

TECHNOLOGY AND RESEARCH INITIATIVE FUND

UNIVERSITY OF ARIZONA

FISCAL YEAR 2022



Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	Access and Workforce Development																																											
Program Name:	Expanding Undergraduate Research Opportunities																																											
Problem Statement:	<p>Undergraduate research is well known as a high-impact educational practice that leads to increased retention and a stronger workforce. An early undergraduate research experience (URE) in social sciences and humanities leads to significant gains in analytical and critical thinking skills for first- and second-year students, especially for first-generation students. UREs, particularly during the academic year, lead to increased interest and persistence in STEM, especially for underrepresented minorities. However, the traditional one-on-one apprenticeship model prevalent at UArizona limits the number of students with these experiences to a select few.</p>																																											
Program Description:	<p>TRIF funds will support the expansion of undergraduate research opportunities to provide equitable access to research experiences for students who historically have had less access to research early in their academic careers. The funds will also be used to support student's direct participation in TRIF-funded research projects and the dissemination of best practices in the various models of undergraduate research engagement.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>UArizona offers numerous long-running undergraduate research programs supported by the institution that address societal needs. As a Hispanic-Serving Institution and an American Indian and Alaska Native-Serving Institution, the university is now more intently focused on the "servingness" aspect of these designations. The culture within science departments has been shifting to recognize the value of offering research opportunities to a wide majority of students and not to just the top, most academically talented.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> •Increased diversity and representation among UArizona students who have access to research experiences and research-rich curriculum •Increased number of research-rich courses and other research opportunities targeted to first- and second-year students, and VIPs •Increased number of awarded proposals that incorporate scaled-up research experiences in their education plans •Overall increased retention in STEM of underserved and underrepresented students •Overall increased enrollment in graduate research programs among historically underserved and underrepresented students necessary to realize Arizona's workforce challenges 																																											
Investment Detail	<table border="1"> <thead> <tr> <th></th> <th>2022</th> <th>2023</th> <th>2024</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Infrastructure</td> <td>83,394</td> <td>83,394</td> <td>83,394</td> <td>250,182</td> </tr> <tr> <td>Basic Research</td> <td>49,862</td> <td>49,862</td> <td>49,862</td> <td>149,586</td> </tr> <tr> <td>Applied Research</td> <td>49,862</td> <td>49,862</td> <td>49,862</td> <td>149,586</td> </tr> <tr> <td>Development</td> <td>39,890</td> <td>39,890</td> <td>39,890</td> <td>119,670</td> </tr> <tr> <td>Total</td> <td>223,008</td> <td>223,008</td> <td>223,008</td> <td>669,024</td> </tr> </tbody> </table>					2022	2023	2024	Total	Infrastructure	83,394	83,394	83,394	250,182	Basic Research	49,862	49,862	49,862	149,586	Applied Research	49,862	49,862	49,862	149,586	Development	39,890	39,890	39,890	119,670	Total	223,008	223,008	223,008	669,024										
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Access and Workforce Development
Program Name:	Expanding Undergraduate Research Opportunities

2022 Progress Summary:

In addition to coordinating various undergraduate research initiatives across campus, UArizona has launched an Undergraduate Research and Inquiry Collaborative. The collaborative makes it easier for students to discover undergraduate research opportunities, get earlier access to opportunities embedded in the curriculum, and benefit from additional mentored research experiences developed by faculty. The collaborative also ensures that students representing all Arizona communities get access to these opportunities, especially those who have been historically underrepresented in research. Beyond this, UArizona invested TRIF funds to support the expansion of mentored apprenticeship research experiences with faculty, industry internships, and course-based research experiences as well as direct funding for paid student positions. TRIF supported 222 undergraduate research experiences.

Select highlights:

- Faculty: 55 additional directed research positions were added (an approximately 6.5% increase), enabling more students to engage with research on topics such as the neurobiology of learning and memory associated with drug abuse, oral rehydration solutions with impaired water sources for children with dysentery in a low-income communities, agrivoltaics, and drought assessment in Pima and Maricopa counties.
- Industry: The TIMESTEP Summer Internship Program allowed UArizona undergraduates in the physical sciences and mathematics to connect with small to mid-sized businesses based in southern Arizona. This engagement creates pathways for employment and exposes businesses to university resources. Many see graduate school as the only post-baccalaureate option for physics and astronomy majors, resulting in a high student attrition rate from these majors. TIMESTEP provides an opportunity for undergraduates to find an alternative option by preparing them for industry careers in these fields, leading to greater retention. TRIF supported 26 intern positions, most from physics, astronomy, math, and computer science; 52% were either first generation students, from low-income households, female, or from an underrepresented ethnic group. Fifteen companies offered summer internships. Eight of the 15 were returning companies who provided donations to support the program in the amount of \$22,500.
- CUREs: We have developed course-based undergraduate research experiences (CUREs) through a CURE Training Institute to teach faculty how to incorporate authentic research experiences into courses targeted for first- and second-year students, making it possible for larger groups of undergraduates to engage in authentic research as early as their first year. By fall 2023, over 1,000 students will have the opportunity to engage in an authentic research experience through their Introductory Biology II lab course. Twelve faculty, graduate students, and research staff were funded through the 2021-22 CURE Training Institute to develop eight new introductory CURE courses. Through May, 11 introductory CUREs across six colleges were taught, serving 141 students. Only 11 to 22 students would have been served through a traditional apprenticeship research experience by the 11 instructors.

Investment Detail

	2022	2023	2024	Total
Infrastructure	178,912	265,517	265,516	709,945
Basic Research	0	0	0	0
Applied Research	0	0	0	0
Development	0	0	0	0
Total	178,912	265,517	265,516	709,945

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	0	0	0	0
Postdocs Supported	0	0	0	0
Graduate Students	1	0	0	1
Undergraduate Students	196	0	0	196
Sponsored Project Funding	800,743	0	0	800,743
Publications in Academic Peer-Reviewed Journals	0	0	0	0
Startups	0	0	0	0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona			
TRIF Investment Area:	Access and Workforce Development			
Program Name:	Supporting Diverse Graduate Student Researchers			
Problem Statement: Graduate students are the backbone of the research workforce at UArizona and frequently transition to high-tech industries in their careers. They generally outnumber other staff researchers, and prospective students are actively recruited by research-intensive graduate programs. Upon graduation, they are highly sought by industry. However, diverse graduate students pursuing these programs often face barriers, at both the recruitment and acceptance stages. Even if accepted into a program, they can face a lonely and unwelcoming environment. UArizona seeks a highly representative group of passionate graduate students who have the training to succeed in research-intensive careers after they leave graduate school.				
Program Description: TRIF funding will prioritize research projects that include graduate student researchers from across Arizona's complex demographics; connect research efforts and lived experiences to address issues of importance to Arizona's communities; are open to recruiting graduate students from within UArizona's existing undergraduate community; require inclusive mentor training for their research teams; and provide professional development opportunities so students can master technical skills and those that promote collaboration, creativity, and critical thinking. These are exactly the skills that Arizona's high-tech industries are seeking.				
What is the University's Advantage and/or Anticipated Funding Opportunities? With TRIF investment, UArizona can leverage and support a number of existing programs and structures to address the challenges described above. The Graduate College oversees the McNair Program, funded by the U.S. Department of Education, and the Undergraduate Research Opportunities Consortium, both of which serve diverse undergraduates and prepare them for graduate school. A number of graduate training programs and Graduate Interdisciplinary Degree Programs exist on campus in disciplinary areas that TRIF funds, and we will work with these programs to advance efforts towards growing Arizona's research and technical workforce and a vibrant economy.				
Is there an Arizona Specific Benefit or Impact? <ul style="list-style-type: none"> •TRIF-funded research teams representing the breadth of Arizona society •TRIF-funded research teams are more likely to tackle Arizona's grand challenges that directly impact Arizona's communities and industries •Among TRIF-funded research projects, higher numbers of underrepresented students persist year-to-year in research-intensive fields, developing the skills to succeed in the high-tech workforce •Among TRIF-funded research projects, graduate students report feeling welcome in their research-intensive environment 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	62,254	62,254	62,254	186,762
Basic Research	44,775	44,775	44,775	134,325
Applied Research	44,775	44,775	44,775	134,325
Development	14,925	14,925	14,925	44,775
Total	166,729	166,729	166,729	500,187
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses				0
Postdocs Supported				0
Graduate Students				0
Undergraduate Students				0
Sponsored Project Funding				0
Publications in Academic Peer-Reviewed Journals				0
Startups				0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona			
TRIF Investment Area:	Access and Workforce Development			
Program Name:	Supporting Diverse Graduate Student Researchers			
2022 Progress Summary:				
<p>Because graduate students are the backbone of research at UArizona and key to the development of our future workforce, we invested TRIF funds to help give them and those traditionally underrepresented in research the financial means, mentoring, and training to succeed in research-intensive careers after they complete their degrees. Select highlights:</p> <ul style="list-style-type: none"> •TRIF funds provided financial support to four graduate students from diverse communities, underrepresented in higher education, who lacked the funding and supportive infrastructure to otherwise earn their degree. Their STEM plan of study required practical work experience requiring hundreds of hours of unpaid work. •TRIF funding is partially supporting a position that facilitates graduate student placements in internships. •A team of graduate students and their faculty mentor have gathered resources about inclusive mentoring practices and strategies for supporting diverse graduate students and are creating a shared library for faculty. They have also analyzed written responses from approximately 500 graduate students about their experiences. Findings from this project will be submitted for presentation at the American Educational Research Association and will be disseminated to faculty and staff working with graduate students. We expect that understanding and addressing the barriers that graduate students encounter will allow us to better serve graduate students and increase the numbers of students who are retained, with particular attention to students in degree programs that will contribute to TRIF-related research and technology. •TRIF funds eliminated the need for student loans or paid employment to fund internship participation. •TRIF funds supported degree completion and student interest in pursuing doctoral training and research-intensive careers for the following projects: <ul style="list-style-type: none"> oDesigning and implementing an engineering education curriculum for Native American STEM undergraduates engaged in climate resilience research. oExploring the use of hydroponics as a sustainable food production system that conserves water while producing higher plant yields in shorter time frames. oProviding over 500 hours of preventative medicine, nutrition counseling, and collaborative, community healthcare to address the health disparities in a small, rural community. oOffering bilingual, multicultural Speech Language Pathologist expertise to underserved communities that cannot afford therapeutics when recovering from strokes and neurological disorders. 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	88,112	221,335	221,334	530,781
Basic Research	0	0	0	0
Applied Research	0	0	0	0
Development	0	0	0	0
Total	88,112	221,335	221,334	530,781
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	0	0	0	0
Postdocs Supported	0	0	0	0
Graduate Students	5	0	0	5
Undergraduate Students	0	0	0	0
Sponsored Project Funding	454,335	0	0	908,670
Publications in Academic Peer-Reviewed Journals	0	0	0	0
Startups	0	0	0	0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona			
TRIF Investment Area:	Access and Workforce Development			
Program Name:	Inclusive Mentoring for a Diverse Research Workforce			
Problem Statement: Many of us need the support of high-quality mentors to succeed and advance in our professions. This is especially true for those who are pursuing careers in research and high-tech fields. Mentoring often is most impactful when the mentor and mentee share the same gender, cultural background, or life experience. UArizona must be able to ensure that future and early-career researchers receive high quality, culturally inclusive mentoring through a robust training landscape and increase the pool of diverse mentors to serve the needs of our students and our future workforce.				
Program Description: Through TRIF funding, we will leverage these efforts and provide support to establish a mentoring community focused on innovating, increasing awareness, and disseminating best practices; develop higher-quality mentoring across TRIF-funded research projects and participants; create a centralized infrastructure to support culturally responsive and asset-based mentoring workshops; and implement a system for follow-up support to research mentors, particularly those participating in TRIF-funded research initiatives and projects. Additionally, we anticipate supporting an increased campus-wide understanding of how to overcome insensitivities in the mentor-mentee relationship; a series of events convening research thought leaders from community colleges and UArizona to identify barriers and solutions to mentoring challenges; and increased rewards and recognition for faculty who engage in high-quality mentoring practices and who carry higher-than-normal mentoring loads to provide mentoring to students who are from similar backgrounds.				
What is the University's Advantage and/or Anticipated Funding Opportunities? A number of early-stage efforts exist on campus around research mentor training, mentoring in STEM and health science, peer mentoring, and inclusive mentoring. The Office of Societal Impact has developed workshops for faculty, staff, and peer mentors on culturally responsive and asset-based, inclusive mentoring. An interactive training series is under development, supported by the Provost's Office of Diversity & Inclusion, in which Black, Indigenous, and People of Color (BIPOC) faculty will mentor other faculty as they undergo training to mentor BIPOC students. The UAHS Office of Diversity & Inclusion offers a series of training and support for mentoring students specifically in the health sciences.				
Is there an Arizona Specific Benefit or Impact? <ul style="list-style-type: none"> •Development of a comprehensive database of training opportunities and mechanisms to track trainings offered and taken •Among TRIF-funded research projects, an increased number of faculty and staff who have completed research mentor trainings •Among TRIF-funded research projects, an increased number of students with high-quality, inclusive research mentors 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	48,746	48,746	48,746	146,238
Basic Research	35,067	35,067	35,067	105,201
Applied Research	35,067	35,067	35,067	105,201
Development	11,689	11,689	11,689	35,067
Total	130,569	130,569	130,569	391,707
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses				0
Postdocs Supported				0
Graduate Students				0
Undergraduate Students				0
Sponsored Project Funding				0
Publications in Academic Peer-Reviewed Journals				0
Startups				0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Access and Workforce Development
Program Name:	Inclusive Mentoring for a Diverse Research Workforce

2022 Progress Summary:
 Supporting diversity and inclusion is a critical part of UArizona’s work to engage undergraduate students in research and develop the STEM workforce of the future. Mentoring underrepresented minorities and transfer students plays a fundamental role in our efforts, and TRIF funds were key to making critical hires, developing a system to support STEM transfer students, providing related training, and creating a peer ambassador program.

Select highlights:

- We hired a diversity and inclusion professional who worked with several administrators to develop STEM-focused, inclusive, and asset-based training materials for faculty who are leading diverse research teams in the biological sciences, physical sciences, mathematical science, computer and information sciences, geosciences-related and engineering.
- UArizona was awarded a five-year, NSF award to support the academic success of STEM transfer students enrolling at the university. This grant includes a year-long professional development institute for STEM faculty who seek to become effective mentors, advisors, and teachers to an increasingly diverse STEM student population. This type of training is critical: Of the 36,503 undergraduates enrolled at UArizona in fall 2020, 24.12% were STEM majors (8,805 students). Of the STEM majors, 33.85% were Pell-eligible (i.e., low income), 28.19% identified as first-generation college, and 28.63% identified as underrepresented minorities (URM) and were either Hispanic/Latinx, African American, Native American and/or Pacific Islander. As the student body continues to diversify, this work will empower faculty to work effectively with students who will help to diversify Arizona’s STEM workforce.
- A graduate assistantship related to this new position was included in the previous TRIF cycle as a project analyst who conducted an environmental scan of faculty mentor training programs across the university. That work is now being used by the newly established MENTOR (Mentorship through Effective Networks, Transformational Opportunities and Research) Institute that will provide additional resources to the campus around mentoring.
- A team of undergraduate peer mentors, the Undergraduate Research Ambassadors (URAs), provided 1:1 and group support in identifying research opportunities and in training on submitting competitive applications. The URAs met with or presented to 127 students, primarily over the spring semester. Due to the high demand for support from the URAs, TRIF funding will double the number of URAs hired, increasing from three to six for the next academic year. This effort is intended to reduce personal and cultural barriers to participating in undergraduate research.

Investment Detail

	2022	2023	2024	Total
Infrastructure	68,299	173,684	173,683	415,666
Basic Research	0	0	0	0
Applied Research	0	0	0	0
Development	0	0	0	0
Total	68,299	173,684	173,683	415,666

