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

## Five-Year Project Plan

## July 1, 2016 through June 30, 2021

NORTHERN ARIZONA UNIVERSITY

# Table of Contents

# Section 1: Introduction

## Contents

# 1. Introduction

## 1.1 Executive Summary

Northern Arizona University (NAU) has long been recognized for impactful research in forest management and environmental sciences, astronomy and planetary science, and biosciences and biotechnology. The work done in these fields provides a strong research foundation to advance creativity and collaboration, and enhance NAU's leadership position within the Northern Arizona community.

The establishment of the Technology and Research Initiative Fund (TRIF) has helped the university expand on these key research strengths—driving innovation and discovery, and creating new knowledge that improves life quality in the region and beyond. The implications are far-reaching, affecting workforce and economic development, social welfare, environmental stewardship, and more.

Northern Arizona University's proposed Five Year TRIF Project Plan continues to build on the impact and successes of the past 15 years of the program. In addition to continuing programs in *Access and Workforce Development, Improving Health (iHealth), and Water, Environmental and Energy Solutions (WEES)*, this Plan includes significant investments in two new initiatives—*Exploring Planetary Systems* and *National Security Systems*, addressing all five research areas under the Arizona Higher Education Enterprise Technology and Research Initiative Fund.

The addition of these two new initiatives is possible due to our success in generating returns on investment across WEES and iHealth, and their precursors, over the past fifteen years, and based on increased research capacity recently acquired and developed in cybersecurity and computational sciences, and in Astronomy. This increased capacity is demonstrated through the recruitment of a significant number of new research-intensive faculty, and through the development of interdisciplinary PhD programs in Informatics, Astronomy and Bioengineering. We will apply proven strategies for investing TRIF funding across all four research initiatives, generating external funding, commercializing research outcomes, and training large numbers of undergraduate and graduate students. By producing a skilled workforce, we will help to attract and retain businesses in the state, while innovating for the creation of new business endeavors led by our graduates and faculty.

Under all of its FY17 – FY21 TRIF initiatives, Northern Arizona University will pursue scientific discoveries and cutting-edge technology developments that will (a) train undergraduate and graduate students for a knowledge-based workforce in Arizona, (b) transfer new knowledge and technology to Arizona companies to improve their economic competitiveness, and (c) continue to increase external funding to support our mission and stimulate the Arizona economy. In addition, we will serve rural and urban communities throughout Arizona, providing opportunities for all Arizona citizens to reach their educational goals.

**Water, Environmental, and Energy Solutions (WEES).** Northern Arizona University's programs under the WEES initiative are based on the understanding that Arizona's natural resource base drives the viability of key economic activities of tourism, farming, ranching and recreation. WEES supports rigorous scientific research, sound scientific and technical

assistance, and information transfer to landowners, managers, and stakeholders. NAU's efforts under the WEES initiative help to minimize the risks of catastrophic wildfires and rebuild a strong forest products economy in Arizona, maintain affordable and secure water resources across the state, and resolve multiple-use conflicts through collaborative planning and analysis.

**Improving Health (iHealth).** Northern Arizona University's efforts under the *Improving Health (iHealth)* initiative expands Arizona's biosciences economy by building increased research capacity in the biosciences/bioengineering and health research areas. Our research programs in health and the biosciences directly affect Arizonans through hospitals and healthcare institutions, medical technology industries, and by addressing healthcare disparities for underserved populations (Native American, Hispanic, and rural poor). The resulting solutions and discoveries are translated into economic activity through healthcare practice, workforce development, and technology transfer.

**National Security Systems.** Banking, health care, energy, travel, and manufacturing are just some of the industries that require (a) increasingly more secure means of protecting data and thwarting deliberate attempts to disrupt computer networks, (b) ever more sophisticated approaches to safeguarding computing systems operations, and (c) a more cyber-savvy workforce. We see this growing need as a core national security priority that will affects thousands of Arizona businesses in the coming decade. Cutting edge research in this area will be needed in real time, and a highly qualified and dynamic workforce will be necessary to meet these challenges.

**Exploring Planetary Systems.** Northern Arizona University's investment in *Exploring Planetary Systems* will leverage the state-of-the-art astronomical resources found in Northern Arizona to prepare a workforce with unique skills that will strengthen Arizona's stature as a worldwide leader in astronomy and planetary science research. Institutions in Arizona employ approximately 2,000 people in this field, with a payroll exceeding $84 million. Under this initiative, NAU post-docs and graduate students will develop cutting-edge skills that will prepare them for high-paying positions in Arizona. A key aspect of our program under this initiative will include a specialization in the development and commercialization of customized instruments that will be sought after by astronomers and planetary sciences worldwide for use on Cubesats—miniature satellites now used for many aspects of space research.

**Access and Workforce Development.** The Northern Arizona University Access and Workforce Development (A/WD) initiative addresses the needs of Arizona employers and their current and future employees in the areas of Education and Health Sciences in response to the 2025 ABOR Strategic Goals. The initiative includes the development and delivery of courses and degree programs to support health and education fields, and the use of technologies to increase student achievement, accelerate student progress through degree completion, and enhance efficiency across university courses and programs.

Investments from Proposition 301, passed by the voters in 2000, through the Technology Research Initiative Fund have had a dramatic impact on Northern Arizona University's Extended Campus and research enterprise—providing direct economic benefit through advances in science, workforce training, and access to a higher education for all Arizonans.

## 1.2 University mission/goals/values

**Mission**
Our academic programs, research, public service, and creative endeavors enrich lives and create opportunities in Arizona and beyond. We develop solutions to challenges and drive innovation in a supportive, inclusive, and diverse environment.

**Vision**
Rigorous programs and pioneering research with substantial community impact provide the foundation for transformational student opportunities that prepare graduates to excel in creating a sustainable future, nationally and globally.

- NAU is distinguished for its quality of teaching, focusing on student-centered learning experiences in creative environments and for its dynamic research. We challenge students to adapt and respond to evolving social pressures and global issues.

- NAU is celebrated for its personal and transformational relationships that enhance educational opportunities. We empower students to succeed by ensuring accessibility and inclusiveness of diverse experiences and backgrounds.

- NAU is renowned for its national and global leadership and service as our graduates guide the world toward a vibrant future, creating cultural vitality, superior education, improved public health, and positive economic outcomes throughout our communities.

**Strategic Goals**
- Student Success: Promote high levels of student access, engagement, achievement, and affordability.

- Nationally Recognized Research Excellence: Expand the boundaries of knowledge to improve lives.

- Global Engagement: Advance the internationalization of the university to prepare students for global citizenship.

- Diversity, Civic Engagement, and Community Building: Promote issues of diversity, civility, democracy, citizenship, and community engagement and collaboration.

- Commitment to Native Americans: Become one of the nation's leading universities serving Native Americans.

- Sustainability and Effectiveness: Exemplify a sustainable, innovative, and effective university community.

**Institutional Values**
- Excellence in Education—Offer a rigorous, high-quality education to all students

- Student Success—Place learner needs at the center of our academic and service planning, policies, and programs.

- Educational Access—Provide all qualified students with access to higher education.

- Diversity—Achieve multicultural understanding as a priority of educational and civic life.

- Integrity—Operate with fairness, honesty, and the highest ethical standards to sustain a community of trust.

- Civility—Support a civil, engaging, and respectful campus climate.

