplinary research centers that currently boast a portfolio of more than 200 active externally funded research projects.

Scientific, clinical and professional excellence is the foundation of the Biodesign Institute's world-class research. Its 65 faculty members, comprising both tenure line and research faculty, include one Nobel Prize winner and four National Academies members, who regularly publish in top-tier, high-impact scientific journals and collaborate with research and commercial enterprises around the world.

2.1.3 Description of programmatic investments

As stated, the Biodesign Institute will anchor the Improving Health focus area with the support of other health outcome-focused units and facilities:

In response to the rapidly expanding population of older adults in the state of Arizona, the **Center for Healthy Outcomes in Aging** convenes investigators to develop and test interventions that promote the highest level of health and quality of life for individuals who are aging within a culturally diverse society. The center emphasizes multidisciplinary, theory-based interventions across a variety of clinical settings.

Research conducted by the renowned faculty in the **College of Health Solutions** focuses on addressing society's most pressing problems related to health and health care. Students engaged in our multidisciplinary research will be on the front lines, testing innovations to improve the health of populations and communities, enhance health care delivery and patient-centered care, and improve function and reduce disability across the lifespan.

Complex Adaptive Systems (CAS) represents a unique framework for biomedicine. The group collaborates broadly within ASU and with major institutions globally. Initiatives led by CAS include the National Biomarker Development Alliance (NBDA) and CAS Biomedicine, which works on models and analytics to integrate big data in biomedicine.

The

scientific community collaborative access to research components and expertise that our faculty have. Advances in genomics at these facilities will continue to impact the way human disease is diagnosed, prevented and treated.

2.2 Expected outcomes as a result of TRIF investments

2.2.1 Specific and realistic goals that are clearly measurable

As mentioned previously, Improving Health is ASU largest TRIF funded initiative and so it likewise accounts for the largest proportion of ASU's TRIF enabled sponsored awards, technology transfer activities, and workforce contributions. Over the proposed 5-year TRIF funding period, ASU's planned expansion of its Improving Health Initiative to additional health-related units and infrastructure investments will synergistically accelerate our ability to deliver economically important research outcomes.

2.2.1.1 Return on investment

For the proposed TRIF funding period from 2017 to 2021, ASU anticipates that it can continue its remarkable trajectory in the biosciences and health related fields. We expect that the proposed TRIF investments of \$75M will allow us to grow TRIF-enabled annual sponsored project funding from \$77.5M in 2017 to more than \$124M in 2021, a 60% increase. Over the 5-year period, our investments in the Improving Health Initiative will attract more than \$500M in sponsored project funding to the State. Furthermore, we expect that this funding will be complimented by almost \$10M dollars of research-focused gifts and royalty income.

2.2.1.2

Institute researchers who are studying 96 diseases and 16 types of cancer

Provide technical instruction, resources and development opportunities to form meaningful local, national and international collaborations

Market the capabilities of our core facilities available to partners to establish new partnerships and encourage new research

2.2.1.4 Workforce contributions

TRIF investments in ASU's Improving Health Initiative have provided advanced education and training in state-of-the-art biosciences research for both graduate and undergraduates students for more than a decade. More than 1,000 students have had the opportunity to gain hands-on laboratory experience with the latest technologies, develop proficiencies in interdisciplinary research, and establish innovative scientific thinking that have prepared them for employment in healthcare, government, private sector and academia.

2.3 Initiative structure

2.3.1 Organizational structure

Joshua LaBaer leads the Biodesign Institute supported by an executive leadership team comprised of the institute's 15 research center directors. The Institute's operations staff provide institutional support in financial services, research infrastructure, human resources, research operatio

3 National Security Systems

3.1 Investment description/rationale/justification

Since 2012, ASU's National Security Systems Initiative has allocated just over \$10 million of TRIF funding to stimulate its research activities in defense and security related areas. Over the same period, ASU's National Security Systems initiative has enabled more than \$100 million in sponsored research projects primarily funded from the Department of Defense, the Intelligence Community and companies that serve these organizations. Our success in this area has propelled ASU to rank 34th in the nation in terms of DOD funding. In addition to bringing external research money to the state, ASU's National Security Systems Initiative is contributing to Arizona's economic development by leveraging research and development efforts to form new spinoff companies, providing relevant and effective postgraduate pathways to entrepreneurial development that is keeping money and talent in state.