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	0	0	0	0
Postdocs Supported	0	0	0	0
Graduate Students	2	0	0	2
Undergraduate Students	0	0	0	0
Sponsored Project Funding	108,696	0	0	108,696
Publications in Academic Peer-Reviewed Journals	0	0	0	0
Startups	0	0	0	0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona			
TRIF Investment Area:	Access and Workforce Development			
Program Name:	Building Pre-College Interest in Research and Technical Careers			
Problem Statement: One of the pre-college barriers to early development of Arizona’s technically skilled workforce is an overall lack of awareness and interest among K-12 students about the requirements for the desirable Arizona jobs they ultimately will want to pursue. This is particularly true within communities with less access to research and fewer technically skilled role models with whom to engage. Early exposure to research and technology, and the career possibilities that go with those skillsets, through a variety of targeted outreach activities, will help inspire the future workforce.				
Program Description: By building and supporting broader pre-college awareness of, and interest in, research opportunities and highly skilled careers among Arizona’s students, UArizona can help influence the next generation of diverse leaders taking Arizona’s industries to new heights of productivity and growth. These future leaders will develop new perspectives on the variety of research and technical careers available to them, how those career paths will positively impact their communities and the state, and the skills needed to join the workforce. As UArizona works to overcome the barriers that historically have limited participation in such careers, we will develop more meaningful partnerships with community stakeholders, engaging them to participate in building these talent pipelines for the betterment of our state.				
What is the University's Advantage and/or Anticipated Funding Opportunities? UArizona has a long history of supporting pre-college students through a multitude of programs and structures designed for K-12 audiences to advance Arizona’s future workforce. Many of our programs provide expertise in skill building and mentoring in key areas that are typically barriers to STEM and technical career preparation readiness. TRIF funds can leverage these existing programs and structures, which have resulted in trusted relationships with Southern Arizona’s young learners, their teachers, and their families. While not a comprehensive list, examples of programs that work directly with youth include the Upward Bound program, Early Academic Outreach, Engineering 102, Native Student Outreach and Resiliency (Native SOAR), Mentoring and Education for Science in Tucson (MESCIT), Keep Engaging Youth in Science (KEYS, discussed in the Improving Health section of this plan), Girls Who Code, and Imagine Your STEM Future.				
Is there an Arizona Specific Benefit or Impact? <ul style="list-style-type: none"> •Increased awareness of and interest in research and technical careers among Arizona pre-college students and their larger community, particularly among populations who have historically had less access to such careers •Increased opportunities for exposure to state-of-the-art scientific and technical infrastructure and research faculty •Knowledge of or participation in research projects that are co-created between researchers and community stakeholders •Increased awareness of important Arizona economic development and research initiatives, and the associated future career opportunities •Development of formal and informal educators that have the skills to support student research and technical career-related experiences 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	84,209	84,209	84,209	252,627
Basic Research	0	0	0	0
Applied Research	0	0	0	0
Development	24,270	24,270	24,270	72,810
Total	108,479	108,479	108,479	325,437
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses				0
Postdocs Supported				0
Graduate Students				0
Undergraduate Students				0
Sponsored Project Funding				0
Publications in Academic Peer-Reviewed Journals				0
Startups				0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona			
TRIF Investment Area:	Access and Workforce Development			
Program Name:	Building Pre-College Interest in Research and Technical Careers			
2022 Progress Summary:				
<p>Building the workforce of the future requires planting the seeds of interest in STEM early and nurturing them throughout the educational journey. UArizona is committed to reaching students from kindergarten through high school, with a special focus on diverse and underserved populations. TRIF funding supports the university's work in breaking down pre-college barriers and increasing awareness of potential jobs and career paths among all of Arizona's K-12 students.</p> <p>Select highlights:</p> <ul style="list-style-type: none"> • Under the Southern Arizona Research, Science, and Engineering Foundation's (SARSEF's) Rural Teachers in Research program, TRIF supported four teachers and four UArizona graduate students as research mentors. This program provides professional development for teachers who want to offer research experiences to their students through course-based projects. Training is currently underway, and teachers will be ready to implement course-based research projects in the 2022-23 academic year. • The Quantum Quest Camp for high school girls, held in summer 2022, introduced girls to careers in quantum information science and technologies and encouraged them to continue their quantum education journey with research opportunities. By helping girls become quantum literate, learn the basics in quantum computing, and start their journey in quantum circuitry, the camp positions attendees to become Arizona's next leaders in the field. Outcomes are currently being analyzed. • The UArizona Data Sciences Educator Fellowship supports professional development for Arizona middle and high school educators to bring data sciences into classrooms. Thirty educators have been selected for the second cohort of fellows; however, funds have not yet been disbursed. Outcomes for the first cohort included facilitating a professional development session at the UArizona Mathematics Educator Appreciation Day (MEAD) Conference, bringing data-driven activities into their classrooms, working at the district level to institute a high school data science course, and supporting and mentoring students to complete research projects that were entered in the International Science and Engineering Fair. • TRIF supported the development of four separate \$1.3 million Department of Education Upward Bound proposals. To date, one proposal was awarded to support high school students in preparing for college, one proposal was not funded, and notification of the two remaining proposals is expected during late July or August 2022. 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	47,750	148,796	148,797	345,343
Basic Research	0	0	0	0
Applied Research	0	0	0	0
Development	0	0	0	0
Total	47,750	148,796	148,797	345,343
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	0	0	0	0
Postdocs Supported	0	0	0	0
Graduate Students	7	0	0	7
Undergraduate Students	58	0	0	58
Sponsored Project Funding	373,185	0	0	373,185
Publications in Academic Peer-Reviewed Journals	0	0	0	0
Startups	0	0	0	0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona			
TRIF Investment Area:	Access and Workforce Development			
Program Name:	The Community College to Four-year University Transition			
Problem Statement: Many Arizona students begin their postsecondary study at a two-year community college, due to financial resources or because they lack the academic qualifications and competitiveness to begin at one of the state's four-year universities. Students who seek to transfer to UArizona and have an interest in STEM majors often face several barriers. Research opportunities and other experiential learning experiences are scarce at community colleges, so transfer students struggle to compete for such experiences when they arrive at UArizona. Additionally, a difference exists in the academic cultures between community colleges and four-year universities, especially in the research-intensive STEM and pre-health fields.				
Program Description: TRIF funding will support UArizona programs that assist students through the transfer process into technical and research-intensive majors, provide paid research opportunities to transfer students to work on TRIF-funded research initiatives, and involve foundational research that will help us understand and overcome barriers for community college transfer students into research-rich degree programs and careers.				
What is the University's Advantage and/or Anticipated Funding Opportunities? UArizona houses the nationally known Center for the Study of Higher Education, with leading scholars whose research on the following topics can inform initiatives relevant to strengthening workforce development programs with community colleges: <ul style="list-style-type: none"> •The challenges Latinx, African American, and low socioeconomic status (SES) students face transitioning into four-year college, research-intensive degree programs •College planning strategies and trajectories of diverse community college transfer students •Recruitment and access issues for community college students into research-rich majors and careers 				
Is there an Arizona Specific Benefit or Impact? <ul style="list-style-type: none"> •Increased number of students accessing communication tools or events •Increased transfer overall from Arizona community colleges into research-intensive majors at UArizona •Increased number of students selecting STEM or other research-rich majors upon transferring •Increased faculty partnerships between community colleges and UArizona researchers •Increased indicators for participation in undergraduate research before transferring •Increased retention of community college transfer students in STEM to graduation 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	52,144	52,144	52,144	156,432
Basic Research	8,453	8,453	8,453	25,359
Applied Research	12,679	12,679	12,679	38,037
Development	21,132	21,132	21,132	63,396
Total	94,408	94,408	94,408	283,224
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses				0
Postdocs Supported				0
Graduate Students				0
Undergraduate Students				0
Sponsored Project Funding				0
Publications in Academic Peer-Reviewed Journals				0
Startups				0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Access and Workforce Development
Program Name:	The Community College to Four-year University Transition

2022 Progress Summary:
 TRIF funding is supporting efforts to help students, especially those from community colleges, navigate the transfer process to UArizona into technical and research-intensive majors, provide paid research opportunities to transfer students to work on TRIF-funded research initiatives, and involve foundational research that will help the students overcome barriers to research-rich degree programs and careers. As part of these efforts, UArizona is taking a comprehensive approach to increase the number of Latinx students and students from low-income households who attain degrees in STEM fields, an approach that includes a STEM student learning community, course articulation tools, early access to undergraduate research, and a campus-wide faculty and staff training on culturally responsive teaching and mentoring.

Key to these goals is a TRIF-supported \$5M Title III HSI STEM award aimed at building institutional capacity to remove barriers for Latinx students and students from low-income households in attaining bachelor’s degrees in STEM, with a strong emphasis on transfer students. Related activities to support transfer students include scaling up STEM learning communities with mentors and academic support for transfer students, expanding research opportunities by converting STEM lab courses into course-based undergraduate research experiences, and developing an online mapping with required courses, prerequisites and units for STEM majors for accurate transfer articulation.

The grant is expected to impact more than 5,000 students over the course of the five-year period. We expect the long-term impact to include higher graduation rates among Arizona STEM students who are pursuing degrees and gained workforce skills that are relevant to Arizona research and technology industries. TRIF funding will help us achieve two goals: develop an online tool to register students into STEM learning communities, and support Pima Community College faculty in developing and incorporating research experiences into STEM lab courses. These courses will parallel the UArizona student research experiences in their STEM lab courses, under development through TRIF and Title III funding.

Investment Detail				
	2022	2023	2024	Total
Infrastructure	16,568	141,990	141,990	300,548
Basic Research	0	0	0	0
Applied Research	0	0	0	0
Development	0	0	0	0
Total	16,568	141,990	141,990	300,548

Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	0	0	0	0
Postdocs Supported	0	0	0	0
Graduate Students	1	0	0	1
Undergraduate Students	0	0	0	0
Sponsored Project Funding	75,000	0	0	75,000
Publications in Academic Peer-Reviewed Journals	0	0	0	0
Startups	0	0	0	0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	Improving Health																																											
Program Name:	Technology for Health																																											
Problem Statement:	<p>Advances in technology always have been quickly adopted to aid human health and well-being. For example, the rise of computer technology in the 1950's enabled computational tomography (CT) scans that allowed clear visualization of the human brain for the first time. More recently, strong, flexible, and inert materials have made long-term implantable vascular shunts possible. Improving Health depends upon continual adoption of technology and innovation to solve problems identified by scientists and physicians.</p>																																											
Program Description:	<p>The Fourth Industrial Revolution envisions a convergence of biological, physical, and data sciences. This collaborative approach has long been a hallmark of BIO5. Specifically, we will do the following: Point-of-care imaging: We will create new, noninvasive imaging tools for earlier diagnosis and treatment of disease -enabling point-of-care imaging that can even be done by an individual with a smartphone; Closed-Loop Sensors Lab: Sensors/detectors/cameras and closed-loop "sensors/data -> analysis -> intervention -> measure impact" experiments will measure the effect of environmental perturbations on workplace performance, analyze reaction to social interactions, negotiation, team building exercises, etc., and develop/monitor the effects of "electroceuticals" or wearable therapeutics; Wearable technology: Develop new materials and electronic technologies further enabling battery-less, wireless, conformable wearables; Shared resources: Modern biology requires ever more complex instrumentation, to expedite large-scale, team science grants. These grants in turn will boost federal research funding, serve as a resource for local industry, and create new services and companies in Arizona.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>With co-located engineering, optical sciences, and medical disciplines, UArizona is poised to make technology advances and rapidly apply them to human health. The culture of interdisciplinary research and strong translational sciences, together with a supportive intellectual property environment with Tech Launch Arizona and the Eller College of Management's McGuire Entrepreneurship Program, mean that innovations are rapidly turned into products to improve the health and wellness of Arizonans and beyond.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> •Increased industry engagement with faculty and students through facilities and services, including analytical chemistry, imaging, bioinformatics, and sensors, leading to synergies in research and development, and accelerating Arizona bioindustry •An increase in technology transfer activities related to sensors and imaging technology with more patents and licenses •Additional external funding in wearable technology, home health, and telemedicine related to expertise in cutting-edge technology and resources such as the Sensors Lab 																																											
Investment Detail	<table border="1"> <thead> <tr> <th></th> <th>2022</th> <th>2023</th> <th>2024</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Infrastructure</td> <td>1,568,901</td> <td>1,568,901</td> <td>1,568,901</td> <td>4,706,703</td> </tr> <tr> <td>Basic Research</td> <td>381,158</td> <td>381,158</td> <td>381,158</td> <td>1,143,474</td> </tr> <tr> <td>Applied Research</td> <td>762,315</td> <td>762,315</td> <td>762,315</td> <td>2,286,945</td> </tr> <tr> <td>Development</td> <td>127,052</td> <td>127,052</td> <td>127,052</td> <td>381,156</td> </tr> <tr> <td>Total</td> <td>2,839,426</td> <td>2,839,426</td> <td>2,839,426</td> <td>8,518,278</td> </tr> </tbody> </table>					2022	2023	2024	Total	Infrastructure	1,568,901	1,568,901	1,568,901	4,706,703	Basic Research	381,158	381,158	381,158	1,143,474	Applied Research	762,315	762,315	762,315	2,286,945	Development	127,052	127,052	127,052	381,156	Total	2,839,426	2,839,426	2,839,426	8,518,278										
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Improving Health
Program Name:	Technology for Health

2022 Progress Summary:
 Through collaborations that blend the biological, physical, and data sciences, UArizona researchers advanced and tested non-invasive medical techniques and wearable technologies that improve the health, well-being, and resiliency of Arizonans; worked with students to develop techniques for engineering musculoskeletal tissues that can be used as implants for patients, including those with arthritis and injured military personnel; and acquired laboratory equipment and research supplies to develop novel biomaterials that can be potentially used for promoting neural recovery.

Select highlights:

- A UArizona researcher has spent nearly a decade developing a falloposcope to detect ovarian cancer in its early stages, and this year a Banner – University Medical Center surgeon used the device to capture images of study participants' fallopian tubes for the first time. This device uses advanced optical imaging techniques and is designed to detect very early, curable, stages of ovarian cancer. Due to a lack of effective screening and non-invasive imaging and diagnostic tools, more than three-fourths of ovarian cancer cases are not found until the cancer is in an advanced stage. As a result, fewer than half of all women with ovarian cancer survive more than five years after diagnosis. The U.S. Army has funded work to develop a clinical translation of the device since 2018. Tech Launch Arizona is helping explore strategies to eventually bring it to the marketplace and has filed three patents for technologies behind the device.
- UArizona researchers have developed next-generation blue-filtration glasses that can improve sleep and circadian health. A worldwide patent cooperation treaty (PCT) application for these devices is being drafted based on five provisional U.S. patent applications. The researchers received a grant from the Department of Defense Military Suicide Research Consortium to identify service members who may be more prone to suicidal thinking when they experience insomnia.
- A team of researchers is creating new tools for a method called optogenetics, which shines light at specific neurons in the brain to excite or suppress activity. They demonstrated an untethered light delivery tool to enable seamless optogenetics in the brain, a technique that allows the use of optogenetics without having to penetrate the skull or brain tissue. This less invasive optogenetic device takes researchers a step closer to new treatments for chronic pain, depression, epilepsy, and neurodegenerative diseases.

Investment Detail				
	2022	2023	2024	Total
Infrastructure	1,850,634	2,153,157	2,153,157	6,156,948
Basic Research	0	404,472	404,472	808,944
Applied Research	185,882	808,943	808,943	1,803,768
Development	0	134,823	134,823	269,646
Total	2,036,516	3,501,395	3,501,395	9,039,306

Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	242,603	635,263	635,263	1,513,129
Postdocs Supported	12	25	25	62
Graduate Students	121	65	65	251
Undergraduate Students	95	70	70	235
Sponsored Project Funding	15,004,103	20,000,000	20,000,000	55,004,103
Publications in Academic Peer-Reviewed Journals	56	92	92	240
Startups	0	1	0	1

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona			
TRIF Investment Area:	Improving Health			
Program Name:	Aging and Resilience			
Problem Statement: With more and more individuals living longer, an aging Arizona population will bring unique challenges and opportunities in health care. Critical research and development still needs to be done to understand the processes of normal and healthy aging; determine the causes of age-related diseases; develop and test drugs, devices, and behavioral interventions to minimize handicap and disease; and maximize functionality and independence for a higher quality of life.				
Program Description: We expect to gain a better understanding of common initiating mechanisms across four age-associated neurodegenerative diseases (Alzheimer's, Parkinson's, multiple sclerosis, and ALS). We also will continue trials into potential therapeutics and interventions to reverse cognitive decline. Technology developments will be leveraged into advances in home health, mobile health (mHealth), and telemedicine applications that bring safety, security, and medical care to all corners of the state and beyond. Working with the resources of the University of Arizona's NCI-designated Comprehensive Cancer Center, we will embark on programs to prevent cancer through precision lifestyle modifications and early detection, and cure cancer with greater understanding of its biological underpinnings and new treatments, such as immunotherapy.				
What is the University's Advantage and/or Anticipated Funding Opportunities? We are uniquely poised to conduct both basic and clinical research into the biology of aging and age-related brain diseases such as Alzheimer's, Parkinson's, and other neurological conditions. We have expertise in many areas related to aging and age-related disease, particularly in psychosocial, cognitive, immune, inflammation, neurodegenerative, metabolic, and geriatric care. Our studies range from brain imaging to looking at molecular and genomic changes during aging to dietary and exercise interventions. Together with our health and community partners, we have the expertise and support to translate basic studies into effective treatments and life-enhancing strategies for humankind, which ultimately will reduce health care costs and increase the chance for a long, healthy, productive, disease-free life.				
Is there an Arizona Specific Benefit or Impact? Arizonans will benefit from this initiative in many ways, including: <ul style="list-style-type: none"> •New discoveries into the interactions between aging brain and aging body in health and diseases •Development of therapeutics, together with the Arizona Center for Drug Discovery, to target age-related diseases •Development of innovations in brain science that lead to precision therapeutic treatments for neurodegenerative diseases •The ability to create a customized plan for optimized physical and cognitive aging utilizing big data and meta-omics •Increased number of, and enrollment in, cancer prevention and treatment trials 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	569,289	569,289	569,289	1,707,867
Basic Research	220,048	220,048	220,048	660,144
Applied Research	385,084	385,084	385,084	1,155,252
Development	55,012	55,012	55,012	165,036
Total	1,229,433	1,229,433	1,229,433	3,688,299
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	275,060	385,084	495,108	1,155,252
Postdocs Supported	25	25	25	75
Graduate Students	65	65	65	195
Undergraduate Students	70	70	70	210
Sponsored Project Funding	20,000,000	20,000,000	20,000,000	60,000,000
Publications in Academic Peer-Reviewed Journals	92	92	92	276
Startups	0	1	0	1

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Improving Health
Program Name:	Aging and Resilience

2022 Progress Summary:
 Understanding the biological mechanisms behind normal versus disease-laden aging is essential to achieving a lifetime of good health. In FY22, BIO5 researchers furthered our understanding of aging and resilience, advanced therapies for neurodegenerative diseases, worked to develop a platform for assessing cognitive impairments in older adults using portable wearable sensors, and worked to identify genetic risk factors for equine metabolic syndrome, which could translate to treatment of metabolic syndrome in humans.

Select highlights:

- A team of UArizona researchers developed the first regenerative therapeutic for Alzheimer’s designed to restore cognitive function in early-stage patients, meaning we now have a drug therapy that restores brain cell function in people with the disease. The therapy is now proceeding through a Phase 2b clinical trial. Working with Tech Launch Arizona, the team has launched a startup, NeuTherapeutics, Inc., to advance the technology toward making it available for patients. This work has significant implications: More than 200,000 Arizonans aged 65 and older are predicted to be affected by Alzheimer’s by 2025.
- UAzrizona was awarded a five-year, \$60 million grant from the National Institutes of Health to lead the Precision Aging Network, a national effort to transform the way we think about the aging brain. The network is designed to bring together researchers from across the country to better understand how and why people experience brain aging differently, with the goal of developing more effective treatments and interventions targeted to the individual.
- UAzrizona researchers have developed a new class of drugs that can cross the blood-brain barrier and could be used to treat degenerative neurological diseases and conditions. With this technology, the researchers demonstrated that they can now reach previously unreachable receptor targets in the brain. This work has significant implications, as brain disorders like Alzheimer's disease, Parkinson's disease, Huntington's disease, traumatic brain injury and stroke affect over 8 million people in the United States each year and have limited effective treatments. UArizona has licensed the technology to the researchers' startup, Teleport Pharmaceuticals.