### 1.3 Outcomes

The goal of the Technology and Research Initiative Fund is to stimulate Arizona's knowledge-based economy by supporting innovation, entrepreneurship, research and development, and workforce development, as well as the infrastructure needed to advance in these areas. The capacity of TRIF activities to accomplish this goal is measured through the generation of a set of deliverables in three primary areas:

**Financial Impact: Sponsored awards; gifts and external funds from other sources; intellectual property income.** TRIF funds are leveraged to attract external funds from the Federal government, industry and other public and private sponsors from outside of the State of Arizona. These funds are spent by the university on local goods and services needed to conduct the work, and to pay wages to students and employees who pay income and sales taxes, thereby stimulating the local economy. Over the past 9 years (2007 – 2015) that financial impact of TRIF research initiatives has been measured in leveraged funding, Northern Arizona University has generated more than $1.50 for every TRIF dollar spent on research, or $94.6 million dollars in external grants, contracts and gifts.

**Technology Transfer Activity: Invention disclosures transacted; U.S. patents issued; licenses and options executed; start-up companies.** The four technology transfer deliverables represent stages of technology commercialization and are among the major goals envisioned by the TRIF program. These outcomes have the potential to generate economic activity, create jobs, and benefit Arizonans through the introduction into the commercial marketplace of new devices, drugs and other innovations that improve lives. In addition, the revenue received by the university through licensing of new technologies is invested back into the university research enterprise.

**Workforce Contributions: Post-doctoral scholars; graduate students; undergraduate students.** Many activities funded by TRIF at NAU enable faculty to engage post-docs, graduate and undergraduate students in advanced research and development activities that enhance their technical skills and make them more competitive job seekers. Thousands of NAU students, K-12 teaching professionals, community college students, tribal professionals and other community-based stakeholders have received advanced training and valuable professional and technical skills through the university's TRIF programs in research and workforce development.

Other important outcomes of NAU's TRIF activities are partnerships and collaborations with public and private organizations. Under this five-year plan, we aim to build new and stronger relationships across all four Research initiatives. Under *Improving Health*, we will build upon growing partnerships with Northern Arizona Healthcare (parent company of Flagstaff and Verde Valley Medical Centers), North Country Health Care and its Cancer Center, the Northern Arizona Regional Behavioral Health Authority Institute, and others to increase research collaborations and build capacity to conduct clinical trials. Under *Water, Environmental and Energy Solutions*, long-term partnerships with federal government entities such as the USGS, National Park Service, U.S. Forest Service and the Bureau of Land Management will continue to generate environmental, economic and social wellbeing improvements for stakeholders across the rural portions of the State. Under *Exploring Planetary Systems,* we will partner with Lowell Observatory, the USGS, United States Naval Observatory, the Naval Research Laboratory, the Naval Precision Optical Interferometer, and the Discovery Channel Telescope to study the origin and evolution of planetary systems through telescopes. Finally, under NAU's *National Security Systems* initiative, we will build upon existing partnerships with our sister institutions as well as develop collaborations with industry partners to conduct and translate cutting-edge research and build a highly-skilled workforce that can address the computing and cybersystems challenges of the 21st Century.

### 1.4 Budget (All Initiatives)

## Northern Arizona University

TECHNOLOGY AND RESEARCH INITIATIVE FUND (TRIF)

| FINANCIAL SUMMARY | Budget FY 17 | Budget FY 18 | Budget FY 19 | Budget FY 20 | Budget FY 21 |
|---|---|---|---|---|---|
| **REVENUE** | | | | | |
| TRIF Revenue | 13,659,200 | 14,459,200 | 15,259,200 | 16,059,200 | 16,859,200 |
| **TOTAL** | **13,659,200** | **14,459,200** | **15,259,200** | **16,059,200** | **16,859,200** |
| **EXPENDITURES** | | | | | |
| OPERATING BUDGET | 11,883,200 | 12,435,200 | 12,665,200 | 13,008,200 | 13,487,200 |
| CAPITAL BUDGET | 1,776,000 | 2,024,000 | 2,594,000 | 3,051,000 | 3,372,000 |
| **TOTAL** | **13,659,200** | **14,459,200** | **15,259,200** | **16,059,200** | **16,859,200** |
| **SUMMARY BY INITIATIVE** | | | | | |
| AWD | 4,510,000 | 4,556,000 | 4,602,000 | 4,648,000 | 4,694,000 |
| AZUN | 500,000 | 505,000 | 510,000 | 515,000 | 520,000 |
| Water, Environmental and Energy Solutions | 2,100,733 | 1,348,167 | 2,267,503 | 2,738,905 | 3,369,423 |
| Improving Health | 1,949,827 | 2,275,585 | 2,191,793 | 3,201,053 | 3,220,755 |
| National Security Systems | 4,376,957 | 3,465,588 | 3,394,525 | 2,335,607 | 1,377,873 |
| Space | 221,683 | 2,308,860 | 2,293,378 | 2,620,635 | 3,677,149 |
| **TOTAL** | **13,659,200** | **14,459,200** | **15,259,200** | **16,059,200** | **16,859,200** |

NAU's TRIF operating and capital budgets align with the ABOR Enterprise Strategic Plan and the 2025 Enterprise metrics supporting that plan. The budgets are planned to dedicate an increasing amount to one-time capital throughout this five year plan as a way to build NAU's research and program capacity within these key initiatives through the renovation and construction of new labs and facilities. These capital investments will support NAU's continued growth in research and public service expenditures and in further expanding key program areas in the high demand fields of Health Professions, STEM, and Education. The specific investment decisions as whether to renovate, versus add new space will be made in context of maximizing the impact of these investments within the context of NAU's overall space management strategy.

### 1.5 Marketing/Communication overview

As part of the outcomes that we generate from the five TRIF initiatives outlined in this introduction, we will develop and execute marketing and communications strategies to raise awareness of TRIF initiatives and outcomes. All marketing and communications materials will report our progress toward each goal, returns on investments from external grant funding, describe new discoveries and their translations through commercial use, highlight workforce training successes, and emphasize associated economic growth across the State.

We will carry out this communications and marketing activity with the goal of reaching Arizonans and demonstrating how the TRIF money is being used wisely for the good of the citizens of State. We will demonstrate the effectiveness of our TRIF investments in the following ways:

- We will create a TRIF website at NAU that will provide regular updates on TRIF successes and progress toward major goals. These updates will cover research discoveries, technology innovations, workforce growth, economic developments, and new metrics that will be readily accessible for viewers coming onto the website. We will promote the website through different tactical efforts to drive visitors to the website to learn more about the work. This will include using publications, social media, news coverage, and other mediums as appropriate. In addition, we will track website visits to measure the success of communications efforts and make adjustments according to the findings.

- We will provide stories for news outlets that highlight TRIF supported successes that impact the region and state economy. We will track the success of these placements using analytics and make adjustments as needed to ensure the message is being successfully distributed.

- We will incorporate these stories in specialty publications and presentations, targeting a broad audience of influencers including potential financial partners, government and business leaders, community advocates and citizens, and more as appropriate. Specific venues may include NAU Campus Forum presentations, ABOR updates, NAU Annual Reports, Alumni or other specialty magazines, etc.

- We will use social media to create excitement and present information on how TRIF investments are leading to economic growth and new jobs. These updates will be aligned with other university marketing and communications efforts to ensure the greatest impact in the marketplace.