ASU's National Security Systems Initiative is spearheaded by its Global Security Initiative (GSI), a university-wide interdisciplinary hub for global security research that focuses on openness, inclusiveness and connections to the global defense, development and diplomacy communities. The Global Security Initiative and its associated programs address emerging global challenges characterized by complex interdependencies and conflicting objectives, where there may not be obvious solutions. GSI serves as ASU's primary interface to the Department of Defense (DOD) and intelligence community (IC), positioning Arizona for industry, government and philanthropic investments. Research efforts at GSI also provide insights on new learning approaches to create and sustain the national security workforce needed for Arizona and the U.S. to maintain a competitive edge in the global economy.

3.1.1 Brief overview of industry or area being addressed by the initiative to include benefit to Arizona

GSI's work, by exploring and addressing challenges that are directly relevant to Arizona, will serve to benefit Arizona citizens. For example, the State of Arizona has targeted the aerospace and defense industry as a primary focus area for building sustained technology related economic growth in the state. GSI's work, and that of the NewSpace initiative, will help to solidify Arizona as a prime location for security research

Arizona's economy" and the CDF's will serve Arizona as center of excellence for research and development in this important field and an source of highly trained graduates.

Additionally, Arizona has witnessed considerable growth in the Information and Communications Technology (ICT) sector in recent years, with "nearly 70,000 people currently e

Pacific Northwest National Laboratory, Oak Ridge National Laboratory and Argonne National Laboratory.

Human health and human security. Increased connectivity (both virtual and physical), urbanization and environmental change will all have important implications for human health and well-being. Current and future climate variability is expected to significantly impact ecosystems, water, energy and food security, as well as human health. A critical impacted area of human health is that of vector-borne infectious diseases. GSI contributes to the understanding of how these diseases spread, as well as the timely decision-making necessary in a pandemic or epidemic situation. Our work on extreme heat and water scarcity and the impact on vulnerable communities is also relevant to this area, particularly in relation to their potential effect on Arizona's aging population.

The following programs complement GSI in support of ASU's National Security Systems Initiative:

An **Exploration Initiative** focused on the intersection of an Exploration paradigm with su8]TJ22.66004F005C0003>604C005113(ty ion onp 12 -3(A c5(pl) edu2(a)4(thn,03>6m)-

growth in this competitive area. Under GSI's leadership, ASU expects to increase its research funding from \$36 million to \$60 million annually – a 65% increase over the five year period. In total, the expected research funding attracted to Arizona in this economically important sector is expected to total \$240 million.

3.2.1.2 Technology transfer

urban security, and infrastructure resilience will be the core of ASU's National Security Systems Initiative funding portfolio, GSI also expects to attract additional funding for resilience and health from organizations such as USAID, NIH, DTRA, DOE and others. GSI collaborates with The ASU Foundation on an outreach plan to foundations for funding primarily in health, human security and resilience and expect these efforts to result in \$4 million of funding by 2020. Las

Gail-Joon Ahn, director of the Center for Cybersecurity & Digital Forensics

Jaqueline Wernimont, co-director of the Human Security Collaboratory

Jessica Rajko, co-director of the Human Security Collaboratory

3.3.2 Advisory board

GSI is convening an external strategic advisory board to assist in identifying opportunities for impact, relationship building and funding. This board will include past representatives from the DOD and IC, as well as leading researchers with significant security and defense research and research leadership experience.

3.3.3 Infrastructure

University infrastructure supporting the National Security Systems Initiative includes CDF and the ASU Research Enterprise (ASURE), the not-for-profit applied research, development, and consulting affiliate of Arizona State University. CDF brings together leading faculty in engineering, social sciences, law and business to:

- conduct sponsored research focused on identity management, privacy issues, malware attribution, secure mobile devices, predictive analytics/adversarial, dynamics and digital forensics

- create custom education, internship and training platforms

- support entrepreneurial activities in partnership with ASU SkySong

ASURE specializes in conducting classified and midrange technology readiness level (TRL) services for the defense and security industry. ASURE connects the defense and security industry with the unsurpassed intellectual resources of America's fastest growing research university. We develop outcome-driven, customer-focused, real-world solutions designed to meet near- and longer-term security and defense needs.