Investment Detail				
	2022	2023	2024	Total
Infrastructure	658,551	798,498	798,498	2,255,547
Basic Research	2,471	233,507	233,507	469,485
Applied Research	117,916	408,638	408,638	935,192
Development	136,918	58,377	58,377	253,672
Total	915,856	1,499,020	1,499,020	3,913,896

Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	197,155	385,084	495,108	1,077,347
Postdocs Supported	6	25	25	56
Graduate Students	35	65	65	165
Undergraduate Students	54	70	70	194
Sponsored Project Funding	29,020,922	20,000,000	20,000,000	69,020,922
Publications in Academic Peer-Reviewed Journals	54	92	92	238
Startups	1	0	1	2

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	Improving Health																																											
Program Name:	Infectious Disease and Microbiome Sciences																																											
Problem Statement:	<p>Infectious disease is the major cause of death in low-income countries, and emerging infectious diseases threaten countries worldwide, as the COVID-19 pandemic has shown. Researchers learn more every day about the role the human microbiome (both bacteria and viruses) plays in health and behavior. An example includes respiratory diseases that are considered to result from a combination of genes, environment, and lifestyle. The role of microbes in health and disease through interconnected human-animal-plant-earth reservoirs presents a complexity which is of vast importance and not yet completely understood.</p>																																											
Program Description:	<p>We will leverage the considerable infrastructure we have developed for testing and serology of COVID-19 into a broader infrastructure for understanding, preventing, and treating infectious disease and possible future pandemics, as well as understanding the long-term effects of these diseases. We will also develop models of vector-borne infections such as Zika. Understanding the variables affecting mosquito spread in Arizona may inform strategies to stop the transmission of Zika and keep Arizona free of this disease. Finally, we will look inside the human body to understand the healthy microbiome in niches throughout the body, as well as dysbiosis and its effect on diseases such as gastrointestinal cancers and infertility.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>UArizona's interdisciplinary researchers are pushing the boundaries of knowledge. Our outstanding investigators across immunobiology, public health, medicine, animal and comparative biomedical sciences, and others work together with complemented expertise to solve complex problems. TRIF-supported facilities such as the genetically engineered mouse models and biosafety level 3 and omics capabilities support cutting-edge research to enable new discoveries related to the role of microbes in human health and disease.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> •Development of more accurate, rapid, and inexpensive tests for COVID-19 and future infectious diseases •Better understanding of demographic and health history effects on immunoprotection gained with vaccination against COVID-19 and other diseases •New clinical trials to show the effect of potential therapies for respiratory illnesses •Better understanding of the healthy biome in various human organs, and development of therapies for dysbiosis 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Improving Health
Program Name:	Infectious Disease and Microbiome Sciences

2022 Progress Summary:

Using specialized TRIF-enabled UArizona facilities, seed grants, and equipment, BIO5 researchers continued their robust response to COVID-19, pursuing actionable products and strategies to detect and fight the virus. They also worked toward developing better prevention, diagnostic, and treatment options to decrease the global burden of other infectious and noncommunicable diseases. Select highlights:

- UArizona researchers have identified what may be the key molecular mechanism responsible for COVID-19 mortality – an enzyme related to neurotoxins found in rattlesnake venom that has long been known to play a critical role in defense against bacterial infections. The enzyme may be the most important factor in predicting which patients with severe COVID-19 eventually succumb to the virus and could provide a new therapeutic target to reduce COVID-19 mortality. The research on the mechanism of lethality of COVID-19 led to significant funding, four filed patents, and the formation of a new start-up company, Resonance Pharm.
- Module Therapeutics Inc. is commercializing cell therapies that use novel engineered receptors to precisely target and eliminate disease-causing T cells, immune cells that attack the body. The startup is based on the work of UArizona researchers, who engineered immune cells to fight off rogue T cells that can damage the pancreas, causing type 1 diabetes. Nearly 2 million Americans suffer from type 1 diabetes — a condition that causes drastic spikes or drops in sugar levels and, in turn, dizziness, nausea, and fatigue and has no cure.
- UA scientists found that a metal common in Arizona may prove vital for developing future antibiotics used to treat common upper respiratory infections that are becoming more resistant to current drugs. In 2019, the Centers for Disease Control and Prevention reported that more than 2.8 million antibiotic-resistant infections occur in the U.S. each year. Researchers identified a compound that, when bound with copper, can kill *Streptococcus pneumoniae*, the bacteria that commonly causes pneumonia, meningitis, and sepsis.

Investment Detail

	2022	2023	2024	Total
Infrastructure	353,607	937,033	937,033	2,227,673
Basic Research	0	233,507	233,507	467,014
Applied Research	285,179	408,638	408,638	1,102,455
Development	0	58,377	58,377	116,754
Total	638,786	1,637,555	1,637,555	3,913,896

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	0	385,084	495,108	880,192
Postdocs Supported	13	25	25	63
Graduate Students	61	65	65	191
Undergraduate Students	48	70	70	188
Sponsored Project Funding	78,657,229	40,000,000	20,000,000	138,657,229
Publications in Academic Peer-Reviewed Journals	80	92	92	264
Startups	0	1	0	1

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	Improving Health																																											
Program Name:	Precision Medicine and Omics																																											
Problem Statement:	<p>Omics refers to collective technologies that explore the role of different molecules and how they interact with various bodily systems. Proteins, lipids/fats, and their metabolic products are all important and accessible indicators of human health. The study of omics is critical to developing personalized, targeted therapies to boost efficacy, improve health, lessen adverse exposures, and reduce health care costs. To analyze the vast amounts of omics data and turn it into actionable precision medicine, the science of bioinformatics needs not only to be used, but be further developed, using the combination of computer science, statistics, mathematics, and engineering.</p>																																											
Program Description:	<p>We expect to make major strides in four general areas. First, we will create a comprehensive approach in the nascent field of pharmacogenomics. Rather than a one-size-fits-all approach to therapy or dosage based on gross factors such as body surface area, drug prescriptions—and in particular polypharmacy—we need to take into account an individual’s genomic factors. Second, with gene interactions, we are beginning to understand not just the impact of single genes on health but also the interplay of many, or even hundreds, of genes on complex conditions such as diabetes and heart disease. Extracting this information using conventional naive biostatistical models may require numbers of participants exceeding the world’s population. We will develop new models to enable extraction of complex data. Third, we will develop models of the transcriptome, which is the initial product of gene expression. We will determine the difference between “nature and nurture,” or the effect of the environment (internal and external) on gene expression. Finally, to address the unsustainable cost of drug development, we will advance an adaptable clinical trials model to improve outcomes and reduce costs.</p>																																											
What is the University’s Advantage and/or Anticipated Funding Opportunities?	<p>UArizona has a strong infrastructure in both expertise and instrumentation to develop omics and precision medicine. Investments in sequencing and mass spectroscopy facilities have occurred with past TRIF investments, with a particular emphasis on metabolomics and precision nutrition. The National Science Foundation-sponsored CyVerse and the UArizona Center for Biomedical Informatics and Biostatistics bring strengths in extracting actionable knowledge from large data sets. In addition, UArizona’s partnership with Banner Health, including the All of Us program, means that enormous amounts of health data are available for researchers to analyze and drive subsequent experiments and therapy development.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> •UArizona is successful in obtaining a Clinical and Translational Science Award with partners across Arizona to move promising science to translation •An increase in Banner Health and other clinical partner collaborative grants and contracts, bringing research dollars to Arizona and increasing research and clinical staff jobs •More clinical trials in Arizona because of the expertise in adaptive clinical trial design, which will provide cutting-edge treatment options for Arizonans and more rapid development of cures 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Improving Health
Program Name:	Precision Medicine and Omics

2022 Progress Summary:

BIO5 researchers made significant progress this year in advancing personalized, precision therapies; embraced an entrepreneurial culture where discovery leads to innovation; were elected to the National Academy of Inventors for creating a bioengineered patch to implant on damaged hearts—patented technology licensed to a spin-off company; and advanced understanding and potential for treatment of epilepsy, including childhood epilepsy, with significant implications for more than half of the 77,000 Arizonans with active epilepsy who continue to get seizures despite medical treatment.

Select highlights:

- Aqualung Therapeutics, a Tucson-based drug startup headed by a UArizona pulmonologist, closed a \$2.5 million investment to help take its flagship drug, a monoclonal antibody for treatment of life-threatening acute respiratory distress syndrome, into initial human clinical trials. In addition, Aqualung announced promising preclinical study results for use of its drug to treat prostate cancer and is looking at a variety of diseases that may respond to the therapy. These advances are the result of foundational research that began more than 30 years ago and signify a major step toward patients' bedsides.
- A team led by Valley Fever Center for Excellence researchers successfully tested a Valley fever vaccine for dogs, with two doses providing high levels of protection. The development of a potential canine vaccine serves as a positive harbinger of a human vaccine. The study was a first-of-its kind experiment that showed strong protection for canines injected with two doses of the vaccine, and the commercial veterinary version of the vaccine could be available within the next two years. The findings have significant implications for a disease now on the rise in Arizona and across the Southwest.
- A UArizona researcher and co-founder of startup Procyon Technologies is developing and commercializing technology with a special focus on diabetes. The technology is providing a "functional cure" for people with type one diabetes without the need for drugs that suppress the immune system. It also has potential for treating other serious medical conditions.
- A UArizona researcher is developing MRI biomarkers to improve risk stratification of future adverse outcomes of those with carotid atherosclerosis, or artery disease, to prevent stroke. The team is collaborating closely with Siemens Medical Systems, the leading manufacturer of magnetic resonance imaging systems in the world, and they have several NIH grants funded as academic-industry partnerships. Siemens has an on-site research scientist dedicated to work with their group. This close collaboration has significantly increased the pace of this research, and several of the techniques developed at UArizona are now being distributed worldwide as "Work-In-Progress (WIP)," the stage of work prior to becoming a "product" by Siemens.

Investment Detail

	2022	2023	2024	Total
Infrastructure	503,138	706,201	706,201	1,915,540
Basic Research	0	233,507	233,507	467,014
Applied Research	291,221	408,638	408,638	1,108,497
Development	306,092	58,377	58,377	422,846
Total	1,100,451	1,406,723	1,406,723	3,913,897

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	86,084	385,084	495,108	966,276
Postdocs Supported	28	25	25	78
Graduate Students	106	65	65	236
Undergraduate Students	125	70	70	265
Sponsored Project Funding	48,929,390	20,000,000	20,000,000	88,929,390
Publications in Academic Peer-Reviewed Journals	95	92	92	279
Startups	1	0	1	2

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	Improving Health																																											
Program Name:	KEYS and Engaged Training																																											
Problem Statement:	<p>As one of the core tenets of our mission, we are committed to training and inspiring our next generation of scientists. Many students interested in the biosciences are never able to practice and contribute to hands-on research in actual laboratories. Through BIO5's KEYS Research Internship Program, we provide real-world application of classroom learning to spark intellectual and creative curiosity and connect Arizona's excelling students with UArizona while still in high school. These real-world laboratory experiences with BIO5 build a pipeline of talent into our state universities, prepare students for success in college and career, and help strengthen our state's future knowledge-based workforce.</p>																																											
Program Description:	<p>BIO5 engages and trains our future generations of scientists through innovative internship programs and an interactive learning environment that promotes experiential learning and STEM proficiency in Arizona. Undergraduates, graduates, postdocs, and even high school interns experience practical application of what they learn in the classroom by working side by side with world-class researchers in BIO5 labs. Forty percent of those working in BIO5 are students. We will continue to engage the pipeline of trainees from the high school through postdoc levels through programs like KEYS and active learning research opportunities for UArizona students. We will also demonstrate how student success and experiential research are integrally linked. Our KEYS Research Internship Program binds talented high school students to UArizona early, which often provides the foundation to keep them in Arizona for, and after, college.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>The seven-week KEYS Research Internship Program offers a unique opportunity to talented high school students who have a strong interest in science, health, or the environment. The internship provides students with laboratory experience and the ability to work with world-class scientists on real research projects. Since 2007, 526 students have completed the KEYS internship. Of those, 71 percent have chosen to stay in Arizona for college, with the majority of those attending UArizona. KEYS alumni are automatically accepted into UArizona's Honors College, and most pursue STEM-related degrees and careers. BIO5 also engages students at post-secondary levels through initiatives including the Student-Industry Networking Event, Post-Doctoral Fellowship program, and the BIO5 Ambassadors program.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> •Increased student participation in KEYS statewide through both a computational, remote version and an in-person laboratory-based version, boosting the interest in STEM careers among Arizona high school students •Increased number of companies and external entities who participate in activities such as the student-industry networking event leading to connections and internships •Increased number of well-trained personnel from bachelors to doctoral levels available to work with and/or be hired by our Arizona biosciences industry 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Improving Health
Program Name:	KEYS and Engaged Training

2022 Progress Summary:
 In FY22, more than 1,200 undergraduates, graduates, postdocs, and high school interns had opportunities to engage in STEM activities and apply classroom learning by working side by side with world-class researchers in BIO5 labs. Building a pipeline of talent for the state's workforce, BIO5 trained students through programs like the KEYS Research Internship, BIO5 Ambassadors, and the Postdoctoral Fellowship, and engaged the community in public offerings like Science City (Arizona's largest STEM event), Precision Wellness, Ignites Science, the Women in STEM series, and BIO5's Science Talks podcast/video series.

Select highlights:

- The 2022 KEYS cohort comprised 55 in-person and virtual interns from 23 Arizona high schools and 294 applications. With this group, the number of KEYS alumni totals 631 students from 96 high schools.
- The first class of students in the new Accelerated Pathway to Medical Education (APME) program at UArizona College of Medicine – Tucson included four KEYS alumni (out of the six chosen). The APME offers a unique educational experience for talented students anticipating a career in medicine or medical science.
- Quidel Corp., a major provider of rapid diagnostic testing solutions, cellular-based virology assays and molecular diagnostic systems, committed \$500K to KEYS for programming that supports tomorrow's scientists and health professionals.
- BIO5 was awarded \$34.5K in one-time UArizona Hispanic Serving Initiative relief funds for the purchase of laptops/software that will be loaned to underserved interns who do not typically have personal access to these technology resources while participating in KEYS.
- A 2021 KEYS alumnae and 2022 KEYS peer mentor was one of 20 Arizona students selected for the Flinn Foundation's scholarship. There are now 17 KEYS alumni Flinn Scholars.

Investment Detail				
	2022	2023	2024	Total
Infrastructure	800,315	762,993	762,993	2,326,301
Basic Research	0	78,797	78,797	157,594
Applied Research	0	78,797	78,797	157,594
Development	0	0	0	0
Total	800,315	920,587	920,587	2,641,489

Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	0	0	0	0
Postdocs Supported	0	0	0	0
Graduate Students	1	0	0	1
Undergraduate Students	58	50	50	158
Sponsored Project Funding	3,717,460	1,000,000	1,000,000	5,717,460
Publications in Academic Peer-Reviewed Journals	0	0	0	0
Startups	0	0	0	0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	National Security Systems																																											
Program Name:	Advanced Communications Systems																																											
Problem Statement:	<p>The requirement for assured, secure, and ad hoc communications with independent, remote, and other systems operating under attack requires creative, innovative, and breakthrough approaches to consistently establish connections and deliver that data in a timely way. Quantum communications, optical communications, new approaches to encryption, and other approaches to sound and radio-frequency devices are desperately needed by the military and may add value to the methods of the Fourth Industrial Revolution.</p>																																											
Program Description:	<p>We anticipate the development of fundamental science and prototype systems that, with additional federal or industrial engagement, can lead to effective commercial and military solutions. We would expect to see even greater collaboration among the colleges and such sites as Ft. Huachuca, providing students with multidisciplinary research experiences ready to compete for top jobs in these industries and fields.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>The UArizona Colleges of Science, Optical Sciences, and Engineering are perfect sources of these types of solutions. From the \$26M NSF-funded Center for Quantum Networks, an engineering research center, to our efforts in the Frontiers of Sound, acoustic waves research for next-generation information processing, we have the skill and the scientific and technical collaborations in place to answer these challenges.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> ● Increased industrial-sponsored research in advanced communications systems ● Increased federal, defense, and intelligence agency sponsored projects ● Increased recruiting of top faculty and students ● Increased licensing and tech transfer impacts 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	National Security Systems
Program Name:	Advanced Communications Systems

2022 Progress Summary:
 To advance national security-related communications, TRIF investments were used not only to support cutting-edge research, but also to train the next generation of experts. According to feedback provided by one undergraduate senior, TRIF funds enabled him to “get hands on experience building optical telescopes and doing research with them that helps our national security.” This student was able to gain valuable knowledge on optical systems and the large data streams they generate while applying that knowledge and delivering insights for the United States Space Force (USSF). Our efforts in this area have placed the UArizona at the forefront of academic research institutions paving the way for an effective USSF.

- Select highlights:
- We received \$7.5M in new business with USAF Air Force Research Laboratory (AFRL).
 - This investment is already supporting and will continue to support up to 38 undergraduate students in the innovative area of space security.
 - TRIF investments contributed significant momentum to the creation of the Space Safety, Security, and Sustainability (Space4) Center, a university-wide center that will work to support governmental and industrial access, use, and benefits from space in the economy and in National Security.
 - We created the JEDI Aquanautics platform to fuse the world's most powerful experiential supercomputer, the NSF Holodeck, with the transformative capabilities of Ocean Space Habitat. This world-class sociotechnical convergence catalyst is now being tested at Biosphere 2 in partnership with diverse participants. The project is well on its way to creating the envisioned international JEDI Inventioneering Network to advance understanding, use, and the sustainability of our planet’s oceans.

Investment Detail				
	2022	2023	2024	Total
Infrastructure	798,438	1,037,681	1,037,681	2,873,800
Basic Research	480,864	624,949	624,949	1,730,762
Applied Research				0
Development				0
Total	1,279,302	1,662,630	1,662,630	4,604,562

Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	798,438	258,879	258,879	1,316,196
Postdocs Supported	3	2	2	7
Graduate Students	25	3	3	31
Undergraduate Students	17	3	3	23
Sponsored Project Funding	2,037,482	1,666,667	1,666,667	5,370,816
Publications in Academic Peer-Reviewed Journals	0	22	22	44
Startups	0	1	2	3

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	National Security Systems																																											
Program Name:	Cyber Defense																																											
Problem Statement:	<p>Our hyper-digital world, where anything that can be referred to as a “device” is probably connected or connectable to the internet, creates a vast attack surface for bad behavior, whether from script-kiddies, criminals, or nation states. This is true for commercial, government, consumer systems, and a wide swath of America’s defense systems. Preventing attacks that deny or degrade the confidentiality, integrity, or availability of the data or systems is critical to a well-functioning military, economy, and society.</p>																																											
Program Description:	<p>TRIF investments in cyber defense activities are intended to develop countermeasures and solutions to phishing, ransomware, advanced persistent threat, and more subtle attack mechanisms.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>The university is home to talented and innovative electrical and computer engineers and scientists and draws globally competitive students to Arizona. They are backed by top physicists and mathematicians, and they have access to some of the most advanced modeling and research platforms in the world. Our College of Applied Science and Technology (CAST) in Sierra Vista offers degree and certificate programs to train personnel in machine learning, artificial intelligence, and cybersecurity. We have achieved the highest level of recognition from defense agencies for our ability to contribute to solutions in this area.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> ●Open-source solutions ●Increased industrial-sponsored research in cyber defense ●Increased federal, defense, and intelligence agency sponsored projects ●Increased recruiting of top faculty and students ●Increased licensing and tech transfer impacts 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	National Security Systems
Program Name:	Cyber Defense

2022 Progress Summary:

UArizona researchers, including five undergraduate and graduate students, are studying the critical application space of point-of-sale contactless payments. Tap cards are not patchable once they are deployed in the field, meaning most security for the transaction has to be supplied by the application through which the tap card interacts. This requires a secure stand-alone environment in which to conduct dynamic transaction analysis of the systems; static analysis to assess obfuscation, to prevent reverse-engineering, and to study the strength of code virtualization; and it requires research to assess integrity and security to defeat relay and man-in-the-middle attack methods. This work not only seeks to secure the growing number of contactless payment interactions around the world, but to begin to establish the protocol and assessment methods that will lead to standards for the industry.