- We will report regularly to ABOR and other venues on TRIF supported discoveries and new workforce training initiatives that improve the quality of Arizona's workforce.

### 1.6 University Administration of TRIF

**Research.** Northern Arizona University's five Research-focused TRIF initiatives are coordinated through the Office of the Vice President for Research. As the institution's senior administrator with primary responsibility for research, the Vice President for Research (VPR) has overall administrative responsibility for developing, facilitating and stimulating research activity at NAU, for enhancing and managing external funding, and for determining the strategic direction of the university's research enterprise. In that capacity, the VPR is well-positioned to provide leadership in the planning and implementation of this Plan.

The Office of the VPR provides the necessary infrastructure to manage and allocate TRIF funds and coordinate programs through numerous investment mechanisms across the four initiatives. Senior staff, including the Associate Vice President for Research and Director of Technology Transfer, share responsibility for managing the TRIF program by providing direct oversight of the use of TRIF funds by research centers and individual faculty, providing technical and administrative assistance to the recipients of TRIF-funded awards, and by monitoring and reporting on outcomes annually.

TRIF budgetary oversight is provided by the Office of the Vice President for Research and the NAU Office of Budget and Planning.

**Access and Workforce Development.** Programmatic oversight for A/WD is in the Extended Campuses division with the Vice President for Extended Campuses directly responsible for the activities. By integrating the initiative into ongoing Extended Campuses operations, sustainability is ensured. For FY17 the Extended Campuses enterprise has a proposed budget of $37M, including $3.6M in TRIF dollars.

Programmatic responsibility for the e-Learning Center is in the Office of the Provost reporting to the Vice Provost for Academic Affairs. The e-Learning Center provides expert learning design, educational graphics and creative design, learning technology implementation and services, and training support for all faculty members at NAU, regardless of location.

# Section 2: Water, Environmental and Energy Solutions

## 2. Water, Environment and Energy Solutions (WEES)

### 2.1 Investment description/rationale/justification

Arizona's identity as a state is deeply rooted in its rural landscapes and multicultural heritage. Our citizens draw inspiration and pride from our collective sense of place. Preservation of the state's natural beauty, combined with prudent management of the state's natural resources, are therefore crucial goals for economic growth and social achievement.

Through the TRIF investment in the Water, Environmental and Energy (WEES) research initiative, Northern Arizona University is generating outcomes that contribute to economic and societal advances for the state of Arizona. Research conducted under WEES contributes to our understanding of Arizona's natural resource base that drives the viability of key economic activities including tourism, farming, ranching, forestry, and recreation. Through WEES, NAU is developing solutions that (a) generate new technologies to drive the state's economic growth engine; (b) lead to better stewardship of our natural resources including water, wind, solar energy, and forests; and (c) produce future leaders for Arizona's technology-driven and knowledge-based economy.

#### 2.1.1 Brief overview of industry or area being addressed by the initiative to include benefit to Arizona.

The WEES initiative impacts multiple industries and economic components of the State of Arizona. Research conducted under this initiative will affect the management of rangelands in response to environmental change and the impact of people on natural ecosystems. The research and restoration work that we do in forestry, and through the Four Forest Restoration Initiative, supports the revival of the forest products industry in Arizona. Science-based thinning and restoration practices minimize the chance of catastrophic wildfire all across the state; the economic impact of the mitigation of risk of catastrophic fire is often overlooked. One only has to understand the economic impact of catastrophic wildfire to understand that preventing such fires has a major positive an impact on the economy of Arizona. Work done under WEES will also bring strong scientific support to public deliberation of land use and management, through the development of new tools for visualizing current conditions and the expected outcomes of proposed state-wide policies.

#### 2.1.2 Discussion of mission, goals, values and vision.

**Mission**: Through the WEES initiative, Northern Arizona University facilitates economic opportunities for the residents of Arizona around sustainable environments and effective resource management. **Vision**: We are stewards of the state's vast and unique ecosystems—deserts, grassland, high-elevation forests, and rangelands—preserving their beauty, accessibility, and economic value while providing high-quality livelihoods and economic opportunities for Arizona citizens.

**Values**: Northern Arizona University brings a core set of values for achieving this vision:

- A commitment to the use of rigorous scientific research methodology and investment in technology and infrastructure befitting an institution that is nationally recognized for research excellence in environmental and ecosystem sciences.
- A responsibility to promote community engagement in innovative research programs and to translate important discoveries for landowners, sustainability industries, and community stakeholders.
- A belief that interdisciplinary teams will best address today's technical, economic and environmental challenges.
- A conviction that sustainability is a crucial aspect of the university's research endeavors to maintain and grow the economic, cultural, and environmental future for the state's citizens.

**Goals**: Our specific goals include the following:

- Leveraging NAU's existing research and intellectual assets to generate external funds.
- Creating curricular innovations related to key workforce needs in the state and region.
- Catalyzing an entrepreneurial spirit among university faculty and students.
- Building and strengthening partnerships with environmental and land management groups across Northern Arizona.
- Generating new environmental business opportunities and jobs in the region.

### 2.1.3 Description of programmatic investments.

The investments under the WEES initiative at NAU are currently focused on two areas: *Adapting to a Changing Environment (Environmental Sciences)*, and *Forest Health and Land Management (Forest & Land)*. These programs build on NAU's historical strengths in environmental and ecosystem sciences.

Under *Environmental Sciences*, NAU makes investments in two Research Centers: The *Center for Ecosystem Science and Society (Ecoss)* and the *Merriam-Powell Center for Environmental Research (MPCER)*. Researchers in *Ecoss* investigate the interactions of biological communities—from single cells to the entire globe—how they both respond to and influence environmental change. Ecoss also prioritizes the training of future scientists and disseminating information about their discoveries to the public. *Merriam Powell* has been instrumental at NAU in advancing cross-disciplinary environmental research and training with a focus on the Colorado Plateau. It also generates the scientific knowledge needed to address significant environmental challenges in the Southwestern United States.

Under *Forest & Land*, NAU invests in two key land management research centers: *The Ecological Restoration Institute (ERI)* and the *Landscape Conservation Initiative (LCI)*. Investments in the ERI support the development of solutions to the costly environmental problems of degraded forest health and unnatural wildfire. Losses of city and county revenue from decreased tourism, short-term job losses, damage to water supplies, and the emotional devastation experienced by those who live through catastrophic wildfire are just some of the economic impacts that ERI's work seeks to alleviate. Additionally, past TRIF investments in ERI have enabled NAU to provide training in restoration science, including fieldwork experiences, to hundreds of graduate and undergraduate students.

Through investments in the LCI, NAU applies bioscience research, community-based planning, and field training to forge alliances among ranchers, industries, and environmental researchers. In partnership with a spinoff, Conservation Science Partners, and other stakeholder groups, LCI provides science-based and community leadership for addressing emerging broad-scale conservation and environmental challenges in the Grand Canyon region and across the West.