3.3.4 Description of investment mechanisms

GSI has been formally in operation since February 1, 2015. Its launch was preceded by a six-month effort to redesign and reconceptualize ASU's approach to working with the DOD and IC, aligning ASU's unique strengths with key local, national and global research and development needs across the security and defense space.

During this conceptualization phase, we held discussions with a wide range of relevant government agencies to identify key areas of interest in security and defense, as well as the best methods of collaboration with these entities. Coordination with government agencies, foundations and industry partners will continue to ensure the alignment of ASU capability with funding sources.

GSI coordinates closely and continuously with existing ASU institutes, centers and

4 Water, Environmental and Energy Solutions

4.1 Investment description/rationale/justification

The Julie Ann Wrigley Global Institute of Sustainability (Wrigley Institute) is the hub of ASU's sustainability initiatives, advancing research, education and business practices for an urbanizing world. Its School of Sustainability, the first of its kind in the country and celebrating its tenth anniversary, offers transdisciplinary degree programs focused on finding practical solutions to the most pressing social, economic and environmental challenges of our times.

The proposed TRIF investment in the Wrigley Institute will enable the institute to:

- continue to advance ASU's university-wide commitment to sustainability
- enable

valued institutions.

The LightWorks initiative within the Wrigley Institute is an example of this investment model. LightWorks fosters economic growth by providing advanced technologies, supporting local firms and enhancing the attractiveness of Arizona to outside investors. Expanded programs at LightWorks serve to create high-quality jobs in manufacturing, services, research and development. These support increased tax revenues and enhance the reputation of Arizona as the leader in developing and deploying sustainable energy solutions, especially solar energy.

For example, two startup companies founded on ASU technology were developed with LightWorks TRIF investments:

Fluidic Energy is estimated to generate over \$15 million in annual revenue and employs 35 people. The company has raised \$150 million in equity financing from investors.

Heliae had sales of \$4.2 million in 2014 and employs 105 people.

4.1.2 Discussion of mission, goals, values and vision

ASU is a leader in the global movement to help solve enduring challenges of sustainability, promoting human prosperity and well-being for all while protecting and enhancing Earth's life support systems. The overarching goal of the proposed TRIF investment in the Wrigley Institute and other initiatives is to enable the institute to focus select ASU talent on the development of solutions to sustainability challenges.

The measure of the number of people affected is the best measure of a project's impacts. For example, developing a technology designed for hot, arid environments that has a real value proposition in the market has the potential to impact 1–2 billion people worldwide.

The impacts of convening stakeholders will be examined across all activities to quantify the number of events and the level of potential influence within the respective stakeholder group. For example, local stakeholders and international experts studying desalination would examine the tradeoffs of having desalinated water become a fourth source of water for the Phoenix metro area.

We can measure, in a semi-qualitative/quantitative way, how often and where our experts have brought their perspectives to bear upon relevant issues where decision makers could take action. An example would be hosting a webinar where sustainability scientists offer varying perspectives on the future of sustainable transportation fuels and attendees from funding and regulatory agencies act to create a funding opportunity focused on emerging technologies.

4.1.3 Description of programmatic investments

renewable energy, advanced manufacturing and processing.

4.2 Expected outcomes as a result of TRIF investments

4.2.1 Specific and realistic goals that are clearly measurable

4.2.1.1 Return on investment

The Water, Environmental and Energy Solutions (WEES) initiative is a key interdisciplinary ASU TRIF-funded initiative that has been instrumental to ASU's emergence as one of the nation's leading research universities in this multidisciplinary field. One example of ASU's prominence in this broad discipline comes from the National Science Foundation (NSF), which currently ranks ASU as 5th nationally in Earth Sciences total research expenditures and 22th nationally in Environmental Sciences total research expenditures. These impressive national rankings reflect the university's ability to turn TRIF investments into research projects and programs that have attracted substantial funding to the State of Arizona.