Select highlights:

- Already, 16 exploits have been identified and shared with the relevant banks and app developers.
- This project will result in a \$1.2M NSF proposal later this year.
- We have submitted a research article to USENIX Security 2023 entitled, "On the tamper-proof and security analysis of mobile payment applications."

Investment Detail				
	2022	2023	2024	Total
Infrastructure	324,401	441,944	441,944	1,208,289
Basic Research	829,415	1,129,943	1,129,943	3,089,301
Applied Research	0	0	0	0
Development	0	0	0	0
Total	1,153,816	1,571,887	1,571,887	4,297,590

Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	324,401	258,879	258,879	842,159
Postdocs Supported	0	1	1	2
Graduate Students	6	3	3	12
Undergraduate Students	6	2	2	10
Sponsored Project Funding	169,777	1,666,667	1,666,667	3,503,111
Publications in Academic Peer-Reviewed Journals	0	22	22	44
Startups	1	1	2	4

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona			
TRIF Investment Area:	National Security Systems			
Program Name:	Advanced Manufacturing			
Problem Statement: Advanced manufacturing (AM) includes concepts in rapid prototyping and parts-on-demand, additive manufacturing (e.g., 3D printing), sustainable and environmentally sound processes, and advanced robotics and other forms of automation. Enabling technologies can include materials, equipment, processes, software, and computation. AM has the potential to shorten product development timelines, improve worker safety, increase production, reduce waste, and preserve the natural environment. Significant challenges remain for widespread implementation of many AM technologies and include materials research, robotics, in-process quality control, and product inspection.				
Program Description: Presently there are several elements of AM that are coalescing around areas such as aerospace research. These elements include advanced materials and additive manufacturing. TRIF funding will help accelerate and expand these efforts, fostering maturation toward larger extramural funding mechanisms. Opportunities exist for novel application of AM to new domains, and TRIF resources will be devoted to supporting projects that will target these opportunities with unique ideas. Over the next five years, we expect continued aggregation of related areas of research (e.g. AR/VR, advanced materials, robotics) around AM, facilitated by TRIF support.				
What is the University's Advantage and/or Anticipated Funding Opportunities? UArizona has many research programs and experienced investigators active in new materials development, additive manufacturing equipment and processes, artificial intelligence for process improvement, environmental engineering, and advanced robotics. In one particular area of AM, additive manufacturing, faculty across several units have collaborated to form the Additive Manufacturing Initiative. This group seeks to leverage faculty expertise and resources to further research and training in the application of 3D printing to challenges in manufacturing in extreme conditions, next-generation manufacturing, and adaptive process control. The team also has initiatives in workforce development, including using virtual and augmented reality technology to teach advanced manufacturing practices.				
Is there an Arizona Specific Benefit or Impact? <ul style="list-style-type: none"> •Maturation of at least one program area into a research center focused on AM •Increased coordination of related research and technologies around AM •Development of new application areas for AM and the number of potential sponsors of extramurally funded research •Cultivation of a larger number of partnerships with a growing AM industry base, particularly those in Arizona 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	552,980	552,980	552,980	1,658,940
Basic Research	178,238	178,238	178,238	534,714
Applied Research	262,115	262,115	262,115	786,345
Development	178,238	178,238	178,238	534,714
Total	1,171,571	1,171,571	1,171,571	3,514,713
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	209,692	209,692	209,692	629,076
Postdocs Supported	1	1	1	3
Graduate Students	3	3	3	9
Undergraduate Students	2	2	2	6
Sponsored Project Funding	2,083,333	2,083,333	2,083,333	6,249,999
Publications in Academic Peer-Reviewed Journals	17	17	17	51
Startups	0	1	2	3

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona			
TRIF Investment Area:	National Security Systems			
Program Name:	Advanced Manufacturing			
2022 Progress Summary:				
<p>Broadly, researchers in advanced manufacturing worked to develop manufacturing techniques aimed at supporting the aerospace and defense industries, additive manufacturing, and smart buildings; investigated computational methods that aid material design as well as in-process techniques using artificial intelligence that can improve additive manufacturing processes in real time; and provided students with training and research experiences.</p> <p>A major topic addressed with this initiative is finding solutions to quality control challenges in traditional manufacturing. Using TRIF funding, investigators are conducting research on non-destructive testing methods, as well as monitoring methods, data collection and analysis techniques, and auto/self-correction processes that can assure the quality of each product. Future advances in this field will help establish Arizona as a leader in advanced manufacturing and support the continued growth of industries in the state such as the aerospace and semiconductor sectors.</p> <p>Select highlights:</p> <ul style="list-style-type: none"> •Researchers are investigating and further developing autonomous robots that can insulate and seal a building envelope for improved energy efficiency, metals, and composite materials that can withstand the extremely high temperatures of hypersonic flight, and "green" composite materials made from naturally derived polymers plus recycled "geo-materials" that form environmentally friendly cement. Such approaches can optimize the resulting product and reduces or even eliminates defects, thereby producing a better part than might be made manually or using traditional manufacturing approaches. •The Visual and Autonomous Exploration Systems Research Laboratory devised, built, and demonstrated a proof-of-concept fully articulated robotic system that can assist in the automated coating of insulation panels for building envelope retrofits. The underlying devised human robotic haptic interface can take over a variety of manual applications in other fields and subject them to automation to increase productivity and enhance worker safety. •We filed as an international patent application as well as an additional invention disclosure with Tech Launch Arizona to protect the devised human robotic haptic interface in general, and robotically applied/assisted building envelope retrofits in particular. •We engaged with one of the industry leaders in building envelope retrofits. This greatly informed our direction in terms of understanding industry needs and technical goals of interest. •Undergraduate and graduate students were heavily engaged in this effort, giving them unique research and engineering experience, ranging from project planning, design, and construction; 3D printing; programming' sensor real-time access; and successful demonstration of an integrated proof-of-concept robotic system. •We proposed a method to connect the product design, process design, and in-situ monitoring to identify the physical manifestations of cyber-attacks. The proposed approach can verify the geometric integrity of a machined part by observing cutting power signals during machining. This work was published in a special issue of the Journal of Manufacturing Systems. NASA's Aeronautics Research Mission Directorate and Transformative Aeronautics Concepts Program awarded UArizona a \$803K grant to conduct a study related to this effort. •We filed the patent application, Sensor Signal Prediction at Unreported Time Periods. 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	1,588,081	658,088	658,088	2,904,257
Basic Research	306,546	127,030	127,030	560,606
Applied Research	144,812	60,009	60,009	264,830
Development	0	0	0	0
Total	2,039,439	845,127	845,127	3,729,693
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	122,427	209,692	209,692	541,811
Postdocs Supported	1	1	1	3
Graduate Students	14	3	3	20
Undergraduate Students	20	2	2	24
Sponsored Project Funding	5,228,930	2,083,333	2,083,333	9,395,596
Publications in Academic Peer-Reviewed Journals	0	17	17	34
Startups	0	1	2	3

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	National Security Systems																																											
Program Name:	Artificial Intelligence																																											
Problem Statement:	<p>The field of artificial intelligence (AI) can encompass research in machine learning, computer visioning, and natural language processing. Application of such research can create computational approaches to human-like reasoning that can augment decision making. A laudable goal of AI is to replace human decision making, particularly where the task is extremely complex and/or large amounts of data are involved. The quality of any AI system is dependent on the data used to develop and support it. Major challenges are data quality, bias, structure, labeling, and methods to curate large datasets.</p>																																											
Program Description:	<p>An important objective for TRIF support in the AI initiative is to bring existing research and application capabilities together in new ways to create synergies and increase opportunities for both funding and impact. We expect there are step-function gains that can be realized by connecting investigators and seeding new projects that will expand the development and application of AI. At present, there is fervent excitement around AI that is making it challenging to understand what represents true opportunity for UArizona. TRIF funding will be employed to bring together AI investigators from across campus to sort through potential strategies for expansion of AI research and technologies and determine the best path. We expect at least one outcome to be a cogent roadmap that will help UArizona establish itself as a leader in AI in one or more research and/or application domains.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>UArizona currently deploys AI approaches across several research domains, including AI research itself. Recent and current programs include applications of AI in cybersecurity, space exploration, health care, education, sustainability, transportation, and border security. UArizona investigators are developing new approaches to AI itself, such as machine learning algorithms that adapt over time. Current efforts span multiple departments and colleges and provide the potential to pull teams of AI specialists together to address even larger challenges.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> •Development of an AI roadmap that details a strategy for UArizona to follow toward a position of national prominence •Determination of AI-related areas where UArizona can be competitive and establish world-class programs •Demonstration of UArizona leadership in one or more research or application domains related to AI (e.g., major grant award, center of excellence) 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	National Security Systems
Program Name:	Artificial Intelligence

2022 Progress Summary:

Artificial intelligence applications include such complex operations as autonomous driving, where human interaction and the variation in the physical environment makes the application of AI even more challenging. The future of AI is evolving and growing rapidly, and the boundaries of use remain unclear as basic research continues to reveal new applications. While several projects in FY22 employed the use of artificial intelligence, two projects explored AI at a fundamental level by addressing a major challenge with AI algorithms, prediction, and reasoning under uncertainty. With the advent of fast computation at low cost, as well as the ability to store and work with extremely large datasets, methods like AI are enabling predictive modeling and real-time decision making based not on theoretical models, but on empirical data. Computation speed and data handling can allow rapid sampling of sensor systems or existing datasets to build predictive models that account for uncertainties in the system. Multiple models can be optimized and compared to see what approach is the most accurate very quickly, allowing for near real-time outputs. As these methods become faster and more accurate, they allow systems to run in increasingly uncertain environments.

Select highlights:

- This work led to increased engagement with the Institute for Automated Mobility Statewide project, which aims to improve many aspects of transportation safety. The project is focused primarily on Arizona with engagement from the Arizona Department of Transportation (ADOT) and Mesa County DOT (MCDOT). The project has gathered and analyzed many hours of traffic data from roadside cameras in the Phoenix metro area.
- Research advancements have led to robust methods for risk-sensitive sequential decision making in settings with uncertainty about the environment and observation (sensor) model.
- Additional research advancements have led to efficient methods for quantifying uncertainty in complex statistical models with a paper under review at a top machine learning conference, Advances in Neural Information Processing Systems.
- TRIF funds supported one computer science PhD student for the spring semester as well as the purchase of an additional computing node for the university’s High Performance Computing (HPC) resources.
- We were awarded a \$450K Young Investigator Program grant from the US Air Force Office of Scientific Research.

Investment Detail

	2022	2023	2024	Total
Infrastructure	0	0	0	0
Basic Research	61,860	1,833,916	1,833,916	3,729,692
Applied Research	0	0	0	0
Development	0	0	0	0
Total	61,860	1,833,916	1,833,916	3,729,692

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	0	209,692	209,692	419,384
Postdocs Supported	0	0	0	0
Graduate Students	5	1	1	7
Undergraduate Students	2	3	3	8
Sponsored Project Funding	0	2,083,333	2,083,333	4,166,666
Publications in Academic Peer-Reviewed Journals	17	17	17	51
Startups	0	1	2	3

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	National Security Systems																																											
Program Name:	Cyber-Physical Systems																																											
Problem Statement:	<p>Industry has traditionally relied on highly linear data and communications for decision making. Cyber-physical systems (CPS) enables real-time access to data and intelligence from a myriad of sources and locations simultaneously, with the potential to fundamentally change the way businesses operate. Challenges in CPS include many fundamental questions regarding system integration, safety, accuracy, data processing, and reliability.</p>																																											
Program Description:	<p>At present there are several active programs that focus on CPS problems and technologies. TRIF funding would support further growth and expansion. Over the next five years, we expect that the number of competitive grants submissions from these programs will grow and the number of research sponsors will increase beyond past experience, which recently has been limited mostly to NSF. In particular, current opportunities exist with the Department of Defense, NASA, and industry that we can and should pursue. TRIF funding will also make investments to increase UArizona's activities in this domain by bringing current groups together for larger projects, as well as introducing new investigators to the field through seed grants. One area that may be particularly fruitful is CPS application to health care. With the growth of telemedicine, which is largely focused on video-enabled patient interactions (especially during the SARS-CoV-2 pandemic), innovators are turning to the next frontier. This will undoubtedly involve CPS-enabled platforms such as remote surgery.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>UArizona has a history of involvement in CPS research since at least 2014. We held a workshop for faculty interested in CPS funded by the NSF and most recently were awarded another NSF grant in "Computationally Aware Cyber-Physical Systems." UArizona has many units and individual investigators across the university conducting research and student training in the broad field of CPS. The Compositional Systems Labs, housed within Systems and Industrial Engineering and aligned with the UArizona Transportation Research Institute, works in the fields of transportation and autonomous vehicles. The College of Science (Applied Math), Electrical and Computer Engineering, and the Center for Applied Genetics and Genomic Medicine also are engaged in CPS activities.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> •Growth of existing CPS activities and an increase in the number of submitted proposals, particularly beyond NSF •Increased participation of faculty in CPS-related research, especially from related areas (e.g., mechanical engineers that work on the physical systems side) •Expanded application space for CPS-related technologies in all relevant areas, but importantly in health care 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	National Security Systems
Program Name:	Cyber-Physical Systems

2022 Progress Summary:

The two projects funded by TRIF in the Cyber-Physical Systems domain addressed the challenge of humans interacting with computer-controlled systems such as autonomous robots and drones. Certain types of robotic systems are designed to work in close proximity to humans to assist with physically demanding or repetitive tasks. Such close contact risks injury to people if the system cannot operate predictably or respond to actions by the person. Similarly, drones that operate around humans, such as swarms made up of dozens of small drones, risk causing serious injury if they cannot react to human presence and avoid collisions.

Select highlights:

- UArizona researchers focused on the computer control of cyber-physical systems in the presence of uncertainty or unpredictable events such that human safety can be assured. One scenario considered a drone swarm where one or more of the drones fails or displays erratic flight. The researchers developed an algorithm to account for this event and adapt the remaining drone flight patterns accordingly, to avoid a domino effect. Outcomes of this research appear in the proceedings of the 2022 American Control Conference and the 2022 European Control Conference.
- Researchers also developed a physics-inspired automation for resilient unmanned aircraft systems (UAS) coordination in the presence of time-varying (non-cooperative) failed UAS. The proposed automation consists of safe mode, which is activated when there exists no failed UAS, and unsafe mode, when there exists at least one noncooperative failed UAS among the group. The outcome of this research task was submitted to the Aerospace Science and Technology Journal, and it is currently under review.
- By integrating high-level, mid-level, and low-level planning and control, we developed a novel framework for continuum deformation optimization of a large-scale UAS team. The outcomes of this research have resulted in two journal papers published in the IEEE Transactions on Aerospace and Electronic Systems and Automatica Journal.
- We also completed work on a UAS traffic management model to build time-invariant air corridors at low altitude airspace in urban areas.

Investment Detail

	2022	2023	2024	Total
Infrastructure	75,191	874,384	874,384	1,823,959
Basic Research	78,562	913,586	913,586	1,905,734
Applied Research	0	0	0	0
Development	0	0	0	0
Total	153,753	1,787,970	1,787,970	3,729,693

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	75,191	209,692	209,692	494,575
Postdocs Supported	1	2	2	5
Graduate Students	2	5	5	12
Undergraduate Students	6	3	3	12
Sponsored Project Funding	8,000	2,083,333	2,083,333	4,174,666
Publications in Academic Peer-Reviewed Journals	17	17	17	51
Startups	0	1	2	3

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	National Security Systems																																											
Program Name:	Internet of Things (IoT)																																											
Problem Statement:	<p>The Internet of Things (IoT) is represented by devices with a multitude of capabilities, including self-identification, localization, diagnostic status, data acquisition, processing, and device-to-device and device-to-network communication. Devices function under the umbrella of the internet, which serves as a means of data transfer and communication. Application areas can be broadly categorized in terms of consumer, organizational, industrial, infrastructure, and military sectors. Technologies that support the IoT include wireless, low-power consumption electronics, energy storage, miniaturization, cloud computing, and data analytics. Barriers such as compatibility and lack of a clear value-proposition have hampered adoption. Security and privacy concerns with respect to data usage also have tempered enthusiasm.</p>																																											
Program Description:	<p>We anticipate this initiative will focus resources around current areas of demonstrable leadership in IoT technologies (e.g., transportation, agriculture, mining), as well as emerging areas (e.g., health monitoring), to deepen expertise and solidify critical mass. Over the next five years, one or more of these programs will be capable of maturation to national research center status, with commensurate federal funding support (e.g., ERC, MURI, NIH P01 or P50). TRIF funding also would support smaller programs in a "seed and feed" approach. The nature of IoT research involves a wide application space, and new discoveries can potentially be directed toward a myriad of applications and/or combined with related technologies to address ever-larger challenges. TRIF seed grants in the IoT initiative will be used to ensure that a pipeline of discoveries emerges over the five-year timeframe, and that this culture persists in the future.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>As a large land-grant university, UArizona is positioned to address complex system problems in a variety of application domains. Current research in wireless communications, low-energy consumption sensors, agricultural automation, data analytics, machine learning, wearables, advanced manufacturing, robotics, and transportation provide broad capabilities and expertise that can be directed toward important research questions that currently limit the effective application of IoT technologies. The university's ability to form strong academic-industry partnerships can help focus research and accelerate translation through proof-of-concept, technology transfer, and commercialization.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> •Development of a community around IoT technologies that includes multiple investigators, a convergence research approach, education and training programs directed toward workforce development, and increased technology transfer activity •Increased synergy between currently diffuse areas of IoT research and improved competitiveness for large, center-type funding awards •Development of a robust pipeline of seed projects that address emerging challenges and new application spaces 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	National Security Systems
Program Name:	Internet of Things (IoT)

2022 Progress Summary:

TRIF-funded projects directed toward the Internet of Things (IoT) trended toward sensor systems and devices designed to improve quality of life. Examples include a pair of holographic glasses that can improve the user experience for human computer interface applications ranging from simple web browsing and emails to operation of computer-controlled equipment, new signal processing technology based on sound waves (rather than electrical current or digital information) that can perform functions within a cell phone, and a tiny sensor that monitors bone health in an individual patient. These devices/applications are enabled by the internet, where control, data collection and analysis, data transfer, and adaptation of the device based on changing conditions can happen continuously, with or without human interaction.

There are numerous considerations in IoT, particularly in complex or sensitive applications. The safe operation of such devices often needs to be assured, as does data integrity and security. Protection from hacking, either of the device operation or data being produced and/or collected by the device, is of primary importance. Projects in FY2022 investigated the design and development of technologies that can harness the power of the "connectedness" of the internet through applications such as remote sensing.