## 2.2 Expected Outcomes as a result of TRIF investments

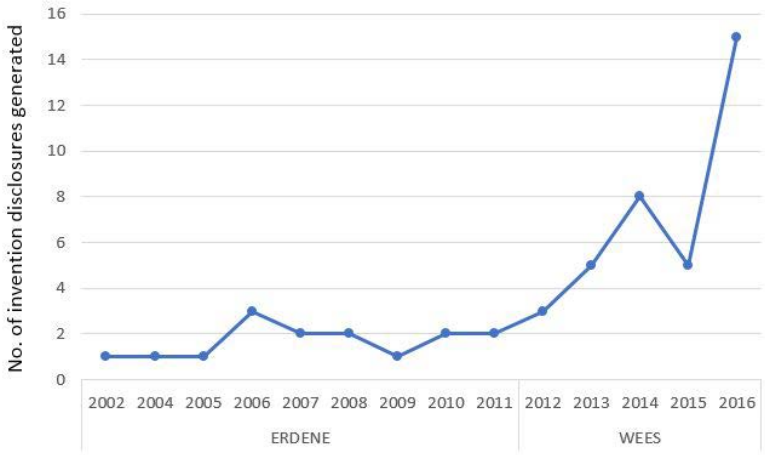
Researchers supported by the TRIF WEES initiative will continue to discover new knowledge and disseminate that knowledge through scientific publications, public seminars, and undergraduate and graduate students trained. Researchers will leverage TRIF support with external funding which will allow them to engage more students in lab research and fieldwork as well as further their own scientific and translational objectives. The Ecological Restoration Institute (ERI) provides a strong example of how resources are mobilized at the university to generate outcomes that have a huge impact on the economy of Arizona. ERI assists land management agencies and communities by providing comprehensive focused studies, monitoring and evaluation research and technical support—the outcomes of which are the restoration of Arizona forests in ways that mitigate the effects of catastrophic wildfire.

### 2.2.1 Specific and realistic goals that are clearly measureable

**2.2.1.1 Return on investment**: We anticipate that the investment mechanisms targeted for WEES will enhance researchers' ability to successfully compete for external funding, leading to increased proposal submissions and awards and, conservatively, a 20% or higher increase in external research funding for WEES areas over the five years of this Plan. Northern Arizona University's past performance with respect to the financial impact of WEES investments is consistent with this projection. For example, between FY12 and FY14, NAU invested an average of $2.4 million annually in the WEES initiative. **In FY15 alone, however, the financial impact (external funds generated) of these investments was $14 million.**

**2.2.1.2 Technology Transfer:** Over the past five years, NAU has put a greater emphasis on TRIF investments that would generate innovations. As shown in the chart below, the result of this shift has been significant increases in

invention disclosures transacted over the previous 10-years (investments made through Environmental Research, Development and Education for the New Economy).




Between FY17 and FY21, NAU will place an even greater emphasis on making investments in WEES that will leverage external funding and generate technology transfer outcomes. We anticipate that strategic and targeted investments in new research-intensive faculty, Post-doctoral Research Scholars, and research infrastructure will result in a similar trend over this business cycle.

**2.2.1.3 Industry Engagement (outreach, partnerships, collaboration)**
**N/A**

**2.2.1.4 Workforce contributions**: We will prepare students and postdoctoral researchers for careers in high demand STEM fields through direct engagement in research activities funded through the WEES initiative. We anticipate providing such experiences to 150 or more undergraduates in each of the first two years of this cycle. We will reach higher numbers of undergraduates in subsequent years. These investments are anticipated to increase enrollment, retention, and degrees awarded in high demand fields by greater than 24%.

**2.2.1.5 Educational outreach.** Through the WEES initiative, Northern Arizona University will partner with state and federal forest services, Arizona Game and Fish, and non-profit organizations to provide students with research experiences on public lands located throughout the Colorado Plateau. In addition, Northern Arizona University has recently formalized an agreement with Diné College that will increase collaboration between the institutions and generate research opportunities for Diné students in the areas of land use, basic ecological research and resource management. Diné students may be able to participate in WEES-supported programs and short-courses through the Landscape Conservation Initiative, such as the Grand Canyon

Semester, Tools for Evaluating Populations and Habitats, and the Field and Laboratory Infrared Spectroscopy Workshop.

**2.2.1.6 Government Agency/Community Engagement (outreach, partnerships, collaboration):** Northern Arizona University has an active, productive partnership with the Southern Colorado Plateau Network (SPCN) of the National Park Service, located on the NAU campus. NAU works collaboratively with the SCPN to understand natural resource conditions and to communicate this understanding to the citizens of Arizona and the nation. The SPCN serves 19 national parks, including the Grand Canyon, the Petrified Forest, and Sunset Crater Volcano. The goals and objectives of SCPN are well-aligned with NAU's continuing commitments to research training and development.

Northern Arizona University also partners with the United States Geological Survey (USGS) to cooperate in scientific research, monitoring, education and interpretive activities related to the conservation and management of the natural and cultural resources of the Department of Interior, State of Arizona, and the Colorado Plateau. USGS personnel give guest lectures at NAU, serve on graduate student committees, and provide field experiences for NAU students.

### 2.2.2 Annual metrics table of expected outcomes and timeline for achievement

**NORTHERN ARIZONA UNIVERSITY**
Water, Environmental and Energy Solutions

| PERFORMANCE MEASURES | Projected FY17 | Projected FY18 | Projected FY19 | Projected FY20 | Projected FY21 |
|---|---|---|---|---|---|
| **TRIF EXPENDITURES** | | | | | |
| Total | 2,100,733 | 1,348,167 | 1,536,332 | 2,738,905 | 2,249,712 |
| **FINANCIAL IMPACT OF TRIF INVESTMENT** | | | | | |
| Sponsored Awards | 3,151,100 | 2,022,251 | 2,304,498 | 4,108,358 | 3,374,568 |
| Gifts & Other Sources | 157,555 | 101,113 | 115,225 | 205,418 | 168,728 |
| Intellectual Property Income | 8,333 | 9,375 | 23,438 | 0 | 0 |
| **TOTAL** | **3,316,988** | **2,132,738** | **2,443,160** | **4,313,775** | **3,543,296** |
| **TECHNOLOGY TRANSFER ACTIVITY** | | | | | |
| Invention Disclosures Transacted | 8 | 9 | 10 | 12 | 13 |
| US Patents Issued | 0 | 0 | 2 | 2 | 2 |
| Licenses and Options Executed | 1 | 1 | 1 | 0 | 0 |
| Startup Companies | 0 | 0 | 0 | 0 | 0 |
| **WORKFORCE CONTRIBUTION** | | | | | |
| Postdoctoral Appointees | 2 | 4 | 5 | 5 | 4 |
| Graduate Students | 15 | 20 | 25 | 30 | 35 |
| Undergraduate Students | 150 | 150 | 200 | 200 | 200 |

## 2.3 Initiative Structure

### 2.3.1 Organizational structure

Northern Arizona University's Vice President for Research (VPR) oversees the implementation of all TRIF-supported research initiatives. The Associate Vice President for Research (AVPR) and the Executive Director (ED) of the Office of the VPR jointly manage the five TRIF-supported initiatives; they advise and report directly to the Vice President. They are supported by an internal advisory committee of faculty (two for each initiative), directors of research centers in bioscience, health, and engineering and individual faculty in departments carrying out key research projects that support the mission and goals of the five initiatives. TRIF budgetary oversight is provided by the Vice President's office and by the NAU Office of Budget and Planning. Research centers that receive support through the TRIF program report to the Deans of Colleges (currently, all such centers are organized under the College of Engineering, Forestry and Natural Sciences).