Over the last five years, the \$20M in TRIF funding ASU has invested in its WEES initiative have resulted in the competitive acquisition of more than \$60M in sponsored projects dollars and more than \$15M in research gifts.

Looking forward, ASU aims to grow capabilities in this area substantially as these efforts will have a direct and certain benefit for the citizens in the State of Arizona. With increased TRIF investments totaling \$35M over the five year period from 2017 to 2021, ASU's WEES initiative intends to attract more than \$140M in sponsored projects funding and an additional \$22.5M in research gifts.

4.2.1.2 Technology transfer

ASU's Water, Environmental and Energy Solutions initiative has increasingly focused its efforts on applied solutions to the grand challenges in sustainability. These efforts have manifested in substantially increased technology development. Whereas in 2012 and 2013 ASU's WEES initiative produced just one invention disclosure, in 2015 the initiative produced a record number of 28 invention disclosures. Over the proposed additional funding period, ASU expects this trend to continue due to its use-inspired research efforts and will generate more than 60 invention disclosures, 11 US patents, and create 24 licensing and options agreements to translate its research into the marketplace.

on proposal development, student internships, guest speakers, joint fora, co-authorship of research reports and executives-in-residence. We expect to establish at least 140 industry engagements during this TRIF funding cycle:

4.2.1.4 Workforce contributions

At the core of ASU's WEES initiatives lies the Julie Ann Wrigley Global Institute of Sustainability and its pioneering School of Sustainability, which is the first of its kind in the US. As our WEES related research has grown, the educational focus of the School has been paramount and has driven an initiative-wide focus on student engagement. Over the last 5 years, the WEES initiative has provided advanced research training in this emergent interdisciplinary field to hundreds of graduate and undergraduate students and been the choice of more than 60 postdoctoral appointees and research professionals to continue their education in. Over the proposed period of continued TRIF funding, the WEES initiative plans to broadly expand this engagement by providing research opportunities to more than 1,800 graduate and undergraduate students. Additionally, we expect that continued TRIF funding would allow us to attract and support 161 postdoctoral appointments.

4.2.1.5 Educational outreach

ASU is committed to sustainability education at all grade levels and our planned WEES initiative activities reflect this promise. Our National Sustainability Teacher's Academy supports ASU's commitment to making high quality education accessible to all of Arizona's students by bringing sustainability into middle school classrooms. Another award-winning program, the Ecology Explorers program, has brought over 2,000 K-12 students in 75 schools across the Phoenix metro area together with university researchers and public school science teachers to bring scientific discovery into the lives of young students.

Other important examples of educational outreach include but are not limited to: K-12 teacher trainings, conference presentations, public speaking, community fora, curriculum development and dissemination. During this TRIF funding cycle the Wrigley Institute will establish, partner and support 50 distinct educational outreach events:

4.2.1.6 Government agency/community engagement (outreach, partnerships, collaboration)

Over the last decade, the Julie Ann Wrigley Global Institute of Sustainability has

attracted more than \$80M in federal research funding for its innovative, solutions-focused research. Over the proposed five year TRIF funding cycle, the WEES initiative

4.2.2 Annual metrics table of expected outcomes and timeline for achievement

Expected Outcomes	Projected FY 17	Projected FY 18	Projected FY 19	Projected FY 20	Projected FY 21
TRIF EXPENDITURES					
Total	\$ 7,050,459	\$ 7,349,538	\$ 7,768,132	\$ 8,186,383	\$ 8,604,285
FINANCIAL IMPACT OF TRIF INVESTMENT					
Sponsored Awards	\$ 23,000,000	\$ 26,000,000	\$ 28,500,000	\$ 30,100,000	\$ 34,000,000
Gifts & Other Sources	4,250,000	4,380,000	4,510,000	4,650,000	4,790,000
Royalty Income	100,000	100,000	100,000		

4.3 Initiative structure

4.3.1 Organizational structure

The Wrigley Institute is governed by a directorate that has established an ambitious agenda for our enterprise to become a leader in providing sustainable solutions for a rapidly urbanizing planet. Their combined expertise provides comprehensive oversight for TRIF-directed projects residing within the institute.