Select highlights:

- Researchers are developing the concept of personalized medicine through the fabrication of small, inexpensive sensors that monitor and report aspects of bone healing. In one such application, a patient with a fracture can be monitored by having the sensor relay important information on bone strength to the doctor who performed the surgery.
- TRIF-funded research resulted in high-impact publications in journals including Nature Communications and Science Advances. We totaled 12 publications with average impact factors of over 10.
- There have been several IP applications based on the technologies developed. The research addresses challenges in digital medicine, wearable devices, and central and peripheral nervous system interfaces.
- TRIF funding has enabled new donations and has enabled competitiveness on the national and international level. Most notably, one researcher was in the finalist round of the MIT 35 Under 35 and the Moore Foundation Moore fellows, resulting in \$25K to his research lab from the Moore Foundation. This researcher also received a \$50K NSF award and several NIH subcontracts totaling over \$600K.
- The aforementioned researcher's lab is training more than 20 people, including postdocs, PhD students, undergraduates and high school students. Students received NSF GDRP, the Astronaut Scholarship, and the NIH Oxford Scholarship and have gone in prestigious positions in academia and industry, such as postdoc positions at Northwestern, research lead positions at Meta (former Facebook), and PhD positions at Johns Hopkins.
- The lab has also spawned a startup, Senphonics, which has received considerable attention and federal funding.
- Our research has garnered international research attention and been featured nationwide in over 200 media outlets, including a full-length PBS highlight.

Investment Detail

	2022	2023	2024	Total
Infrastructure	3,234	10,939	10,939	25,112
Basic Research	137,844	466,264	466,264	1,070,372
Applied Research	339,237	1,147,486	1,147,486	2,634,209
Development	0	0	0	0
Total	480,315	1,624,689	1,624,689	3,729,693

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	0	209,692	209,692	419,384
Postdocs Supported	3	2	2	7
Graduate Students	7	5	5	17
Undergraduate Students	19	3	3	25
Sponsored Project Funding	410,797	2,083,333	2,083,333	4,577,463
Publications in Academic Peer-Reviewed Journals	17	17	17	51
Startups	0	1	2	3

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	National Security Systems																																											
Program Name:	Data Sciences																																											
Problem Statement:	<p>Many areas of the Fourth Industrial Revolution (4IR) produce and/or can benefit from large pools of data. However, data in and of itself is not useful unless properly interpreted. Analytics provides for the systematic computational analysis of data using techniques such as text-to-data (e.g., natural language processing), machine learning, data visualization, and image informatics. Current challenges such as analysis of unstructured data, computation time, predictive accuracy, and complex event processing provide opportunities for additional academic research.</p>																																											
Program Description:	<p>Data sciences is at the core of many research activities at UArizona, and establishment of the Data Science Institute (DSI) has been instrumental in creating an array of capabilities available to many investigators and teams. Over the next five years, this initiative will use TRIF funds to expand the application of data science techniques, in particular the use of DSI, among a broader base of users. We will take concepts, practices, and capabilities from tools like CyVerse and support their expansion beyond life science research so that they can be utilized more broadly. We will support projects that apply data science to more application domains and demonstrate utility in a wider array of problems solving endeavors. TRIF support will also be directed toward the application of data sciences at different size scales. This initiative will support projects that seek to implement the use of data science techniques, especially those that enable data analysis and interpretation in new and novel ways.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>Through DSI, numerous faculty across the university have access to core capabilities in many facets of data processing and analysis, visualization, and interpretation. DSI fills the gap between research software and domain science by working with research teams at the cutting edge of data-driven discovery. Currently, DSI offers support in four applied focus areas, including natural language processing, machine learning, large-scale data visualization, and image informatics. Individual investigators working in various 4IR fields can leverage the DSI for their own investigations that require data analytics, as well as collaborate on research that aims to answer important questions and broaden the application of data analytics itself.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> •Increased awareness and utilization of data sciences as a research tool, particularly DSI and CyVerse, across all 4IR- related initiatives •Growth of CyVerse beyond life sciences •Implementation of data science techniques at a range of dataset size scales 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	National Security Systems
Program Name:	Data Sciences

2022 Progress Summary:

TRIF investments in data science research covered a wide variety of topics in FY22. UArizona researchers addressed societal challenges such as pest management, fake news, brain injury, and global warming in a multitude of ways, and they investigated new opportunities in digital health and transportation. Most projects sought ways to use data to understand, model, and predict future occurrences or outcomes. As collecting, analyzing, and storing massive amounts of data become easier and less expensive, data-based modeling is replacing theoretical approaches. UArizona is at the forefront of these techniques, which are being applied to assist in crop and forest product production, predict the devastating effects of flooding before it occurs, and promote healthy aging and recovery from traumatic brain injury.

Select highlights:

- We designed a machine learning-based model to predict a smoking relapse risk. Additionally, to learn about smoking relapse prevention preferences for postpartum individuals, we conducted in-depth, semi-structured interviews exploring the barriers and facilitators to smoking cessation as well as programming preferences for an intervention targeted at preventing postpartum smoking relapse. Though analysis of the interviews is still underway, preliminary analysis has revealed that stress, ability to breastfeed, and family support are all important factors in postpartum smoking relapse.
- We created high spatial resolution, national-scale, daily average temperature map products based on the new climate normal period (1991-2020). This series of maps are a critical advancement in the suite of products offered by the USA National Phenology Network, as they enable consumers of our products to compare a current year's seasonal conditions to a recent and relevant baseline (prior to this award, our long-term average products were based on the previous climate normal period, 1981-2010). The new averages and associated products were used by media outlets across the country in spring 2022, tracking the arrival of spring and plant development.
- We built new and strengthened existing collaborations with regional and local National Park Service and US Fish and Wildlife Service staff, resulting in new co-principal investigators from these agencies on the proposal and clear statements of need for the products of the proposed effort.
- We designed and built a customized wind tunnel and jet engine to teach aerospace concepts to blind students—work that was featured on PBS.

Investment Detail

	2022	2023	2024	Total
Infrastructure	419,260	396,136	396,136	1,211,532
Basic Research	871,429	823,366	823,366	2,518,161
Applied Research	0	0	0	0
Development	0	0	0	0
Total	1,290,689	1,219,502	1,219,502	3,729,693

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	195,914	209,692	209,692	615,298
Postdocs Supported	6	2	2	10
Graduate Students	23	5	5	33
Undergraduate Students	49	3	3	55
Sponsored Project Funding	19,349,775	2,083,333	2,083,333	23,516,441
Publications in Academic Peer-Reviewed Journals	17	17	17	51
Startups	0	1	2	3

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	National Security Systems																																											
Program Name:	Cyber Exploitation																																											
Problem Statement:	<p>Understanding how our digital systems can be adversely impacted by bad actors starts with the initiative on cyber defense, outlined above. The cyber exploitation initiative focuses on the second and third order effects when a breach occurs: How we delay, deny, and defeat attempts to cause our digital systems to mislead us, perform in unintended and dangerous ways, or slow down or confuse the integrated or cyber-physical systems with which they are associated.</p>																																											
Program Description:	<p>TRIF investments in cyber exploitation technologies will deliver techniques, software, and improved instruction in methods to ensure the safe and continuous operation of systems that have been challenged or threatened.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>We are fortunate to have faculty and staff with real-world experience dealing with these threats for the Department of Defense and in industrial settings. Again, in this area, we have achieved the highest level of recognition from defense agencies for the quality of our faculty, infrastructure, and instruction.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> ● Open-source solutions ● Increased industrial-sponsored research in cyber exploitation ● Increased federal, defense, and intelligence agency sponsored projects ● Increased recruiting of top faculty and students ● Increased Licensing and tech transfer impacts 																																											
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Total	1,157,107	867,831	867,831	2,892,769																																								
Performance Measures	<table border="1"> <thead> <tr> <th></th> <th>2022</th> <th>2023</th> <th>2024</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Faculty Startup Package Expenses</td> <td>207,103</td> <td>155,327</td> <td>155,327</td> <td>517,757</td> </tr> <tr> <td>Postdocs Supported</td> <td>1</td> <td>1</td> <td>1</td> <td>3</td> </tr> <tr> <td>Graduate Students</td> <td>4</td> <td>4</td> <td>4</td> <td>12</td> </tr> <tr> <td>Undergraduate Students</td> <td>3</td> <td>3</td> <td>3</td> <td>9</td> </tr> <tr> <td>Sponsored Project Funding</td> <td>1,666,667</td> <td>1,666,667</td> <td>1,666,667</td> <td>5,000,001</td> </tr> <tr> <td>Publications in Academic Peer-Reviewed Journals</td> <td>17</td> <td>13</td> <td>13</td> <td>43</td> </tr> <tr> <td>Startups</td> <td>0</td> <td>1</td> <td>2</td> <td>3</td> </tr> </tbody> </table>					2022	2023	2024	Total	Faculty Startup Package Expenses	207,103	155,327	155,327	517,757	Postdocs Supported	1	1	1	3	Graduate Students	4	4	4	12	Undergraduate Students	3	3	3	9	Sponsored Project Funding	1,666,667	1,666,667	1,666,667	5,000,001	Publications in Academic Peer-Reviewed Journals	17	13	13	43	Startups	0	1	2	3
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	National Security Systems
Program Name:	Cyber Exploitation

2022 Progress Summary:
 UArizona has been identified by Academic Insights as the leading undergraduate cyber program in the nation. We are the largest of the NSA-designated 24 Centers of Academic Excellence in Cyber Operations. As the leading cyber experts in the state, we are best qualified to provide impactful cybersecurity workforce development to address cyber exploitation.

- Select highlights:
- TRIF investments supported the creation of 11 new courses and 633 additional student credit hours during the spring semester and moved the program forward to build expertise in over 2,000 students per year by 2025.
 - Our program created 198 new marketing conversions, leading to the enrollment of 181 new cyber operations students. The program delivered 75 new graduates and 35 new certificate-earning students in May 2022.

Investment Detail				
	2022	2023	2024	Total
Infrastructure	1,064,625	989,050	989,050	3,042,725
Basic Research	9,441	8,771	8,771	26,983
Applied Research	0	0	0	0
Development	0	0	0	0
Total	1,074,066	997,821	997,821	3,069,708

Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	1,064,625	155,327	155,327	1,375,279
Postdocs Supported	0	1	1	2
Graduate Students	0	4	4	8
Undergraduate Students	6	3	3	12
Sponsored Project Funding	921,080	1,666,667	1,666,667	4,254,414
Publications in Academic Peer-Reviewed Journals	0	13	13	26
Startups	0	1	2	3

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	National Security Systems																																											
Program Name:	Advanced Energy Systems																																											
Problem Statement:	<p>Energy systems are required everywhere from deep sea to space, and from miniature applications to electrical grid storage devices. Meeting these demands requires a broad range of energy systems with discrete size, weight, power density, capacity, and cost targets. New approaches to providing these solutions are slow to emerge in the commercial market and must rely on fundamental and applied research that can rapidly scale and transition to commercial production.</p>																																											
Program Description:	<p>We anticipate making advances in fundamental science, prototype systems, and teaching and learning that ensure Arizona serves the needs of commerce and the military, and that the state is an attractive destination for these industries.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>These solutions require the combined creativity of electrical, mechanical, and systems engineers, materials scientists, and application space expertise. The close-knit activities between the UArizona Colleges of Engineering and Science faculty are ideal for attacking these problems.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> •Increased industrial-sponsored research in energy systems •Increased federal, defense, and intelligence agency sponsored projects •Increased recruiting of top faculty and students •Increased licensing and tech transfer impacts 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	National Security Systems
Program Name:	Advanced Energy Systems

2022 Progress Summary:
 TRIF investment in a new "digital twin" of the university will drive fundamental new understandings in the operations, energy consumption, and efficiency of our academic enterprise at a city-level scale of impact. This digital twin models the behaviors and data of the real-world systems of the entire university, but ports that data into a parallel analytic environment against which researchers can run various models and experiments and test out new approaches to increasing efficiencies, driving down cost, and ensuring effective adoption and use of new energy technologies.

Select highlights:

- Phase One of the effort, led by our distinguished cyber operations program at Sierra Vista, has generated a geo-referenced model of the university with data, energy, and human dynamics.
- oNote that Phase 2 of the effort will expand the data layers available for analysis to include additional technologies and features for experimentation. This work has been undertaken in partnership with our Cyber Information Security Office to also allow us to assess, model, and improve the cybersecurity of, and to experiment with, the diverse energy systems of all the many internet of things devices being used and deployed on campus.

Investment Detail				
	2022	2023	2024	Total
Infrastructure	376,331	1,193,203	1,193,203	2,762,737
Basic Research	0	0	0	0
Applied Research	0	0	0	0
Development	0	0	0	0
Total	376,331	1,193,203	1,193,203	2,762,737

Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	0	155,327	155,327	310,654
Postdocs Supported	0	1	1	2
Graduate Students	0	3	3	6
Undergraduate Students	0	2	2	4
Sponsored Project Funding	0	1,666,667	1,666,667	3,333,334
Publications in Academic Peer-Reviewed Journals	0	13	13	26
Startups	0	1	2	3

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona			
TRIF Investment Area:	National Security Systems			
Program Name:	4th Industrial Revolution Workforce Development			
<p>Problem Statement:</p> <p>The Fourth Industrial Revolution is characterized by a period of an unprecedented rapid change. Concepts are advancing so quickly to implementation, led mostly by large companies, that the existing workforce struggles to keep pace. Moreover, academic programs that would train the pool of new workers are falling behind the demand for skills in new employees. Particularly in STEM fields, the imperative for a focus on fundamentals and connection of theory to practice leaves little room for additional training in areas required for the 4IR. Development of new programs that can address the training of both existing workers and current students is necessary to feed the needs of the 4IR workforce.</p>				
<p>Program Description:</p> <p>TRIF funding will support the expansion of STEM education programs at UArizona, especially in those that target growth in enrollment from groups underrepresented in fields of study related to 4IR. We will seek out and fund initiatives that bring faculty and staff together to address an urgent need for the 4IR workforce of the future. Several funding agencies, particularly those in the Department of Defense, are launching new programs related to STEM education and workforce development to fill a current pipeline that has been diminishing over time in the US. We will employ TRIF funding strategically to strengthen programs so that they are competitive on a national level.</p>				
<p>What is the University's Advantage and/or Anticipated Funding Opportunities?</p> <p>UArizona already has institutional strengths in STEM fundamentals education, as well as ongoing emphasis in connecting theory to practice with curricula, such as our four-year Craig M. Berge Engineering Design Program. Faculty with expertise in pedagogical, social, and behavioral research can complement ongoing program development to help implement new teaching modalities (e.g., online learning), and we can expand industry partnerships not only to serve workers interested in continuing education, but also to provide internship and co-op opportunities to traditional students. Current programs such as the Catapult Engineering Program seek to support and mentor underrepresented groups to help students persist in their degrees and graduate.</p>				
<p>Is there an Arizona Specific Benefit or Impact?</p> <ul style="list-style-type: none"> •Development of innovative STEM-based workforce development programs for the pipeline shortages in government and industry •Success in competing for at least one major STEM training grant •Growth in partnerships with stakeholders such as government labs and industry to better align workforce development programs with their needs and expand experiential learning for students •Launch of at least one workforce development program that partners with K-12 and community colleges, across a spectrum of institutions but especially in areas with disadvantaged and/or underserved populations 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	359,635	359,635	359,635	1,078,905
Basic Research	145,619	145,619	145,619	436,857
Applied Research	116,495	116,495	116,495	349,485
Development	29,124	29,124	29,124	87,372
Total	650,873	650,873	650,873	1,952,619
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	116,495	116,495	116,945	349,935
Postdocs Supported	0	0	0	0
Graduate Students	1	1	1	3
Undergraduate Students	3	4	5	12
Sponsored Project Funding	2,083,333	2,083,334	2,083,335	6,250,002
Publications in Academic Peer-Reviewed Journals	10	11	12	33
Startups	0	1	1	2

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	National Security Systems
Program Name:	4th Industrial Revolution Workforce Development

2022 Progress Summary:
 TRIF-funded UArizona efforts included various elements of workforce development for student training, including one new faculty startup package, two development projects, and one each of basic research, renovations, and equipment, as well as faculty training.

Select highlights:
 ·The IT4IR Workforce Development effort included a workshop focused on translational research approaches that direct more funding and research activity at use- and user-inspired projects with high potential for translation from the university ecosystem into a commercialization pipeline. However, the focus is on the translational research itself, rather than other topics such as cultivation of patents. Participants were directed toward experimental activities that would fill technical gaps and perceived translational and commercialization risk as seen through the eyes of downstream stakeholders.

Investment Detail				
	2022	2023	2024	Total
Infrastructure	693,462	425,900	425,900	1,545,262
Basic Research	36,321	22,307	22,307	80,935
Applied Research	0	0	0	0
Development	200,085	122,885	122,885	445,855
Total	929,868	571,092	571,092	2,072,052

Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	0	116,495	116,495	232,990
Postdocs Supported	0	0	0	0
Graduate Students	10	1	1	12
Undergraduate Students	5	4	5	14
Sponsored Project Funding	47,463	2,083,334	2,083,335	4,214,132
Publications in Academic Peer-Reviewed Journals	8	11	12	31
Startups	0	1	1	2

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona			
TRIF Investment Area:	National Security Systems			
Program Name:	Human-Computer Interactions			
Problem Statement:	<p>Computer systems used to be designed to respond to human input efficiently and consistently. With wearables, digital assistants, ubiquitous data, and artificial intelligence-infused and connected objects, we now require approachable, accessible, efficient interactions for compute-capable platforms to interact with humans. In many critical applications and systems, we also have moved from a time of a human operator in the control loop, to a human supervisor on the control loop. Safety, ergonomics, multi-sensory interactions, and intuitive interfaces are critical.</p>			
Program Description:	<p>Research in the area of human-computer interaction should reduce errors in the use of our defense systems, reduce the training burden as users transition to new systems, and reduce human stress in the use of these systems.</p>			
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>UArizona has strong electrical and computer engineering faculty as well as depth in artificial intelligence and mathematics. We have strong language centers; psychology, physiology, and social sciences faculty; and design themes around strengthening the built environment. These multidisciplinary talents will help us shape the interface between the real world and digital terrain, building efficiency and removing impediments to national security system interfaces and practices.</p>			
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> ●Increased industrial-sponsored research in human-computer interactions ●Increased federal, defense, and intelligence agency sponsored projects ●Increased recruiting of top faculty and students ●Increased licensing and tech transfer impacts 			
Investment Detail				
	2022	2023	2024	Total
Infrastructure	148,815	148,815	148,815	446,445
Basic Research	129,439	129,439	129,439	388,317
Applied Research	212,280	212,280	212,280	636,840
Development	88,019	88,019	88,019	264,057
Total	578,553	578,553	578,553	1,735,659
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	103,551	103,551	103,551	310,653
Postdocs Supported	0	0	0	0
Graduate Students	3	3	3	9
Undergraduate Students	3	3	3	9
Sponsored Project Funding	1,666,667	1,666,667	1,666,667	5,000,001
Publications in Academic Peer-Reviewed Journals	9	9	9	27
Startups	0	1	2	3

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	National Security Systems
Program Name:	Human-Computer Interactions

2022 Progress Summary:

TRIF investments—including funding for equipment and personnel costs in HCI for interactions with autonomous and unmanned systems—are bringing new talent to the College of Engineering to reduce errors, training burden, and human stress in the use of our defense systems.