NAU Innovations, the university's technology transfer program, resides within the Office of the Vice President for Research. NAU Innovations has an Advisory Board that includes (but is not controlled by) university representatives and members from the Phoenix and Tucson areas with expertise in technology transfer and experience commercializing emerging technologies and creating start-up companies.

### 2.3.2 Advisory Board

Northern Arizona University has assembled a TRIF Research Advisory Board comprising leaders from across the state whose perspective will help to shape TRIF investments in strategic priorities. Members of this Advisory Board have been chosen from such areas as economic development, banking, aerospace, biotechnology, philanthropy, and astronomy. The group will meet annually with the NAU President and Vice President for Research to (a) review overall direction and the productivity of the TRIF investments in research, (b) provide perspective on the most strategic directions for future investment, and (c) advise the university on sustainability of programs beyond TRIF support.

### 2.3.3 Infrastructure

The WEES initiative is supported by multiple research centers and multiple departments with active researchers. The initiative is further supported by appropriate lab resources, computing resources, and research core facilities. Academic departments support this initiative with graduate programs through which PhD students are trained and mentored to become active contributors to the state's economic development.

### 2.3.4 Description of investment mechanisms

Northern Arizona University is making a number of targeted short-term and one-time investments across all TRIF initiatives under this five-year plan.

**Operational Support for Centers:** Over the past 15 years, NAU has invested TRIF funds to seed a number of research centers. These units provide support for interdisciplinary research that complements the resources provided through academic departments. Such centers foster greater interdisciplinarity efforts across academic units and institutions, generate significant external research funding, provide undergraduates with meaningful employment opportunities, and provide the specialized and intensive research training that NAU graduate students need to complete their master's and doctoral programs. Over the past fifteen years, Northern Arizona University has invested significant TRIF funds in currently-active research centers, such as the Ecological Restoration Institute, the Merriam Powell Center for Environmental Research, the Center for Microbial Genetics and Genomics, and others. These funds are intended to give the centers time to establish their research programs and collaborative efforts, and to build up additional funds from recovered indirect costs. Centers are expected to generate financial returns on these investments many times over. For example, NAU established the Center for Ecosystem Science and Society with a $1 million investment in TRIF dollars over the period July 1, 2013 to the present. That center has thus far generated $3.9 million in extramural funding over the same period. During FY17-21, NAU will support existing research centers and anticipates establishing one or two new centers that will be supported under one of the four TRIF research initiatives.

**New Faculty Start-up Resources:** Northern Arizona University recognizes that, in order to increase the overall economic impact of its research enterprise, we need to facilitate the research success of our faculty. One way we are doing this is by providing the financial resources that all new faculty need to succeed—to start and grow a new research program (for faculty just starting their careers) or to transfer and grow an established research program (for faculty coming to NAU from other academic institutions). Investing TRIF funds to support new faculty enables the university to provide competitive salaries and start-up packages to attract the best, most productive researchers whose work addresses NAU's strategic research priorities. Such support is limited to two or three years, after which time faculty are expected to support their research through external grants.

**Support for Post-doctoral Research Scholars:** Post-doctoral Research Scholars ("Post-docs") play a key role in university research programs. They manage research projects on behalf of their faculty mentors, train graduate and undergraduate students, and write grant proposals and scholarly articles—all while developing the professional networks and skills necessary to succeed in their chosen field. Since 75% of Post-docs do not enter academia, the vast majority of Post-docs are developing the skills needed to land jobs in industry and not-for-profit institutions (*Fonseca-Kelly, Darwin, Operario, Finger and Baucum. 2010. The Role of Post-docs, PIs and Institutions in Training Future Scientists,* *http://www.asbmb.org/asbmtoday/asbmbtoday_article.aspx?id=9198*)

Between FY17 and FY21, we will invest TRIF funds to hire up to twenty-five (25) Post-docs (for 2-3 year appointments) who will bring new technical capacities and/or expertise (that does not currently exist at NAU) to expand current research and research training capacities across all initiative areas. Post-docs funded in this manner are extremely productive as they are able to work across all faculty researcher's projects, unlike Post-docs that are funded on a specific externally-funded research project. In addition, these Post-docs write grant proposals and enable the faculty researcher to write and submit more grant proposals than s/he would otherwise be able to produce. The hiring of Post-docs is expected to increase inter-institutional collaboration between NAU and their prior PhD-granting institutions; a second potential link may be created between NAU and the academic institution, company or other organization to which the Post-docs go at the end of the 2-3 year NAU Post-doctoral appointment.

**Competitive Research and Development Grants:** Under Northern Arizona University's Research Development Grants (RDG) Program, we will invest TRIF funds by providing small grants ($10K - $25K) for planning activities that help to build and solidify interdisciplinary and inter-institutional collaborations for sponsored research opportunities, and to support the generation of preliminary data that can be used to develop competitive research proposals. Faculty researchers are required to demonstrate that they will submit a research proposal to an external sponsor (requesting at least $100,000 in direct costs) as a result of the work conducted under the RDG grant.

**Technology Transfer:** NAU Innovations, the university's technology transfer unit, catalyzes discovery and manages the transfer of research outcomes from Northern Arizona University to the private sector for the benefit of Arizona and the world. Through NAU Innovations, the university provides resources and technical assistance to faculty researchers from the earliest stages of discovery and development, helping to generate and disseminate cutting-edge innovations that can compete in the 21$^{st}$ century marketplace. We will invest TRIF funds to support NAU Innovations across all research initiatives.

**Enhancing Institutional Capacity in Sponsored Projects Administration:** Key to NAU's ability to leverage TRIF funding across all TRIF research initiatives is our ability to significantly increase the number of research proposals submitted to external sponsors and to enhance our ability to manage awards efficiently and effectively. To this end, NAU has recently reorganized its Office of Sponsored Projects (OSP)—the unit responsible for assisting faculty researchers in preparing and submitting external grant proposals and in managing the funds awarded by the external sponsors. We will make a small investment of TRIF funds in FY17 to support the hiring and training of new OSP staff. In FY18 and beyond, increased indirect costs recovered from externally-funded research projects will support these costs.

**MRI Matching Funds:** The National Science Foundation (NSF) provides large grants ($100,000 to $4 million) to universities for the acquisition or development of Major Research Instrumentation through the MRI program. Northern Arizona University

submits two to three proposals (the limit) to this program every year in such areas as Astronomy, Biological Sciences, Chemistry and Mechanical Engineering. The NSF requires the awardee institutions to share 30% of the cost of the entire project, not including personnel costs. Therefore, the investment of TRIF funds as the cost-sharing component to NSF MRI grants generates an immediate return on investment of no less than 2:1. In addition, the acquisition and/or development of such major instrumentation (which, in many cases, would be too costly for the university to acquire) enhances intra- and inter-institutional collaborations, increases our institutional research capacity, provides training opportunities for students and post-docs that make them more valuable in the Arizona workforce, and helps our faculty to be more competitive overall for continuing external project support from the NSF and other federal agencies.

**Research Equipment Acquisition:** The TRIF Research Equipment Acquisition Program (REAP) catalyzes the advancement of research at NAU by providing funds to purchase equipment that extends current research and research training capacity in both laboratory and field investigations and assists investigators in competing for external funding. Faculty are required to demonstrate that equipment will be shared by no fewer than three independent research programs that are aligned with TRIF FY17-FY21 research initiatives and that the research conducted with the equipment will be supported by external grant funding. Equipment purchased under this program has a lower acquisition or development cost ($10K - $100K) than equipment that can be acquired or developed under the NSF MRI program.