The Wrigley Institute directorate includes:

Gary Dirks, director

Rob Melnick, executive director and chief operating officer

Christopher Boone, School of Sustainability dean

Each TRIF activity will have a program lead who will provide expertise and oversight on project expenses, milestones and external funding opportunities. We will identify program leads through the institute's established network of sustainability scientists and scholars. Lead scientists will be chosen based on their expertise and ability to manage cross-disciplinary teams and their entrepreneurial instincts and/or experience.

(NSF), U.S Department of Defense (DOD), National Aeronautics and Space Administration (NASA), Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), World Bank/IFC, and the U.S. Agency for International Development (USAID). Additional investment from corporations such as Wells Fargo Bank, Intel Corporation, Archer-Daniels Midland and Starbucks will also contribute to ongoing support for the Institute and initiatives.

4.5.2 Timeline for transitioning away from TRIF support

We will transition funding from TRIF to external research support, with a goal of becoming self-sustaining by the end of FY2021.

5 Access and Workforce Development: Entrepreneurs

Our impact on the community and marketplace is profound. Startup companies that have licensed ASU intellectual property have attracted over \$500 million in funding from venture capital firms and other investors, with much of this financing achieved during the last five years. Overall, ASU's venture development activities have led to the formation and assistance of more than 80 companies based on ASU discoveries. Many of these co

an ASU accelerator program. ASU faculty with experience in entrepreneurship can participate as mentors and faculty who want to start a venture benefit from this valuable network of area professionals.

ASU Startup Bootcamp provides a structured approach to starting a new company. The summer Startup Bootcamp provides a balanced approach of self-guided training, mentorship and regular consultation with an E+I venture manager to assist faculty in launching their ventures. Faculty startups are embedded with other high-potential startups comprised of ASU alumni- and community-based companies.

ASU Startup Mill is an exclusive program jointly run by E+I and Arizona Technology Enterprises (AzTE). Startup Mill invites the highest-potential student- and faculty-led startups within the university as well as select startups from outside the university to receive top-tier entrepreneurship support from ASU. Participants receive incubation, acceleration and strategic investment from the university. The program also matches participating startups with seasoned venture capitalists and executives who provide mentoring and direction to the ventures, may serve in an administrative capacity, and help identify high-potential intellectual property within the university. Startup Mill aims to retain high-performing startups in Arizona that will create jobs and contribute significantly to regional economic development as they scale.

ASU Startup School is a series of facilitated workshops in which entrepreneurs learn how to develop a successful venture. Offered online and in person, ASU Startup School is available to anyone, anywhere. Faculty can access this resource on their own time or participate in facilitated sessions. Faculty can also become certified ASU Startup School instructors to deploy this resource in their respective colleges.

In addition to the core entrepreneurship focused programs, ASU is redefining innovative economic engagement while having a large-scale impact on the local economy by engaging with corporate partners, municipal and state partners, regional economic development organizations and chambers of commerce, and local community members, including entrepreneurs. Additional services provide by the Office of entrepreneurship and Innovations include:

- Expanding strategic industry collaboration to increase the university's accessibility to businesses and identify opportunities to increase the university's economic impact, both locally and globally

- Developing and launching new centers in collaboration with interested companies

- Introducing faculty to companies that are considering locating in the region

Providing introductions to research and development organizations in the region

Supporting and hosting public or internal conferences, summits, meetings and events at SkySong, the ASU Scottsdale Innovation Center

5.2 Expected outcomes as a result of TRIF investments

5.2.1 Specific and realistic goals that are clearly measureable

5.2.1.1 Return on investment

ASU's Access and Workforce Development Initiative in

Invest Southwest

National Advisory Council on Innovation and Entrepreneurship (NACIE)

Startup AZ

University Economic Development Association (UEDA)

ASU also works with many corporations around the world, aided by a pan-university Corporate Engagement Council and Corporate Relations Task Force, with over 60 administrators across the university working together to coordinate relationships, projects and responses to new engagements.

Corporate partners serve as critical sponsors of ASU's entrepreneurship and innovation programs, including four projects through a Cisco-advised Silicon Valley Community Foundation award, support of women's entrepreneurship through JP Morgan Chase and significant support of youth entrepreneurship programs through the Verizon Foundation.