For example, a new assistant professor is an expert in dynamics for single, multiple, and collaborative groups of unmanned air and ground vehicles as they operate in human-machine teams. His research in cooperative control of multi unmanned aircraft systems (UAS), UAS traffic management, Markov decision processes, cooperative aerial payload transport, stability analysis of communication delays in multi-agent systems, and multi-criteria decision making all advance the transition from human in the loop to optional human in or on the loop human-computer systems interactions for defense and transportation applications.

Investment Detail	2022	2023	2024	Total
Infrastructure	0	0	0	0
Basic Research	172,604	834,609	834,609	1,841,822
Applied Research	0	0	0	0
Development	0	0	0	0
Total	172,604	834,609	834,609	1,841,822

Performance Measures	2022	2023	2024	Total
Faculty Startup Package Expenses	0	103,551	103,551	207,102
Postdocs Supported	1	0	0	1
Graduate Students	3	3	3	9
Undergraduate Students	8	3	3	14
Sponsored Project Funding	0	1,666,667	1,666,667	3,333,334
Publications in Academic Peer-Reviewed Journals	0	9	9	18
Startups	0	1	2	3

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	National Security Systems																																											
Program Name:	Novel Materials																																											
Problem Statement:	<p>Military systems operate in extreme environments that pose challenges to structural and packaging materials. Their energy systems require lightweight and high-electrical discharge capabilities. The structures require materials systems with unique fastening and joining methods. Increasingly, those materials must accommodate additional functionality and embedded systems than previous systems.</p>																																											
Program Description:	<p>We expect substantial progress in fundamental materials development, testing, and evaluation of coupon (small materials samples) and larger scale-up materials models, technical artifacts, and prototypes.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>Through growing collaborations with Arizona's resident military and intelligence components, our scientists are increasingly familiar with the operational and design issues that these systems must accommodate.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> ● Increased industrial-sponsored research in novel materials ● Increased federal, defense, and intelligence agency sponsored projects ● Increased recruiting of top faculty and students ● Increased licensing and tech transfer impacts 																																											
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Faculty Startup Package Expenses	258,879	258,879	258,879	776,637																																								
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	National Security Systems
Program Name:	Novel Materials

2022 Progress Summary:
 TRIF investments include funding for research equipment to support new hires in the College of Engineering, such as an associate professor specializing in solid mechanics and structural analysis for additive manufactured materials and aerodynamic structures. His research focuses on the design, manufacturing, and mechanics of multifunctional materials for complex loading conditions and extreme environments, including hypersonic systems. His special interest in mechanical property optimization by establishing linkages between the processing-microstructure will rapidly accelerate our research impact for Arizona in these and other critical defense and non-defense applications.

Investment Detail				
	2022	2023	2024	Total
Infrastructure	976,178	415,426	415,426	1,807,030
Basic Research	18,795	7,998	7,998	34,791
Applied Research	0	0	0	0
Development	0	0	0	0
Total	994,973	423,424	423,424	1,841,821

Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	859,695	258,879	258,879	1,377,453
Postdocs Supported	1	0	0	1
Graduate Students	7	3	3	13
Undergraduate Students	10	3	3	16
Sponsored Project Funding	6,015,937	1,666,667	1,666,667	9,349,271
Publications in Academic Peer-Reviewed Journals	0	9	9	18
Startups	0	1	2	3

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	Space Exploration and Optical Sciences																																											
Program Name:	Frontiers in Space Exploration and Optical Sciences																																											
Problem Statement:	<p>To achieve any of our objectives in Space Exploration and Optical Sciences, we need to be able to recruit the talent and establish the new programs necessary to respond to the latest developments in—and actively create the future of—those fields. This means hiring the scientists and engineers who are developing those fields and providing them with the resources necessary to succeed. These resources can include students, technical support, and equipment. This investment in the future is crucial to sustaining our current successes and building the new success stories.</p>																																											
Program Description:	<p>UArizona has world leaders in many fields and subfields within the Space Exploration and Optical Sciences focus area. However, to remain a leader as an institution, we need to continue to add future leaders in burgeoning fields and replace the expertise we inevitably lose as the current leaders age and retire. In particular, UArizona has a history of developing sensors and instruments that leverage emerging technologies to make revolutionary measurements, but we need to continue to hire the scientists who are able to make this happen.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>UArizona is home to internationally recognized faculty, staff, and students in Steward Observatory, the Lunar and Planetary Laboratory, and the College of Optical Sciences. This reputation makes the university a destination of choice for the very best talent in space exploration and optical sciences. Securing resources to recruit that talent, however, remains a major challenge.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<p>The primary measure of success is adding faculty who:</p> <ul style="list-style-type: none"> •generate new streams of funding •attract high-quality new students •build programs that integrate with the existing strengths of the university's Space Exploration and Optical Sciences areas 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Space Exploration and Optical Sciences
Program Name:	Frontiers in Space Exploration and Optical Sciences

2022 Progress Summary:

As a global leader in space and optical sciences, University of Arizona is widely recognized for cutting-edge science that pushes boundaries in both the theoretical and the functional spheres. TRIF's Frontiers in Space Exploration and Optical Sciences has funded a variety of projects for individual researchers pursuing new approaches to everything from detecting black holes to developing fabrication techniques for mirrors to designing small sensors for COVID-19 detection. This funding is primarily used to bring in new faculty who are either currently developing new technologies or those who are doing the work that will lead to the use (or necessity) of the kind of new technologies that can best be developed at UArizona

Select highlights:

- UArizona co-led the Dark Energy Survey Year-3 cosmology results, which were disseminated in a webinar attended by over 700 scientists and in 30 scientific publications.
- A UArizona team played an instrumental part in releasing the second image of a black hole. This was the first image of the black hole located at the center of our own Milky Way galaxy. Partially aided by TRIF funding, the work has supported graduate students and undergraduate students participating in that work.
- Researchers developed adaptive optics that increase the resolution of large telescopes by adjusting for atmospheric distortion.
- TRIF seed-grant funding was converted into larger awards and proposals for additional new awards that may lead to next generation instrumentation for the Giant Magellan Telescope that could, for the very first time, allow humans to directly look for life on other "earth-like" exoplanets.
- Researchers filed a patent for a new radio telescope manufacturing technology. Eight students were involved in the science and technology research.
- We developed and published a new laser-based mirror fabrication technique that is particularly valuable to telescopes, national defense, and space applications.
- UArizona researchers established new imaging markers for neuroendocrine tumors using multiphoton imaging were established. These markers could be used for intraoperative guidance and to reduce disparities in esophageal squamous cell carcinoma screening for Mexican-Hispanic individuals.
- Researchers developed a COVID-19 sensor.
- A patent was awarded for a sensitive (bio)chemical sensor based on an optical microresonator.

Investment Detail

	2022	2023	2024	Total
Infrastructure	2,544,695	569,477	569,478	3,683,650
Basic Research	0	0	0	0
Applied Research	0	0	0	0
Development	0	0	0	0
Total	2,544,695	569,477	569,478	3,683,650

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	1,886,985	415,000	415,000	2,716,985
Postdocs Supported	12	1	1	14
Graduate Students	68	2	2	72
Undergraduate Students	75	0	0	75
Sponsored Project Funding	10,771,885	500,000	500,000	11,771,885
Publications in Academic Peer-Reviewed Journals	148	15	15	178
Startups	0	0	0	0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	Space Exploration and Optical Sciences																																											
Program Name:	Optical Sensing and Display for Human-Centered Intelligent and Autonomous Systems																																											
Problem Statement:	<p>Since the dawn of computing, the interface between computers and humans has become progressively more personal, from computer room to desktop to mobile phone. The next revolution, wherein people will live and work in ubiquitous digital spaces, is just starting, and it will spawn entirely new economies and improvements in quality of life. Optical sensing is a critical enabling technology in this revolution, and we already are witnessing the increasing proliferation of sophisticated 3D optical sensing and imaging in consumer mobile platforms, autonomous vehicles, entertainment, smart spaces for enterprise business, remote medicine, and remote sensing for scientific discovery, defense, environment, and agriculture.</p>																																											
Program Description:	<p>This initiative will advance UArizona's scientific/engineering leadership in a very high-impact area. We will establish applications-driven collaborative research teams to accelerate the development of underlying optical technologies, ranging from breakthrough chip-scale 3D imagers with integrated neural processors, to smart displays and interfaces that enable ubiquitous information access, to new free-form optics that enable 100x reductions in size, weight, power, and cost (SWaP-C). In addition to the discovery engendered by cutting-edge applications research, this applications-driven approach lays the groundwork for increased private-sector partnerships, commercial transitions, and economic development.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>UArizona is exceptionally well positioned to take on this challenge. The College of Optical Sciences has eight faculty members strongly engaged in this area of optical sensing and display, including a new Endowed Chair and three additional new hires, spanning the core technologies and application domains mentioned above. These faculty are pursuing innovations that offer exciting promise in providing game-changing technical capabilities and cost reduction. They are also leaders in their field and have exceptionally strong industry engagement, with more than \$10M in private-sector research support and IP revenue over the past four years. By linking with engineering, medicine, and data science, this effort will leverage synergies from university-wide investments.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<p>This TRIF initiative will produce compelling ROI, including:</p> <ul style="list-style-type: none"> •Growth in optical sensor research grants/contracts, including a major center proposal •Workforce development, producing BS, MS, PhD, and postdoc/research scientist talent with application team experience to support regional economic development •Intellectual property generation with an excellent record of licensing potential •New start-up companies and strengthened relationships with local tech companies 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Space Exploration and Optical Sciences
Program Name:	Optical Sensing and Display for Human-Centered Intelligent and Autonomous Systems

2022 Progress Summary:

As one of the most prominent and respected optical sciences programs in the nation, the Wyant College of Optical Sciences is leading the creation of a cross-campus initiative focused on research and innovation. The initiative will advance the broad range of optical technologies that are core-enablers for the next-generation of human-centered autonomous services and intelligent systems. These systems will be comprised of smart spaces and autonomous services that improve the human interface to the cloud, enabling beneficial societal impacts to humankind through unprecedented access and extension to knowledge and effortless new capabilities in pursuit of our professional and social endeavors. Note that while this program builds on existing work, some of which was (and some of which continues to be) supported by TRIF, the program itself is new, so no publications have resulted yet.

Select highlights:

- We created the underlying technology testbeds, including concept media, hardware infrastructure, and testbed application prototypes in education, healthcare, research, and sports entertainment.
- Existing senior faculty leaders were augmented with two new hires, one who is an expert in machine vision and the other who is an expert in polarimetry and image science.
- A strong public-private partnership team will submit an Arizona-focused Type 1 NSF Engine proposal to the new NSF Technology, Innovation and Partnerships (TIP) division in September entitled, "Optics for Autonomous Services and Interactive Systems (OASIS)" that could strongly position UArizona to compete for a \$160M Type II NSF Engine.

Investment Detail

	2022	2023	2024	Total
Infrastructure	0	1,841,823	1,841,823	3,683,646
Basic Research	0	0	0	0
Applied Research	0	0	0	0
Development	0	0	0	0
Total	0	1,841,823	1,841,823	3,683,646

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	0	200,000	200,000	400,000
Postdocs Supported	0	10	14	24
Graduate Students	0	15	20	35
Undergraduate Students	0	0	0	0
Sponsored Project Funding	2,989,822	2,000,000	3,500,000	8,489,822
Publications in Academic Peer-Reviewed Journals	0	12	20	32
Startups	0	0	0	0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	Space Exploration and Optical Sciences																																											
Program Name:	Quantum Technology & Systems Engineering																																											
Problem Statement:	<p>UArizona has successfully launched a vital program in quantum information science and engineering (QISE), including its recent leadership role in the NSF Center for Quantum Networks. Quantum technologies also are positioned to benefit a host of additional applications and markets that harness advanced sensor systems in physical sciences, life sciences, and defense. To lead the emerging quantum economy, UArizona must galvanize a high-impact, integrative, university-wide QISE effort.</p>																																											
Program Description:	<p>This TRIF initiative will focus resources on developing explicit systems-scale solutions and demonstrators with unambiguous quantum performance advantage, ideally in sensor spaces that will strongly complement other UArizona investment areas, such as those in space sciences, National Security Systems, and Improving Health. To support CQN and other emerging systems QISE applications, and to bring experience in deployable quantum systems, the College of Optical Sciences has committed an Endowed Chair faculty position to lead in quantum systems engineering. It will also support committed Research, Innovation and Impact matching funds for CQN and additional infrastructure required for the QISE effort, such as advanced e-beam lithography tools.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>With its prior substantial faculty investments in QISE, combined with its high-visibility national leadership with CQN, UArizona is exceptionally well positioned. Potential quantum systems applications include sensors systems for defense and scientific discovery and communications solutions beyond the scope and budget of CQN. This TRIF initiative will harness resources in the Colleges of Optical Sciences, Engineering, Science, and Medicine, and CQN has additionally broken new ground by funding societal impacts research in the Colleges of Law and Social and Behavioral Sciences.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<p>This TRIF initiative will produce more than a 10x ROI, including:</p> <ul style="list-style-type: none"> •Growth in quantum research proposals, grants, and contracts •Intellectual property generation with an excellent record of licensing potential •Regional workforce development, producing increased BS, MS, PhD, postdoc, and research scientist talent with experience in applications-driven teams •QISE start-up companies and strengthened relationships with local tech companies 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Space Exploration and Optical Sciences
Program Name:	Quantum Technology & Systems Engineering

2022 Progress Summary:

The future is quantum, and with TRIF support, UArizona continues to invest in and strengthen its position as a leader in the field of Quantum Information Science and Engineering (QISE). The university's driving goal is to provide graphic demonstration of real quantum-enabled computational and sensor systems that measurably outperform any classical counterpart. With disruptive and game-changing implications for all areas of science and technology and, critically, the workforce of the future, UArizona's investments in this area are fundamental to our strategic goals.

Select highlights:

- Over 20 extramurally-funded projects were awarded by just one TRIF-supported researcher who has authored 63 papers or conference presentations in just 2021 and the first half of 2022.
- Support continued for junior faculty in QISE who will help build out the program even as they make new breakthroughs in the science.
- Work continues in the second year of the \$52M Center for Quantum Networks (CQN), an NSF Engineering Research Center with core partners Harvard, MIT, and Yale.
- Infrastructure investments were made in faculty and laboratories in the new Grand Challenges Research Building to conduct a multi-million dollar, full-scale system-level demonstration of networked quantum processors and sensors.
- The addition to our faculty of a highly accomplished Distinguished Member of Technical Staff at Sandia National Laboratories will serve as the first participant in a new master agreement between UArizona and SNL.

Investment Detail

	2022	2023	2024	Total
Infrastructure	577,420	1,553,113	1,553,113	3,683,646
Basic Research	0	0	0	0
Applied Research	0	0	0	0
Development	0	0	0	0
Total	577,420	1,553,113	1,553,113	3,683,646

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	577,420	600,000	600,000	1,777,420
Postdocs Supported	3	8	12	23
Graduate Students	10	14	20	44
Undergraduate Students	0	0	0	0
Sponsored Project Funding	13,645,465	2,400,000	3,500,000	19,545,465
Publications in Academic Peer-Reviewed Journals	36	8	12	56
Startups	0	0	1	1

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	Space Exploration and Optical Sciences																																											
Program Name:	University of Arizona Space Institute																																											
Problem Statement:	<p>UArizona has an unparalleled history of involvement and leadership of major space science facilities and missions, both space-based and ground-based. Competition within academia, industry, and the federal government, however, has developed strong infrastructures for proposal development and project management, while UArizona has simply maintained its previously successful approach. The competitive landscape has changed, and UArizona must develop common infrastructure among space exploration and optical sciences to more effectively compete for research support in the future.</p>																																											
Program Description:	<p>The University of Arizona Space Institute (UASI) will provide a structure to aid in the development, proposal, and operation of large spacecraft missions and space- and ground-based instruments. By increasing both the number of operational projects and the support to develop them, UASI will help supply and retain the necessary workforce, providing the engineering and scientific expertise to develop, advance, propose, and operate the next generation of large projects funded by NASA, NSF, NOAA, and other government agencies. Successful proposal of such major missions and projects takes years of work, which is usually beyond the means of individual investigators or departments to support. The integrated UASI enables such long-term, higher-profile investments.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>UArizona was the first university to manage a planetary lander mission (Phoenix Mars Lander) and to lead a New Frontiers mission (OSIRIS-REx). Our scientists and engineers have developed, supplied, and operated a significant number of instruments to NASA planetary flagship missions (Pioneer 10, Voyager, Cassini, and numerous Mars missions) and NASA astrophysics flagship missions (NICMOS for the Hubble Space Telescope, MIPS for the Spitzer Space Telescope, and NIRCcam for the James Webb Space Telescope), as well as ground-based telescopes that have significantly expanded our understanding of the universe (Multiple Mirror Telescope, the two 6.5m Magellan Telescopes, Large Binocular Telescope, the 24.5 Giant Magellan Telescope under construction, Spacewatch, and the Catalina Sky Survey).</p>																																											
Is there an Arizona Specific Benefit or Impact?	<p>This TRIF initiative will produce more than a 20x ROI, including:</p> <ul style="list-style-type: none"> •Growth in the number of multi-million dollar spacecraft mission and instrument contracts •Increased number of positions in a highly skilled workforce capable of designing, building, and operating spacecraft hardware and missions •Increased number of students involved in spacecraft missions and projects •Increased opportunities for Arizona companies to participate in spacecraft missions and projects 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Space Exploration and Optical Sciences
Program Name:	University of Arizona Space Institute

2022 Progress Summary:

The University of Arizona Space Institute (UASI) provides the structural framework for the development, proposal, and operation of large spacecraft missions and space- and ground-based instruments. TRIF support for UASI's mission is critical, but little of the funds committed for FY22 were spent by June 30 because other funds became available that were only accessible in FY22. However, the TRIF funds have been committed and will be spent early in FY23, and the funding for FY23 will be completely expended, or at least committed, and will be a major portion of UASI funding.