**Operational Support for University Research Core Facilities:** University Research Core Facilities (URCFs) support the TRIF research mission by providing a centralized location and cross-campus access to sophisticated and highly specialized major equipment, instrumentation, and services. For example, the scanning and transmission electron microscopes in the Imaging and Histology Core Facility contribute to analysis and characterization of plants, trees, pollen, insects, rocks and soils; the Environmental Genetics and Genomics Laboratory provides high throughput genetics and genomics analysis of plant and microbial DNA, the mass spectrometers in the Analytical Research Core Facility contribute to environmental chemistry, analytical chemistry, and geochemistry; and NAU Greenhouse supports research efforts related to ecology, plant biology, and habitat restoration. The goals of NAU's URCFs are to maximize productivity and quality of NAU-sponsored research and to foster research-intensive learning environments for state-of-the-art student training. Increases in productivity will be measured in papers published, grant proposals submitted and grant awards obtained. TRIF support contributes to maintenance agreements and service contracts for major equipment so that reasonable fee rate schedules can be maintained. This supplementary support protects NAU's TRIF investments in major research equipment, and incentivizes faculty to use such equipment, and to commit time and effort toward obtaining external funding for research and major equipment acquisition.

## 2.4 Initiative budget table (see Appendix Table 2A)

## 2.5 Plan for sustainability

### 2.5.1 Anticipated funding sources for ongoing support

Researchers supported through the TRIF WEES initiative have been successful in garnering federal, state and foundation funding, and will continue to seek external support from all of the following agencies and Foundations:

| | |
|---|---|
| NASA | NOAA |
| National Science Foundation | Department of Agriculture |
| Department of Defense | Department of Energy |
| EPA | Bureau of Land Management |
| USGS | U.S. Forest Service |
| National Park Service | Grand Canyon Trust |
| Arizona Dept of Game and Fish | The Kaplan and Mellon Foundations |

### 2.5.2 Timeline for transitioning away from TRIF support

Sustainability of initiatives and programs funded by TRIF has been a major strength of NAU's TRIF programs. Over the past 15 years of the TRIF program, NAU's research funding from external sources has increased significantly, with federal funds accounting for the majority of this increase. This has been the strategy of all of NAU's TRIF research investments. Because of the uncertainty of the continuation of the TRIF program beyond FY2021, NAU is making primarily short-term and one-time investments with TRIF funds during this final five-year period. For example, investments in new faculty support is commonly only provided for 2-3 years, after which time the faculty member is expected to fund his/her research program with external grants. Therefore, these investments do not require longer-term sustaining. Likewise, investments in post-doctoral research scholars ordinarily take the form of a two-year commitment intended to prepare the scholars for a professional research career and to assist NAU faculty in carrying out preliminary work so that their proposals for external grants will be more competitive. TRIF-funded competitive research grants are short-term in nature (18-months or less) and are intended to provide seed funding so that again, faculty can be more competitive for extramural funding.

We expect that our success at increasing external support of research at NAU will continue. As a result, sustainability of Center support, which will be tapered down to minimal levels during this five-year period, will be made with university funds through increased recovery of indirect costs generated by the extramural funding. In the same way we anticipate that TRIF support of our Technology Transfer program will be replaced by a combination of institutional support (through increased indirect costs) and by royalties and other Intellectual Property income.

# Section 3: Improving Health (iHealth)

## 3. Improving Health (iHealth)

### 3.1 Investment description/rationale/justification

The ability of Arizonans to attain prosperity, individually and collectively, correlates directly with health, which is defined as one's complete state of physical, mental, and social well-being. The ability to achieve and maintain personal health, coupled with the prevention and control of chronic disease, is necessary to allow all citizens of our state to reach their full potential.

Northern Arizona University's efforts under the *Improving Health (iHealth)* initiative contributes to health research outcomes including new discoveries about human health and the translation of scientific knowledge to new devices and interventions that improve healthcare. Investments in *iHealth* also contribute to the state economy by leveraging external funds to increase research, strengthen collaborative relationships between the university and health care partners, and provide workforce training in biomedical fields.

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

Northern Arizona University is committing major TRIF support to infectious pathogen research, healthcare improvements for chronic medical conditions, and bio-engineering innovations. These investments directly affect national security interests, hospitals and healthcare institutions, and medical technology industries across the state. Our investments also target healthcare disparities for underserved populations (Native American, Hispanic, and rural poor). Through the iHealth initiative, NAU will reinforce and strengthen its role in developing biomedical and healthcare advances with multiple industry, non-profit, and university partners. The partnerships, in turn, will result in the development of innovations and translations that improve lives and generate economic activity for the region.

#### 3.1.2 Discussion of mission, goals, values and vision

**Mission:** The Improving Health initiative at NAU leverages research, discovery, and training in health and healthcare-related research, and bioengineering to enhance health, increase the quality of life for Arizonans, and expand and support a growing biosciences economy in Northern Arizona. **Vision:** NAU will become a significant contributor nationally in research on chronic health conditions, healthcare translations for bioengineering innovations, research on pathogen-acquired infections, and improved health equity outcomes for underserved populations. **Values:** Northern Arizona University brings a core set of values for achieving this vision:

- A commitment to the use of rigorous scientific research methodology and investment in technology and infrastructure to respond to modern challenges in human health.

- A responsibility to promote and translate important discoveries for technology innovations around disease prevention, diagnosis, and treatment.
- A belief that interdisciplinary teams will best address today's global health and economic development challenges.
- A conviction that health equity is a crucial aspect of the university's research endeavors to maintain and increase economic prosperity for the state's citizens.

**Goals:** Specific goals of NAU's iHealth initiative include the following:

- Leveraging NAU's existing research and intellectual assets to generate external funds.
- Creating curricular innovations related to key workforce needs in the state and region.
- Catalyzing an entrepreneurial spirit among university faculty and students.
- Building and strengthening partnerships with healthcare providers in Northern Arizona.
- Generating new biotechnology startup enterprises and jobs in the region.

### 3.1.3 Description of programmatic investments

Investments in the Improving Health initiative at NAU will be made in three specific areas: *Bioengineering/Biotechnology, Health Research Initiatives (HRI)* and *Pathogen Genomics.*

Northern Arizona University's program in *Bioengineering/Biotechnology* is supported by the new PhD in Bioengineering and by the Center for Bioengineering Innovations (CBI). The Center and doctoral program share a core of three focus areas for research and development: Biomechanics, Biomaterials, and Biomarkers. Faculty in nine departments, including Biological Sciences, Informatics, Health Sciences, Athletic Training, and Mechanical Engineering, form collaborative interdisciplinary groups to carry out basic and applied research in areas including elite athletic training and evaluation, personal bionics and wearable robotics, rehabilitation, hearing improvement, development of materials and devices for biocompatible implants and sensors, development and validation of biomarkers for human performance and pathology, and identification of biomarkers of human health and disease in underserved populations.