Through the ASU Entrepreneurship Outreach Network, ASU works with 14 libraries providing resources and support to enable them to be robust sources of entrepreneurship information to their communities.

5.2.1.4 Workforce contributions

Each year, through the various Innovation Challenges, we see over 500 applications, representing a body of nearly 2,000 students, who are actively building ventures. Across the university, our Entrepreneurship and Innovation educational programs

applied community-based projects. The program provides a framework for educators of a variety of disciplines, educational settings and grade levels to learn applied project methodologies. The TIF program uses a blended learning approach, combining face-to-face workshops with virtual learning experiences.

Lastly, ASU's Access and Workforce Development Initiative in Entrepreneurship and Innovation advances the university's Access mission in supporting a diversity of programming for minorities, veterans and other underserved populations

5.2.2 Annual metrics table of expected outcomes and timeline for achievement

5.3 Initiative structure

5.3.1 Organizational structure

ASU believes in operating at speed, scale and complexity, and one way we achieve this is through a team of teams approach with a collaboration mindset. By deploying an agile

Keith Walton, vice president of strategic industry collaborations

Ji Mi Choi, associate vice president of strategic partnerships and programs

This team, a small core staff and an additional group of university partners across various functional areas of expertise work to implement the variety of services in support of entrepreneurship and economic development through innovation.

5.3.2 Infrastructure

The leadership team above as well as student employees working on SkySong company engagement support the economic development team. The Office of Entrepreneurship and Innovation employs 12 full-time employees and additional grant-funded personnel marshalling ASU entrepreneurship resources from across the university and serving as a resource to all ASU programs and schools.

ASU supports the following facilities and resources for students, faculty, staff and the community:

ASU Chandler Innovation Center, including 17,000 square feet of makerspace in partnership with TechShop, along with classroom, seminar and event space

Changemaker Central – dedicated student social entrepreneurship spaces on each campus

Cronkite School of Journalism and Mass Communications' Digital Innovation and Entrepreneurship Lab

Edson Student Entrepreneur Initiative, funded by a \$5 million endowment, provides space at SkySong, capital and mentorship to student startups

Ira A. Fulton Schools of Engineering Startup Center and Generator Labs

Herberger Institute for Design and the Arts Pave Program in Arts Entrepreneurship, including an Arts Venture Incubator and InnovationSpace

SkySong includes 16 conference rooms used by on-site companies and the broader community, hosting approximately 500 meetings on-site per month with roughly 5,000 monthly attendees

W. P Carey School of Business Center for Entrepreneurship

14 libraries from around the region participating in the Entrepreneurship Outreach Network

5.3.3 Description of investment mechanisms

The Entrepreneurship and Innovation team seeks to expand the number of people who may participate in its programs to increase access to entrepreneurship training and

support. By enhancing communications, we endeavor to make programming and resources more accessible. In addition, the team aims to better support underserved populations: minority entrepreneurs, women entrepreneurs and veterans. By investing in better supporting and focusing on underserved populations, ASU aims to increase access to social mobility, create and foster a more dynamic and diverse economic development engine, and diversify areas of growth.

Simultaneously, the economic development team will seek to strengthen our corporate engagement strategies, enhance communications channels, and expand business attraction and retention activities.

professional development enabling design thinking and infusion of entrepreneurship in high school classrooms across the country.

ASU anticipates continuing to seek external funding in support of the critical programs that allow for local, regional, and national economic growth in addition to an enriching experience for our students, faculty, and community.

5.5.2 Timeline for transitioning away from TRIF support

Over the next five years, as ASU increases the intensity of its philanthropic campaigns, and as the Office of Entrepreneurship and Innovation continues seeking out external support, we anticipate building on the success of our programs to the point of needing less core support, including TRIF investments.

Support of entrepreneurship, particularly university-based entrepreneurship continues to grow and as the most innovative university in the country, ASU plans on building on the momentum and gains we have realized, especially in recent years.