The primary expense of UASI has been providing seed grants to researchers for preparation of proposals for spacecraft missions, spacecraft instruments, and large projects involving ground-based telescopes. UASI's two biggest upcoming challenges are improving communication among researchers interested in space projects (a new website under development will host several important types of information) and establishing a sustainable funding model (discussions on methods are ongoing).

Select highlights:

- 14 seed grants were awarded to 10 different investigators, including three women and one member of other underrepresented minorities. Because the lead time on these projects can be many years, UASI is not expecting significant scientific returns in the short term (five years or less) but does expect to facilitate the submission of competitive proposals, whose selection will provide a financial return beginning at selection, and scientific return in later years.
- The OSIRIS-Rex mission was extended and will now send the spacecraft to rendezvous (in 2029) with the hazardous near-Earth asteroid Apophis after dropping off the sample return cannister on Earth in September of 2023. The proposal for the \$365M extended mission was funded by UASI. Of the total amount funded, \$73.2M will come to the University of Arizona.
- Progress continued on ASPERA, a \$20M mission to launch a small satellite and one of four Pioneer-class missions selected in FY21 after being one of the first proposals supported by UASI.
- UASI was designated as manager of the Arizona Research Building (ARB), which will contain state-of-the-art laboratories that will be used by UArizona researchers and will be available for use by Arizona aerospace and other high-technology companies. Planned occupancy is January 2023.

Investment Detail

	2022	2023	2024	Total
Infrastructure	0	1,841,823	1,841,823	3,683,646
Basic Research	0	0	0	0
Applied Research	0	0	0	0
Development	0	0	0	0
Total	0	1,841,823	1,841,823	3,683,646

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	0	0	0	0
Postdocs Supported	0	0	0	0
Graduate Students	0	0	0	0
Undergraduate Students	0	0	0	0
Sponsored Project Funding	5,588,724	4,000,000	6,000,000	15,588,724
Publications in Academic Peer-Reviewed Journals	0	5	15	20
Startups	0	0	0	0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	Space Exploration and Optical Sciences																																											
Program Name:	World Leading Facilities for Astronomical Research																																											
Problem Statement:	<p>Over 280 UArizona researchers (and additional students and faculty at ASU and NAU) depend on our world-renowned astronomical research facilities to produce transformative scholarship and return to Arizona, through external funding, 10x the currently provided state funding. We need \$2.4M per year of additional funding to maintain our current level of observatory operations and protect and grow our external funding.</p>																																											
Program Description:	<p>UAArizona will continue to use our facilities to make further ground-breaking discoveries. We anticipate progress in the characterization of planets around other stars, including the search for signs of life in the atmospheres of these planets. The Event Horizon Telescope will perform further tests of Einstein’s theory of gravity by studying the nearest massive black holes. Our well-equipped telescopes will identify the sources of gravity wave-producing events and provide new insights into the formation and evolution of stars and galaxies. We will use our facilities to train the next generation of astronomers and industry innovators.</p>																																											
What is the University’s Advantage and/or Anticipated Funding Opportunities?	<p>UAArizona has been a leader in space sciences for over a century. Our five mountaintop observatories in the desert Southwest, under clear, dark skies, have brought the world’s most talented students, engineers, and faculty to Arizona. These exceptional people have produced the innovations leading to our leadership in both space- and ground-based research facilities, not only in Arizona, but around the world. With our federal (e.g., NASA, Department of Energy (DOE), NSF) and foreign partners, we have developed the observatories and space missions that enable our past transformative discoveries, from proving the existence of dark matter to the first image of a massive black hole.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> •Greater than a 700 percent ROI, through external funding, on the funds provided to support and upgrade our facilities. •Completion of the next five observing campaigns of the Event Horizon Telescope (which uses our radio telescopes on Mount Graham and Kitt Peak) to complete our studies of the massive black holes in the nearest galaxies. 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Space Exploration and Optical Sciences
Program Name:	World Leading Facilities for Astronomical Research

2022 Progress Summary:

TRIF funding for World Leading Facilities for Astronomical Research has primarily been devoted to the Magellan Observatory and the Large Binocular Telescope Observatory (LBTO). The Magellan Observatory includes two state-of-the-art telescopes located in Chile, each with a 6.5m diameter primary mirror fabricated by the Steward Observatory Mirror Lab. Steward Observatory/UAArizona are 10% partners in this facility, entitled to use 10% of the observing time for our research and technical development activities, with the corresponding obligation to cover 10% of the annual operating costs of the observatory. TRIF funding for FY22 covered approximately 46% of UAArizona's share of the annual cost.

The LBTO, located on Mount Graham in Arizona, is the world's largest optical/near-IR telescope. It uses two 8.4m diameter mirrors fabricated by the Steward Observatory Mirror Lab. The Steward Observatory/UAArizona are 25% partners in this facility, and TRIF funding covered 13.5%, of UA's share for FY22.

TRIF funding also provides a crucial lynchpin in other Steward Observatory/UAArizona astronomical facilities, including several in southern Arizona that are used by faculty, students, and researchers from all three of the state universities. These facilities are essential to producing cutting-edge research, training future generations of astronomical leaders, and providing testbeds for innovative techniques that will be used across the world.

Select highlights:

- Several UAArizona instrumentation teams, supported by NSF and NASA, were able to leverage their access to LBT and Magellan to secure extramural support for their research and development efforts.
- Work done with the Magellan and LBT telescopes, including studies of exoplanets and the most distant galaxies and quasars, appears in many public talks (Steward Observatory hosts a biweekly public lecture series during the academic year) and in media accounts.
- Maintaining a presence at the forefront of this science helps identify Arizona as a potential location for top technical talent and for high technology businesses.
- Our research continues to draw top talent to both our undergraduate and graduate programs. Our undergraduates are typically physics majors, who upon graduation, are ready for highly technical jobs in physics, computer science, engineering, and other technical disciplines, in addition to those who plan to continue for an advanced degree in astrophysics.

Investment Detail

	2022	2023	2024	Total
Infrastructure	1,183,163	1,250,240	1,250,240	3,683,643
Basic Research	0	0	0	0
Applied Research	0	0	0	0
Development	0	0	0	0
Total	1,183,163	1,250,240	1,250,240	3,683,643

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	0	0	0	0
Postdocs Supported	14	20	20	54
Graduate Students	15	40	40	95
Undergraduate Students	0	0	0	0
Sponsored Project Funding	21,107,894	14,000,000	14,000,000	49,107,894
Publications in Academic Peer-Reviewed Journals	43	20	20	83
Startups	0	0	0	0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	Water, Environmental and Energy Solutions																																											
Program Name:	Building Resilience from Environmental to Human Health																																											
Problem Statement:	<p>Arizona's changing climate, population, demographics, and land use patterns, as well as sudden shocks to the system from pandemics, heat waves, wildfires, and other natural phenomena, bring a continuous stream of health challenges to our communities. People are moving closer to the urban/wild interface, and changing climate brings new or more intense natural hazards and new vectors for disease transmission into our region. Communities need reliable information about the nature and extent of threats, the economic costs of threats and possible counter actions, where the greatest vulnerabilities lie, and scenarios for building resiliency to their effects. Resource use and extraction industries are critical to the Arizona economy but have an impact to our environment that needs to be addressed.</p>																																											
Program Description:	<p>New research will advance our understanding of the impacts of heat, drought, and other climate impacts as well as of sources of contaminants to water, air, and food systems in order to help develop early warning systems that preempt environment-human crises. Researchers will collaborate with communities to develop mitigation strategies, produce scenario evaluation tools, and build community education programs. New approaches to mining and reclamation will enable these industries to prosper while preserving our environment.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>UArizona researchers study major public health issues such as those due to vector-, air-, and water-borne diseases; heat waves; and water and food contamination as they relate to a changing climate. In addition, UArizona is helping to develop a worldwide early warning system for monitoring other emerging zoonotic mutations with human crossover potential. A newly formed collaborative for global adaptive pandemic solutions led by UArizona places us at the forefront of research dedicated to identifying and filling knowledge gaps to better prepare for pandemic impacts by dedicating attention to prophylactics and treatments that are ready for deployment when needed.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> • Establishment of new partnerships with Arizona communities, governments, and tribes to help them prepare for heat, drought, and disease-related impacts associated with climate change and to build resilience to future threats • Development of new threat-warning and evaluation tools for resource managers, utilities, and industry • Creation of solutions aimed at combating pandemics and addressing their social and economic impacts • Support for the sustainability of the Arizona mining industry through new partnerships and approaches 																																											
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Water, Environmental and Energy Solutions
Program Name:	Building Resilience from Environmental to Human Health

2022 Progress Summary:

This year researchers at the University of Arizona worked to limit the spread of COVID-19 and other airborne contaminants in built environments and aircraft; monitor viral load in wastewater; create new community partnerships with utility companies to study the use of solar mini-splits to cool homes; create heat-related illness medical education materials for the general public; demonstrate the contributions that community science can make in monitoring air quality and the use of plants as low-cost air pollution monitors; and identify native plants that accumulate high concentrations of metal into their leaves to help remediate mining-impacted lands and to recover heavy metals for return back to the supply chain.

Select highlights:

- We are testing enhanced HVAC filtration capabilities that could improve indoor air treatment and reduce pathogen transmission without increasing energy demands. The research team has developed an HVAC simulation system to test real-world conditions (beginning on campus) and will soon be testing under different scenarios.
- Green technologies were advanced to enhance mine dust suppression and extract rare earth elements and uranium from contaminated waste streams; patents are in progress for both new technologies. A low-cost dust monitoring strategy for communities living close to active mines was validated with broad citizen science participation. Results identified associations between seed-mix composition, plant establishment success, and plant adaptations that enhance plant survival on metal contaminated soils. This research was conducted in close collaboration with active mining industry partners.
- Researchers have nearly finished a Med Ed script and faculty guide to help physicians and medical students assess risk, prevent, and treat heat-related illness. This work also includes posters and handouts for use by patients and in health clinics. The team is identifying rural health clinics and hospitals at which to continue this work.
- Researchers are pursuing critical insights into who lives in high-risk flood zones, including key socioeconomic dimensions of race/ethnicity, income, and education, by analyzing housing data for 20 major Arizona metropolitan areas beginning with Maricopa County. The project will generate data about how different sub-populations of Arizonans may be disproportionately harmed by flood risk through their housing, how these decisions are shaped by policy and climate change, and how Arizona compares to other US metropolitan areas.

Investment Detail

	2022	2023	2024	Total
Infrastructure	123,391	169,773	169,773	462,937
Basic Research	280,941	386,545	386,545	1,054,031
Applied Research	318,539	438,276	438,276	1,195,091
Development	95,328	131,161	131,161	357,650
Total	818,199	1,125,755	1,125,755	3,069,709

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	115,452	215,732	215,732	546,916
Postdocs Supported	5	4	4	13
Graduate Students	44	20	20	84
Undergraduate Students	39	15	15	69
Sponsored Project Funding	21,221,868	5,666,667	5,666,667	32,555,202
Publications in Academic Peer-Reviewed Journals	32	20	20	72
Startups	0	1	0	1

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona			
TRIF Investment Area:	Water, Environmental and Energy Solutions			
Program Name:	Future-Proofing Arizona Water			
Problem Statement:	<p>From farmers and ranchers to tourists, developers, miners, and legislators, Arizonans are concerned about the state's water supply. We seek reliable supplies of clean water for our municipalities, industries, and ecosystems. We seek new technologies to treat contaminated water and new means to use it more efficiently and distribute it equitably. The science and technology of clean and reliable water is extremely important, as is having people understand the options and trade-offs associated with alternative paths forward and encouraging the exploration of creative new ways to manage water in the state.</p>			
Program Description:	<p>Water resources are arguably among the most—if not the most—pressing environmental issue facing Arizona. To ensure a reliable and safe water supply for all Arizonans, we will form new types of partnerships between scientists, engineers, and policymakers; produce concept papers that connect science to policy and bring science to bear on addressing and resolving water management challenges; commercialize new water treatment technologies; promote a greater diversity of voices influencing water resources management; and engage in innovative partnerships with the private sector.</p>			
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>Ranked No. 1 in the nation in water resources, the UArizona has more than 280 faculty and researchers in 48 departments and programs that specialize in topics related to water. Expertise ranges from the physical and social sciences, economics, and public policy to civil engineering, biology, and environmental chemistry, addressing drought and climate, environmental systems, management and policy, society and culture, and technology and industry. UArizona works with numerous stakeholder communities at federal, tribal, regional, state, and local scales to develop water management plans and policies, and runs the Arizona Laboratory for Emerging Contaminants. Additionally, the Water and Energy Sustainable Technology (WEST) Center develops new methods to detect, quantify, and treat contaminants in water.</p>			
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> •Establishment of new partnerships with water managers and policymakers in Arizona and the Southwest, ranging from small communities to large municipalities and state/regional scale •New water policies and management decisions informed with science •Creation of new water quality and water management tools and technologies codeveloped with users 			
Investment Detail				
	2022	2023	2024	Total
Infrastructure	575,940	403,354	403,354	1,382,648
Basic Research	43,146	129,439	129,439	302,024
Applied Research	302,025	302,025	302,025	906,075
Development	43,146	129,439	129,439	302,024
Total	964,257	964,257	964,257	2,892,771
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	431,465	215,732	215,732	862,929
Postdocs Supported	4	4	4	12
Graduate Students	20	20	20	60
Undergraduate Students	15	15	15	45
Sponsored Project Funding	5,666,667	5,666,667	5,666,667	17,000,001
Publications in Academic Peer-Reviewed Journals	14	14	14	42
Startups	0	0	0	0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona			
TRIF Investment Area:	Water, Environmental and Energy Solutions			
Program Name:	Future-Proofing Arizona Water			
2022 Progress Summary:				
<p>In support of water resilience in the state of Arizona, we have conducted research related to the interactions between surface and groundwater to better understand statewide water usage; PFAS (per- and polyfluorinated substances), also known as “forever contaminants”;</p> <p>improving the safety of wastewater recycling; and the evaluation of water policy options as Arizona adapts to declining water levels in the Colorado River. Additionally, the Ecosystem-Based Adaptation Options for Coastal Resilience, funded by the U.S. Department of Interior, was a major step toward building a sustained national assessment process for supporting decision-making.</p>				
Select highlights:				
<ul style="list-style-type: none"> •Researchers crafted a new green infrastructure maintenance protocol for the City of Tucson in partnership with Tucson Water, local NGOs, and private sector actors. They helped design and lead University of Arizona cooperative extension courses around green infrastructure maintenance, building a network from these efforts to prepare for applying to be a UA EPA green stormwater center of excellence, and trained community members in best maintenance practices to help create green jobs. •Our annual Tribal Water Resilience in a Changing Environment conference was attended by local, state, federal, and tribal governments, professional associations, water utilities and irrigation districts, academics and students, businesses, and interested citizens. These attendees represented more than 40 Native Nations and Indigenous communities, 22 countries, 27 U.S. states, and 14 of Arizona’s 15 counties. •The WRCC began production of the Arizona Water Factsheet series. The county-level factsheets are tailored to every county in Arizona and designed to answer common questions about water resources to foster understanding of the local nature of Arizona water resource challenges and solutions. Maricopa and Pima County factsheets are completed and the remaining are in progress. •The Center for Climate Change Adaptation Science and Solutions is nearing completion of a five-year Santa Cruz River basin study that addresses the challenges of climate change for water supplies in the Tucson basin, including identifying supply and demand imbalances. This multi-stakeholder project involving local and regional resource managers was described as “state of the art” by the U.S. Bureau of Reclamation in terms of both community engagement and in incorporating the latest University of Arizona climate models, adaptation options, and trade-off analysis approaches. 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	389,943	549,647	549,647	1,489,237
Basic Research	0	0	0	0
Applied Research	413,832	583,320	583,320	1,580,472
Development	0	0	0	0
Total	803,775	1,132,967	1,132,967	3,069,709
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	389,943	215,732	215,732	821,407
Postdocs Supported	4	4	4	12
Graduate Students	21	20	20	61
Undergraduate Students	43	15	15	73
Sponsored Project Funding	6,133,282	5,666,667	5,666,667	17,466,616
Publications in Academic Peer-Reviewed Journals	27	15	15	57
Startups	0	0	0	0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona			
TRIF Investment Area:	Water, Environmental and Energy Solutions			
Program Name:	Observation Systems for Resilience Monitoring and Modeling			
Problem Statement: We can better prepare for change if we are able to monitor it in real time. Data related to weather, water resources, soil and vegetation conditions, air quality, greenhouse gases, wind and solar energy, and other conditions allow us to predict what we might expect in the future and plan accordingly. Monitoring parameters on the ground, while critically important, is time and labor intensive, and each monitoring point has only a limited radius of relevance. Monitoring from above ground using instruments on airplanes, balloons, and satellites permits greater spatial coverage and sampling frequency. Combined, these methods produce higher-resolution results and improved predictions.				
Program Description: Leveraging our existing strengths and programs, we will launch a regional-scale climate forecasting center and produce energy forecasting products codeveloped with utilities. We will contribute to science, policy, economic, and technology solutions to help monitor and manage greenhouse gas emissions and develop more refined local and regional-scale climate, weather, and other models. We also will grow partnerships with communities to codevelop data and information products that allow them to make decisions based on greater understanding of probable conditions.				
What is the University's Advantage and/or Anticipated Funding Opportunities? UAArizona has long-established expertise in space exploration and remote sensing, the study of Earth processes, and climate-related modeling, which, when combined, yield the potential for powerful new observation-based products and physical and economic forecasts. While efforts are distributed in colleges and institutes across the university, the globally recognized Arizona Remote Sensing Center aggregates experts and programs specifically dedicated to supporting decisions informed by its products and services. New programs are designed for identifying ways for communities to identify large methane emitters and other major carbon producers, anticipate growing conditions, help the military prepare for changing conditions and mitigate hazards, and evaluate the economic costs of environmental impacts.				
Is there an Arizona Specific Benefit or Impact? <ul style="list-style-type: none"> •New partnerships with Arizona and other industries and communities •Development of new water and energy management and forecasting tools for Arizona resource managers, industry, and utilities •Establishment of a new regional-scale climate forecasting center •Development of new means to monitor and help manage greenhouse gas emissions •Creation of new energy forecasting products codeveloped with utilities 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	575,940	403,354	403,354	1,382,648
Basic Research	43,146	129,439	129,439	302,024
Applied Research	302,025	302,025	302,025	906,075
Development	43,146	129,439	129,439	302,024
Total	964,257	964,257	964,257	2,892,771
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	431,465	215,732	215,732	862,929
Postdocs Supported	4	4	4	12
Graduate Students	20	20	20	60
Undergraduate Students	15	15	15	45
Sponsored Project Funding	5,666,667	5,666,667	5,666,667	17,000,001
Publications in Academic Peer-Reviewed Journals	14	14	14	42
Startups	0	0	1	1