The mission of the *Health Research Initiatives (HRI)* program is to build NAU's capacity to produce nationally recognized translational health research and discoveries in community-based healthcare research, precision and personalized medicine, infectious disease control, and partnership-based clinical research for the diverse populations of Arizona. The HRI program supports a wide range of research into chronic health conditions such as cardiac disease, obesity, dental health, communicative disabilities, hearing impairment, cancer, physical fitness limitations, social and cultural factors limiting hospital services, and wellness training research. Faculty across multiple departments in the College of Health and Human Services,

the College of Engineering, Forestry and Natural Sciences, and the College of Social and Behavioral Sciences work in collaborative, interdisciplinary groups to transform evidence based bioscience and health care applications to improve lives and foster economic growth in Arizona and beyond. A key strategic goal of HRI is to invest in research and workforce training to address healthcare disparities for underserved populations, including Native Americans, Hispanics, and the rural poor.

Pathogen genomics research is primarily carried out through the world-renowned *Center for Microbial Genetics and Genomics (MGGen)*. Major focus areas include the evolution, ecology, and epidemiology of a number of disease causing bacteria spanning from those involved in hospital-acquired infections, to anthrax, plague, and biological warfare agents. Research strengths encompass microbiology, high throughput genetics and genomics analysis, and bioinformatics. Cutting-edge research efforts are also contributing to our understanding of the human microbiome through identification and characterization of the communities of microorganisms of the human gut, sinuses, and skin, for example, which are associated with human health and disease.

## 3.2 Expected Outcomes as a result of TRIF investments

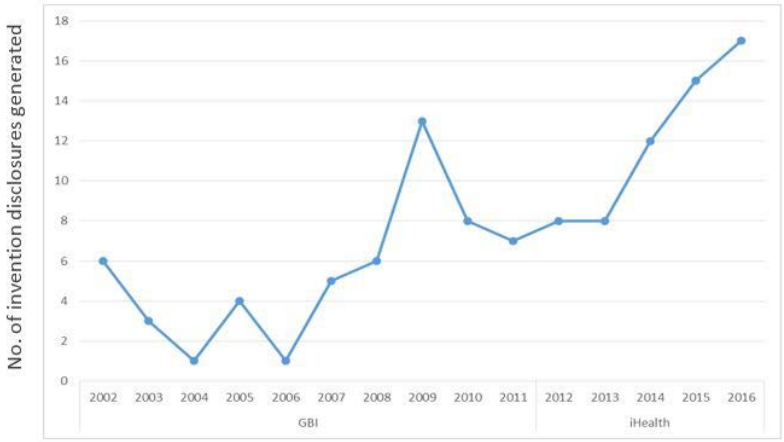
Researchers supported by the TRIF iHealth initiative will continue to discover new knowledge and disseminate that knowledge through scientific publications, public seminars, and through training undergraduate and graduate students. Researchers will leverage TRIF support with external funding to further their scientific and translational objectives. Researchers will continue to participate in a range of professional engagements including offerings of short courses, conferences, workshops, and preparation of white papers and technical reports. Researchers will seek opportunities to translate their research into economically productive innovations with commercial applications.

### 3.2.1 Specific and realistic goals that are clearly measureable

**3.2.1.1 Return on investment.** Investment mechanisms for iHealth will enhance researchers' ability to successfully compete for external funding, leading to, conservatively, a 20% or higher increase in external funding for research in iHealth areas over the five years of this Plan. Northern Arizona University's past performance with respect to financial impact of iHealth investments is consistent with this projection. For example, between FY12 and FY14, NAU invested an average of $1.8 million annually in the iHealth initiative. **In FY15 alone, however, the financial impact (external funds generated) of these investments was $7 million.**

**3.2.1.2 Technology transfer.** Over the past five years, NAU has put a greater emphasis on making TRIF investments that would generate a more focused set of economic outcomes. As shown in the chart below, the result of this shift was significant increases in invention disclosures transacted between (FY11 and FY16) over the previous 10-years (investments made through a related initiative, Growing Biotechnology Initiative).

Between FY17 and FY21, NAU will place an even greater emphasis on making investments in iHealth that will leverage external funding and generate technology transfer outcomes. We anticipate that strategic and targeted investments in new research-intensive faculty, Post-doctoral Research Scholars and research infrastructure will result in a similar trend over this business cycle.




**3.2.1.3 Industry engagement (outreach, partnerships, collaboration).** The iHealth initiative is continuing to strengthen its formal partnerships and collaborative interactions with hospitals, universities, non-profit organizations, and bio-medical companies. All programs within iHealth have multiple partners for collaborations in research and external grant funding. For example, health care partners for the development of health equities research opportunities and research workforce-diversity advancements include Northern Arizona HealthCare (NAH), North Country HealthCare, the Coconino County Health District, the Northern Arizona Regional Behavioral Health Authority (NARBHA) Institute, Coconino County Health District, Navajo Department of Health, and Hopi Department of Health and Human Services.

**3.2.1.4 Workforce contributions.** The investment mechanisms for iHealth will prepare students and postdoctoral researchers for entry into high demand STEM fields. Investments through iHealth will increase professional training experiences for these researchers and increase enrollment, retention, and degrees awarded by greater than 24%, supporting ABOR target metrics for Bachelors, Graduate, and High Demand Degrees.

**3.2.1.5 Educational outreach.** Through the iHealth initiative, Northern Arizona University will partner with companies, hospitals, non-profit organizations, and universities to generate health care solutions for chronic conditions, pathogen acquired infections, socially and culturally driven healthcare constraints, and bioengineering innovations. These objectives will provide numerous student research training and internship opportunities. For

example, with respect to underserved populations, Northern Arizona University has recently formalized an agreement with Diné College that will increase collaboration between NAU and Dine' College and will generate research opportunities for Dine' students in the areas of public health, environmental health, and health equity. NAU is committed to working with Diné College to develop joint admission and 2+2 programs, dual enrollment agreements, integrated academic degree progression plans, faculty exchanges, and collaborative research and scholarly activities among professors and students. All of these activities will train skilled healthcare professionals for underserved populations.

**3.2.1.6 Government Agency/Community Engagement (outreach, partnerships, collaboration).** Northern Arizona University is continuing to strengthen its formal partnerships and collaborations with health care and bioengineering organizations in Northern Arizona. Some current partners include Northern Arizona HealthCare (NAH), North Country HealthCare, the Coconino County Health District, the Northern Arizona Regional Behavioral Health Authority (NARBHA) Institute, Coconino County Health District, Navajo Department of Health, and Hopi Department of Health and Human Services. These relationships provide a growing cluster of community organizations, populations, and health care systems that will generate opportunities for organizing and expanding working relationships with minority and health disparities populations, governmental entities, and other stakeholders.