6 Access and Workforce Development: Advanced Manufacturing

6.1 Investment description/rationale/justification

The meaning of the term “manufacturing” is undergoing a historic transformation. Several important technological trends are revolutionizing the way things are made in America. These include:

- fabrication techniques like additive manufacturing

- novel materials that enable advances in electronics and life sciences applications

- the “democratized” process tooling that is driving the “maker” movement

ASU is already investing in several of these strategic areas through research activities conducted

actively participate. We believe these trends represent an opportunity underexploited by universities. ASU, with its focus on use-inspired research and well-developed corporate engagement activities, has many of the tools in place to become a leader in the targeted development of science and technology that is tightly coupled to economic development activities.

TRIF investments will support key personnel in establishing initiative operations, to fund seed research, and to conduct outreach to prospective corporate and federal agency sponsors. The end goal will be to catalyze and support the advanced manufacturing industry in Arizona by building world-class research and development capabilities, educational and research training opportunities, and a steady stream of graduates well prepared to enter and advance the industry.

6.1.1 Brief overview of industry or area being addressed by the initiative to include benefit to Arizona

Manufacturing is an important component of any healthy economy, and the economy of Arizona is no exception. According to statistics assembled by the Arizona Commerce Authority, Arizona's total manufacturing output (contribution to State Real Gross Domestic Product) in 2014 was \$23.12 billion, or nearly 9% of the state's Real GDP.

Employers of every size consistently express intense interest in working more closely with ASU to tailor curricula to their needs, and to develop new methods for enhancing engagement between potential employers and students during their education. The university has begun to experiment with some of these ideas at its Polytechnic campus with its iProjects program, which pairs ASU student teams and their faculty mentors with industry project sponsors to develop real world solutions to a problem faced by the company. With the Access and Workforce Development Initiative in Advanced Manufacturing, we will build on this foundation to engage more actively with industry in workforce development.

6.1.2 Discussion of mission, goals, values and vision

Several ASU programs will support the Access and Workforce Development Initiative in Advanced Manufacturing to reach the following overall goals:

- Participate as a principal team member in bids for programs under the National Network of Manufacturing Institutes program

- Develop strategic partnerships with the state's principal manufacturers with the intention of expanding this activity beyond the state's borders in future years

- Adapt existing faculty recruitment programs to supplement capacity in targeted advanced manufacturing disciplines and establish ASU research excellence in those areas

- Develop a strategic plan for engagement with federal agencies to promote the development of large-scale programs to promote national manufacturing

- Broadly engage graduate and undergraduate students across

economic ramifications of advanced manufacturing advancements for Arizona. As examples, the semiconductor and electronics industries will undergo significant transformation as new applications are developed to embed sensors and processors into products in virtually every area, from new materials and manufacturing techniques to medical devices and other health care technologies, communications, and clean energy.

Currently, there is a global manufacturing restructuring and a resurgence of U.S.-based manufacturing, expanding and enhancing the Southwest region's capacity to take advantage of opportunities. Technology transfer, licensing and startup encouragement will renew and protect its established production base and open new avenues for growth.

6.2.1.3 Industry engagement (outreach, partnerships, collaboration)

A critical component of regional advanced manufacturing strategy is conducting an annual cycle of strategic technology gap identification in the capabilities of the existing manufacturing companies in the region. This gap identification allows the initiative to develop industrial engagements that target real needs, and to plan technology developments that enhance Arizona's competitiveness. We plan:

- \$5 million per year in public-private partnership engagements in advanced manufacturing by 2021

- A formal commercial partnerships framework with 25 partners by 2021

- Development of an external advisory council made up of industrial collaborators

6.2.1.4 Workforce contributions

ASU expects to be able to provide highly specialized educational experiences and research and development training in advanced manufacturing focus areas to more than 600 graduate and undergraduate students over the proposed five-year funding period.

6.2.1.5 Educational outreach

ASU will deliver education outreach at all levels, with a particular focus on high school and community colleges. Examples of educational outreach include but are not limited to teacher trainings, apprenticeships, conference presentations, curriculum development and dissemination, maker camps and classes and community engagement via speaking, workshops and meetings. ASU will work with community colleges across Arizona to create certificate, on-line and apprenticeship programs in advanced manufacturing that lead to jobs, four-year college and advanced degrees.