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona			
TRIF Investment Area:	Water, Environmental and Energy Solutions			
Program Name:	Observation Systems for Resilience Monitoring and Modeling			
2022 Progress Summary:				
<p>This year, UArizona researchers made progress toward building resilience in monitoring and modeling by establishing the Center for Applied Hydroclimate Sciences to provide reliable information for decision making and increased resilience to environmental stresses; studying changing monsoon patterns that are directly relevant to the future water supply in Arizona; developing more accurate means to estimate water demand for crops; developing new observation systems that show how trees and other vegetation can store carbon dioxide; studying the relationships between marine ecosystems along the Pacific coast and extreme heat waves and drought in the Southwest; and initiating a study on the impacts of urban pollution and surface land changes on energy and water budgets in the Phoenix-Tucson corridor.</p>				
Select highlights:				
<ul style="list-style-type: none"> •Researchers made significant progress understanding the relationship between wildfires, debris flows, and flash floods in the state of Arizona. Debris flows are common following wildfire, and can move very large objects in their path, posing a hazard to people and infrastructure. Researchers developed a model that predicts which areas are likely to be impacted by debris flows downstream of burned areas, which is essential to anticipating and mitigating debris-flow disasters. They developed guidance on rainfall characteristics most likely to lead to flash floods downstream of recently burned areas. They found that debris flow susceptibility drops rapidly following one to two years of recovery. •Researchers at the Center for Applied Hydroclimate Sciences incorporated channel loss into the hydrologic modeling system, resulting in improved streamflow forecasting within the Southwest United States, especially for ephemeral stream channels that are active during extreme events. The researchers also incorporated GPS sensors to improve short-term, high-resolution weather prediction forecasts. The center was recently awarded \$1.2M from the Arizona Board of Regents to develop new technologies and policies to better manage ozone pollution. 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	329,666	1,103,095	1,103,095	2,535,856
Basic Research	0	0	0	0
Applied Research	58,047	194,231	194,231	446,509
Development	11,355	37,995	37,995	87,345
Total	399,068	1,335,321	1,335,321	3,069,710
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	189,317	215,732	215,732	620,781
Postdocs Supported	4	4	4	12
Graduate Students	10	20	20	50
Undergraduate Students	63	15	15	93
Sponsored Project Funding	12,085,759	5,666,667	5,666,667	23,419,093
Publications in Academic Peer-Reviewed Journals	68	30	30	128
Startups	0	0	1	1

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona			
TRIF Investment Area:	Water, Environmental and Energy Solutions			
Program Name:	Resilient Systems Integration			
Problem Statement: Transformational changes in our production of secure and sustainable energy, food, and water sources, and in the efficient use of energy, are among the most significant global challenges of the 21st century. As energy demands, food scarcity, and climate variability increase, the means to create and maintain reliable and resilient energy delivery systems, food production systems, and water supplies sufficient to sustain and enhance our society, our economy, and our ecosystems are of paramount importance, especially in regions like Arizona and the Southwest. An integrated and aggressive approach that incorporates economic considerations is required to solve these problems, especially as these regions are home to many communities that are particularly vulnerable to such changes.				
Program Description: We will develop new materials, technologies, and operations targeted to energy-efficient water reuse and purification for all sectors as well as smarter data and decision-making platforms with robust links to policy and decision-making processes for water and energy production and use. We also will integrate new science and technology with policy development, decision making, support, and education; produce new designs of the future for a more resilient and efficient urban and rural environment; and create regional test beds and new public-private partnerships.				
What is the University's Advantage and/or Anticipated Funding Opportunities? UArizona researchers are at the forefront of the food-energy-water nexus, exploring ways to address our scientific, technological, economic, and societal challenges. UArizona partnerships with Indigenous communities, particularly the Navajo Nation, are developing technical solutions to build reliable, affordable access to energy, water, and food while training the next generation of food-energy-water systems professionals to tackle these challenges. The university has been a pioneer in the development of agrivoltaics, with the flagship project at Biosphere 2 named a 2018 World Changing Idea, subsequent experiments initiated at local area schools, and discussions expanded to large-scale Arizona growers. UArizona researchers work closely with government officials in Yuma to enhance agriculture in the region, where food, energy, and water are of great socioeconomic importance, but would be scarce if not for thoughtful, informed resource management. Further, UArizona's new RESTRUCT program harnesses expertise from across the university to address the				
Is there an Arizona Specific Benefit or Impact? <ul style="list-style-type: none"> •New partnerships with Arizona industry and government •Creation of better data and decision-making platforms for resource managers, utilities, and others users •Creation of knowledge for policymakers and decision makers arising from university-community partnerships •Development of new materials, technologies, and operations targeted to energy-efficient water reuse and purification •Integration of new science and technology with policy development, decision making, and education 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	575,940	403,354	403,354	1,382,648
Basic Research	43,146	129,439	129,439	302,024
Applied Research	302,025	302,025	302,025	906,075
Development	43,146	129,439	129,439	302,024
Total	964,257	964,257	964,257	2,892,771
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	431,465	215,732	215,732	862,929
Postdocs Supported	4	4	4	12
Graduate Students	20	20	20	60
Undergraduate Students	15	15	15	45
Sponsored Project Funding	5,666,667	5,666,667	5,666,667	17,000,001
Publications in Academic Peer-Reviewed Journals	14	14	14	42
Startups	0	0	1	1

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona			
TRIF Investment Area:	Water, Environmental and Energy Solutions			
Program Name:	Resilient Systems Integration			
2022 Progress Summary:				
<p>This year, we promoted resilient systems integration by clarifying the relationship between microbes and storage of carbon by vegetation in changing climate conditions; understanding how to improve the resilience of microbes in soil to ensure that soil remains healthy and productive; testing the ability of novel soil microbes to improve soil quality, plant growth, and carbon capture in arid environments; filing an invention disclosure to build the first comprehensive soil health assessment framework for Arizona; developing novel ways of recycling building materials to create new habitats; and filing a patent for a grasshopper harvesting system.</p>				
Select highlights:				
<ul style="list-style-type: none"> •UArizona economists are developing new connections with environment and energy researchers to help them bring greater cost-benefit analysis and social science data to their work. A product of that collaboration is a website that explores environmental justice issues associated with methane emissions. By mapping detailed methane emissions data onto tract-level demographics for various regions of the country, the population areas most impacted by methane can be easily identified. •We launched the NEPAccess site, providing access to detailed searches of approximately 9,000 environmental documents reflecting decades of records related to the National Environmental Policy Act (NEPA). The NEPAccess team later provided policy and project briefings to White House Council on Environmental Quality (CEQ) staff, including a detailed set of recommendations, portions of which were incorporated into new federal policy guidance. In summer 2022, the NEPAccess team was asked by federal legislative staff to provide information to support the development of currently proposed legislation. •Researchers discovered that adding certain types of soil microorganisms decreased the potential for dust pollution from degraded desert ecosystems in Arizona. A novel soil microbe was found to improve soil structure, plant growth, and carbon capture at sites in Arizona, Texas, and Africa, setting the foundation for a long-term academic-industry partnership. 				
Investment Detail				
	2022	2023	2024	Total
Infrastructure	742,132	636,166	636,166	2,014,464
Basic Research	28,031	24,029	24,029	76,089
Applied Research	251,572	215,651	215,651	682,874
Development	109,151	93,566	93,566	296,283
Total	1,130,886	969,412	969,412	3,069,710
Performance Measures				
	2022	2023	2024	Total
Faculty Startup Package Expenses	452,239	215,732	215,732	883,703
Postdocs Supported	6	4	4	14
Graduate Students	35	20	20	75
Undergraduate Students	106	15	15	136
Sponsored Project Funding	12,650,611	5,666,667	5,666,667	23,983,945
Publications in Academic Peer-Reviewed Journals	37	25	25	87
Startups	0	0	1	1

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	Water, Environmental and Energy Solutions																																											
Program Name:	Adaptable Desert Communities, Culture, and Ecosystems																																											
Problem Statement:	<p>For humans to continue to live in arid lands, we must understand how we can be resilient to impacts associated with climate change and other stresses affecting the linked human and natural systems of the desert. Southern Arizona and northwest Mexico are in the crosshairs of global climate change. Many changes that will eventually affect the rest of the world are starting here in the arid Sonoran Desert; our experiences can inform communities across the globe. Integrated research, education, and outreach grounded in community needs is necessary to guide actions, policies, and decisions that preserve and enhance these linked cultural and ecological systems.</p>																																											
Program Description:	<p>With our history and living-laboratory location in the Sonoran Desert, we will draw upon our geographic heritage, experience, skills, expertise, and relationships with Southern Arizona communities to provide resilience solutions for arid lands in other parts of the world. Additionally, we will establish a program of science, culture, and art; form transdisciplinary university/stakeholder working groups to accelerate innovative solutions to the challenges of future life in the desert; and launch undergraduate, graduate, and community experiential courses that train the next generation of researchers in resilience thinking and science.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>In April 2020, the UArizona established the Arizona Institutes for Resilience (AIR) to aggregate its unique resources and programs under one administrative unit, which will strengthen this initiative. More than a century of research at the Desert Laboratory at Tumamoc Hill has revealed how life has adapted to an arid and unpredictable environment. Building on data from long-term plots, knowledge of ecosystem responses to prior climate changes, and an understanding of the persistence of humans in this region, we can transform how we address future ecological challenges. The potential and opportunities of the Desert Lab are significant and range from place-based research to field courses and programs for students and the community in culture, arts, and sciences. In addition to Tumamoc Hill, activities at Biosphere 2 likewise blend ecosystem science with arts and culture at a world-renowned, unique, controlled-environment research facility.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> • Production of science-based information products that use our unique research laboratories • Increased education of communities about the impacts of climate change and how to build resiliency to change through science, culture, and the arts by taking advantage of the public interest in Tumamoc Hill and Biosphere 2 • Recognition as a world leader in developing and implementing resilience solutions for arid lands elsewhere • Establishment of new university-community partnerships working together to develop new approaches to resiliency • Increased number of students learning about resilience science through hands-on experiences and experimental courses 																																											
Investment Detail	<table border="1"> <thead> <tr> <th></th> <th>2022</th> <th>2023</th> <th>2024</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Infrastructure</td> <td>575,939</td> <td>403,353</td> <td>403,353</td> <td>1,382,645</td> </tr> <tr> <td>Basic Research</td> <td>43,146</td> <td>129,439</td> <td>129,439</td> <td>302,024</td> </tr> <tr> <td>Applied Research</td> <td>302,025</td> <td>302,025</td> <td>302,025</td> <td>906,075</td> </tr> <tr> <td>Development</td> <td>43,146</td> <td>129,439</td> <td>129,439</td> <td>302,024</td> </tr> <tr> <td>Total</td> <td>964,256</td> <td>964,256</td> <td>964,256</td> <td>2,892,768</td> </tr> </tbody> </table>					2022	2023	2024	Total	Infrastructure	575,939	403,353	403,353	1,382,645	Basic Research	43,146	129,439	129,439	302,024	Applied Research	302,025	302,025	302,025	906,075	Development	43,146	129,439	129,439	302,024	Total	964,256	964,256	964,256	2,892,768										
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Water, Environmental and Energy Solutions
Program Name:	Adaptable Desert Communities, Culture, and Ecosystems

2022 Progress Summary:

In support of adaptable desert communities, culture, and ecosystems, we have increased our outreach efforts at the Desert Laboratory on Tumamoc Hill, visited by thousands of walkers every day, by opening new the historic Tumamoc boathouse as a community outreach space and by breaking ground on the Tumamoc Resilience Garden; and continued to study arid-adapted plants that contribute positively to human health and are potential agricultural crops that can be grown in arid conditions.

Select highlights:

- Over 700 Tucson community members participated in 25 workshops focused on the benefits of desert-adapted foods to human and landscape health, and their role in improving the resilience of local food systems to climate change. Attendee surveys provided valuable information about barriers to greater consumption of desert-adapted foods and highlighted the importance of making stronger connections between climate change and local food supplies in future discussions. The workshops are increasing community knowledge and have seeded new partnerships and future collaborations between the university and local and cross-border organizations.
- Artists and scientists teamed up to develop the Science in Motion project, creating products to help make the mechanisms of climate change understandable and immediate for non-scientist audiences. The project engaged students in translating scientific research material into film, animation, infographics, and data visualizations. Much of the collaboration took place at the university's Biosphere 2.
- Funding has been committed to support four new faculty hires under the newly formed Indigenous Resilience Center (IRC) at the University of Arizona. The IRC was officially approved as a university center in FY22 with the goal of positioning the university as a world leader in indigenous resilience research by acting as a campus hub for tribal resilience solutions, scholarship, tribal outreach, and teaching. One of the new faculty arrived on campus in FY22, based in the School of Natural Resources and the Environment, and two more will begin in FY23.

Investment Detail

	2022	2023	2024	Total
Infrastructure	482,430	917,384	917,384	2,317,198
Basic Research	11,009	20,935	20,935	52,879
Applied Research	81,732	155,421	155,421	392,574
Development	63,928	121,564	121,564	307,056
Total	639,099	1,215,304	1,215,304	3,069,707

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	428,167	215,732	215,732	859,631
Postdocs Supported	5	4	4	13
Graduate Students	11	20	20	51
Undergraduate Students	17	15	15	47
Sponsored Project Funding	1,306,029	5,666,667	5,666,667	12,639,363
Publications in Academic Peer-Reviewed Journals	1	5	5	11
Startups	0	0	0	0

Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Proposal

University:	University of Arizona																																											
TRIF Investment Area:	Water, Environmental and Energy Solutions																																											
Program Name:	Fostering Leaders in Resilience																																											
Problem Statement:	<p>Arizona is home to a diverse population with varying strengths, interests, and vulnerabilities. Preparing for a resilient future requires our next generation of leaders and decision makers to reflect that diversity and be able to communicate across sectors and disciplines. STEM training is necessary, particularly for the initiatives described in this planning document, but with fluency that goes beyond just STEM. New cross-disciplinary fields are emerging that mix science with technology or policy, for example, and we need to draw students into them. Students, in turn, seek opportunities to make a difference in their communities even before they graduate.</p>																																											
Program Description:	<p>To prepare the next generation for the future workplace and guide students on a career path related to resilience, we will increase diversity in existing scholarship and internship programs; design and implement experiential learning curricula; expand internship programs to include more opportunities, especially with underserved populations and for less advantaged students; offer more leadership training and mentoring for junior faculty via TRIF-funded programs; grow programs to reach K-12 students in STEM and attract them to the university; and create and offer new environment-focused courses that allow high school students to gain UArizona credit.</p>																																											
What is the University's Advantage and/or Anticipated Funding Opportunities?	<p>The university has established programs in science communications training for graduate students and faculty, experiential learning, and cross-disciplinary collaboration, with strong ties and programs supporting Hispanic and Indigenous communities. This program will be expanded and adapted to undergraduate students. New internship programs will place students in paid positions in the community where they can test potential careers while providing valuable service to local organizations. UArizona also supports several programs that train teachers to bring STEM into K-12 classrooms and is developing a series of environment-focused dual enrollment classes that will allow high school students to gain UArizona credit and familiarity with the many paths an environmental degree can follow.</p>																																											
Is there an Arizona Specific Benefit or Impact?	<ul style="list-style-type: none"> ● Provide increased opportunities for resilience-focused experiential learning through courses and internships ● Increase the number of students engaging in resilience-related training ● Increase the number of students from underserved populations engaged in environmental and resilience-focused programs ● Increase involvement by junior faculty in applied resilience-focused research that engages with communities, strengthening ties between the university and Arizona communities ● Increase the scientific and technical knowledge of Arizona communities through greater engagement with university students and faculty 																																											
Investment Detail	<table border="1"> <thead> <tr> <th></th> <th>2022</th> <th>2023</th> <th>2024</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Infrastructure</td> <td>575,939</td> <td>403,353</td> <td>403,353</td> <td>1,382,645</td> </tr> <tr> <td>Basic Research</td> <td>43,146</td> <td>129,439</td> <td>129,439</td> <td>302,024</td> </tr> <tr> <td>Applied Research</td> <td>302,025</td> <td>302,025</td> <td>302,025</td> <td>906,075</td> </tr> <tr> <td>Development</td> <td>43,146</td> <td>129,439</td> <td>129,439</td> <td>302,024</td> </tr> <tr> <td>Total</td> <td>964,256</td> <td>964,256</td> <td>964,256</td> <td>2,892,768</td> </tr> </tbody> </table>					2022	2023	2024	Total	Infrastructure	575,939	403,353	403,353	1,382,645	Basic Research	43,146	129,439	129,439	302,024	Applied Research	302,025	302,025	302,025	906,075	Development	43,146	129,439	129,439	302,024	Total	964,256	964,256	964,256	2,892,768										
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Arizona Board of Regents

Technology and Research Innovation Fund (TRIF) Program Progress Report

University:	University of Arizona
TRIF Investment Area:	Water, Environmental and Energy Solutions
Program Name:	Fostering Leaders in Resilience

2022 Progress Summary:

In order to foster leaders in resilience, we spent this year engaging students in collaborative research on the effects of heat on livestock and other organisms; creating opportunities for undergraduate students to lead research projects on household energy used for cooling in the state of Arizona; facilitating EMPOWER STEM bootcamps, an office of Naval Research funded program that gives undergraduates hands-on experience working with next-generation printable electronics; and providing opportunities for student engagement with software and emerging technology in a working environment to create software-based solutions to research questions.

Some milestones include the following:

- The first cohort Diana Liverman Scholars, including 15 undergraduates from disciplines such as music, neuroscience, fine arts, environmental science, and American Indian studies, worked with community partners to grow their environmental communication and storytelling skills. The program is designed to build skills including collaborative decision-making, problem-solving, effective communication, and connection to community.
- University of Arizona graduate students spent time in a Southern Arizona border community working on farm and ranch rehabilitation projects in partnership with a local NGO and high school students. The resulting place-based narratives produced by the students advocate for and articulate the importance of human and natural ecosystems in the region.
- The Roots for Resilience program, co-led by the Arizona Institute for Resilient Environments and Societies, CyVerse, and the Arizona Data Science Institute, continued to train graduate students in the use and application of open science, computational infrastructure, and data science tools to their research question. To date, the program has trained 37 students from 15 departments.

Investment Detail

	2022	2023	2024	Total
Infrastructure	0	0	0	0
Basic Research	0	0	0	0
Applied Research	135,024	705,655	705,655	1,546,334
Development	133,019	695,177	695,177	1,523,373
Total	268,043	1,400,832	1,400,832	3,069,707

Performance Measures

	2022	2023	2024	Total
Faculty Startup Package Expenses	0	215,732	215,732	431,464
Postdocs Supported	3	5	5	13
Graduate Students	55	30	30	115
Undergraduate Students	15	15	15	45
Sponsored Project Funding	2,973,345	5,666,667	5,666,667	14,306,679
Publications in Academic Peer-Reviewed Journals	15	5	5	25
Startups	0	0	0	0