6.2.1.6 Government agency/community engagement (outreach, partnerships, collaboration)

Through the Access and Workforce Development Initiative in Advanced Manufacturing, ASU will create formal joint-effort with National Laboratories, companies and NGOs. Traditional federal funding will be secured through DoD, DOE and NIST. Additional funding will be pursued through organizations such as USAID, NIH, DTRA, and others. Collectively, we expect \$15M in Federal partnerships and \$10M in commercial partnerships by 2021.

6.2.2 Annual metrics table of expected outcomes and timeline for achievement

6.3 Initiative structure

6.3.1 Organizational structure

A director whose purview spans engineering, design, the physical and life sciences, and STEM pedagogy will lead this new initiative. Through the first several years, the initiative will incorporate an operations lead and a program development lead, and will utilize management resources from across the institution, such as financial services, research computing and human resources. The goals for organizational structure for this initiative focus on efficiencies and lowest costs to achieve the goals of the initiative.

Each activity funded through this initiative will have a program lead who will provide expertise and oversight on project expenses, milestones and external funding opportunities. These leads will be chosen based on their expertise and ability to

manage cross-disciplinary teams and their entrepreneurial instincts and/or experience.

6.3.2 Advisory board

Primary advisory oversight of the TRIF investment in the Access and Workforce Development Initiative in Advanced Manufacturing will be assigned to the internal advisory board of the Ira A. Fulton Schools of Engineering. In addition, the board of directors for research development at ASU, composed of representatives from business, government, nonprofit and academic organizations, will actively advise the initiative on a regular basis.

6.3.3 Infrastructure

The Flexible Electronics & Displays Center (FEDC) includes fabrication clean rooms, wet/dry laboratories, and a manufacturing pilot line originally constructed for industry use. FEDC was built through \$100 million in US Army investments over 10 years and achieved its goal of delivering flexible displays to support DOD missions. In the process, FEDC produced several processes and technologies that are in testing or have been adopted by commercial entities and DOD (Figure 4.1). FEDC successfully collaborates with more than 40 industry partners and previously facilitated the commercialization of a half dozen enabling technologies for manufacturing (e.g., materials, processes, manufacturing tools, software).

FEDC is housed in the Macro Technologies Works (MTW) building, which seeks a larger scale role for ASU manufacturing research at scale and in commercial world time frames with strategic industry and government partners

6.3.4 Description of investment mechanisms

ASU faculty conduct research in a number of areas that are relevant to emerging manufacturing paradigms through a variety of corporate engagements that are currently largely uncoordinated. Under the Access and Workforce Development Initiative in Advanced Manufacturing, we will employ a formal strategic planning process to organize these existing activities into coordinated campaigns that will provide clear research opportunities for both graduate and undergraduate students.

6.4 Initiative budget table

Initiative Budget	Projected FY 17	Projected FY 18	Projected FY 19	Projected FY 20	Projected FY 21
Access and Workforce Development:	\$ 1,639,104	\$ 1,735,104	\$ 1,831,104	\$ 1,927,104	\$ 2,023,104
Advanced Manufacturing					

6.5 Plan for sustainability

6.5.1 Anticipated funding sources for ongoing support

TRIF-funded manufacturing activities will be led by faculty and staff with proven track records of successful and impactful research, industry engagement, partnership creation, company building and commercialization.

We will transition funding from TRIF to external support in the form of grant funds, contracts and public-private partnerships, with a goal of sustaining the advanced manufacturing capability at ASU at the level of \$5 million in annual expenditures by the end of FY2021.

During the five years of TRIF investment, we will work to secure external funding from Federal agencies (DOD, NASA, DOE, EPA, Department of Commerce and NSF), as well as corporations such as Intel Corporation, Raytheon, Honeywell, Boeing and Medtronics.

6.5.2 Timeline for transitioning away from TRIF support

It is anticipated that by 2021, Advanced Manufacturing at ASU will be supported by external investments, particularly partnerships with companies. TRIF investments that were used to support capital and infrastructure investment plans will have yielded sufficient capacity that companies will be willing to use ASU as a key partner in new development activities