### 3.2.2 Annual metrics table of expected outcomes and timeline for achievement

**NORTHERN ARIZONA UNIVERSITY**
Improving Health

| PERFORMANCE MEASURES | Projected FY17 | Projected FY18 | Projected FY19 | Projected FY20 | Projected FY21 |
|---|---|---|---|---|---|
| **TRIF EXPENDITURES** | | | | | |
| Total | 1,621,364 | 1,634,502 | 1,550,710 | 1,919,045 | 2,579,252 |
| **FINANCIAL IMPACT OF TRIF INVESTMENT** | | | | | |
| Sponsored Awards | 2,432,046 | 2,451,753 | 2,326,065 | 2,878,568 | 3,868,878 |
| Gifts & Other Sources | 121,602 | 122,588 | 116,303 | 143,928 | 193,444 |
| Intellectual Property Income | 8,333 | 9,375 | 0 | 0 | 35,156 |
| **TOTAL** | **2,561,982** | **2,583,716** | **2,442,368** | **3,022,496** | **4,097,478** |
| | | | | | |
| **TECHNOLOGY TRANSFER ACTIVITY** | | | | | |
| Invention Disclosures Transacted | 17 | 20 | 23 | 26 | 29 |
| US Patents Issued | 1 | 1 | 1 | 1 | 1 |
| Licenses and Options Executed | 1 | 1 | 0 | 0 | 1 |
| Startup Companies | 1 | 0 | 0 | 1 | 0 |
| **WORKFORCE CONTRIBUTION** | | | | | |
| Postdoctoral Appointees | 2 | 4 | 5 | 5 | 4 |
| Graduate Students | 15 | 20 | 25 | 30 | 35 |
| Undergraduate Students | 20 | 20 | 50 | 50 | 50 |

## 3.3 Initiative Structure

### 3.2.3 Organizational structure

Northern Arizona University's Vice President for Research (VPR) oversees the implementation of all TRIF-supported research initiatives. The Associate Vice President for Research (AVPR) and the Executive Director (ED) of the Office of the VPR jointly manage the four TRIF-supported initiatives; they advise and report directly to the Vice President. They are supported by an internal advisory committee of faculty (two for each initiative) directors of research centers in bioscience, health, and engineering and individual faculty in Departments carrying out key research projects that support the mission and goals of the four initiatives. TRIF budgetary oversight is provided by the Vice President's office and by the NAU Office of Budget and Planning. Research centers that receive support through the TRIF program report to the Deans of Colleges (currently, all such centers are organized under the College of Engineering, Forestry and Natural Sciences).

NAU Innovations, the university's technology transfer program, resides within the Office of the Vice President for Research and is led by a Director of Intellectual Property and Technology Transfer. NAU Innovations has an Advisory Board that includes (but is not controlled by) university representatives and members from the Phoenix and Tucson areas with expertise in technology transfer and experience commercializing emerging technologies and creating start-up companies.

### 3.2.4 Advisory Board

Northern Arizona University has assembled a TRIF Research Advisory Board comprising leaders from across the state whose perspective will help to shape the university's view of its strategic opportunities and priorities. Members of this Advisory Board were chosen from such areas as economic development, banking, aerospace, biotechnology, healthcare, philanthropy, and astronomy. The group will meet annually with the NAU President and Vice President for Research to review overall direction and the productivity of the TRIF investments in research, to provide perspective on the most strategic directions for future investment and to advise the university on sustainability of programs beyond TRIF support.

### 3.2.5 Infrastructure

iHealth is supported by multiple research centers and multiple departments with active researchers. The initiative is further supported by appropriate lab resources, computing resources, and research core facilities. Academic departments support this initiative with graduate programs through which PhD students are trained and mentored to become active contributors to the state's economic development.

### 3.2.6 Description of investment mechanisms

Northern Arizona University is making a number of targeted short-term and one-time investments across all TRIF initiatives under this five-year plan.

**Operational Support for Centers:** Over the past 15 years, NAU has invested TRIF funds to seed a number of research centers. These units provide support for interdisciplinary research that complements the resources provided through academic departments. Such centers foster greater interdisciplinarity work across academic units and institutions, generate significant external research funding, provide undergraduates with meaningful employment opportunities, and provide the specialized and intensive research training that NAU graduate students need to complete their master's and doctoral programs. Over the past fifteen years, Northern Arizona University has invested significant TRIF funds in currently-active research centers, such as the Center for Microbial Genetics and Genomics and the Center for Bioengineering Innovation. These funds are intended to give the centers time to establish their research programs and formulate collaborative efforts, and to build up a fund of recovered indirect cost funding sufficient to cover administrative and operational costs. Centers are expected to generate financial returns on these investments many times over. During FY17-21, NAU will support existing research centers and anticipates establishing one or two new centers.

**New Faculty Start-up Resources:** Northern Arizona University recognizes that, in order to increase the overall economic impact of its research enterprise, we need to facilitate the research success of our faculty. One way we are doing this is by providing the financial resources that all new faculty need to succeed—to start and grow a new research program (for faculty just starting their careers) or to transfer and grow an established research program (for faculty coming to NAU from other academic institutions). Investing TRIF funds to support new faculty enables the university to provide competitive salaries and start-up packages to attract the best, most productive researchers whose work addresses NAU strategic research priorities. Such support is limited to two or three years, after which time faculty are expected to support their research through external grants.

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Between FY17 and FY21, we will invest TRIF funds to hire up to twenty-five (25) Post-docs (for 2-3 year appointments) who will bring new technical capacities and/or expertise (that does not currently exist at NAU) to expand current research and research training capacities across all initiative areas. Post-docs funded in this manner are extremely productive as they are able to work across all of the faculty researcher's projects, unlike Post-docs that are funded on a specific externally-funded research project. In addition, these Post-docs write grant proposals and enable the faculty researcher to write and submit more grant proposals than s/he

would otherwise be able to produce. The hiring of Post-docs is expected to increase inter-institutional collaboration between NAU and their prior PhD-granting institutions; a second potential link may be created between NAU and the academic institution, company, or other organization to which the Post-docs go at the end of the 2-3 year NAU Post-doctoral appointment.

**Competitive Research and Development Grants:** Under Northern Arizona University's Research Development Grants (RDG) Program, we will invest TRIF funds by providing small grants ($10K - $25K) for planning activities that help to build and solidify interdisciplinary and inter-institutional collaborations for sponsored research opportunities, and to support the generation of preliminary data that can be used to develop competitive research proposals. Faculty researchers are required to demonstrate that they will submit a research proposal to an external sponsor (requesting at least $100,000 in direct costs) as a result of the work conducted under the RDG grant.

**Technology Transfer:** NAU Innovations, the university's technology transfer unit, catalyzes discovery and manages the transfer of research outcomes from Northern Arizona University to the private sector for the benefit of Arizona and the world. Through NAU Innovations, the university provides resources and technical assistance to faculty researchers from the earliest stages of discovery and development, helping to generate and disseminate cutting-edge innovations that can compete in the 21st century marketplace. We will invest TRIF funds to support NAU Innovations across all research initiatives.

**Enhancing Institutional Capacity in Sponsored Projects Administration:** Key to NAU's ability to leverage TRIF funding across all TRIF research initiatives is our ability to significantly increase the number of research proposals submitted to external sponsors and to enhance our ability to manage awards efficiently and effectively. To this end, NAU has recently reorganized its Office of Sponsored Projects (OSP)—the unit responsible for assisting faculty researchers in preparing and submitting external grant proposals and in managing the funds awarded by the external sponsors. We will make a small investment of TRIF funds in FY17 to support the hiring and training of new OSP staff that would include grants and contracts administers and fund managers. In FY18 and beyond, increased indirect costs recovered from externally-funded research projects will support these costs.

**MRI Matching Funds:** The National Science Foundation (NSF) provides large grants ($100,000 to $4 million) to universities for the acquisition or development of Major Research Instrumentation through the MRI program. Northern Arizona University submits two to three proposals (the limit) to this program every year in such areas as Astronomy, Biological Sciences, Chemistry and Mechanical Engineering. The NSF requires the awardee institutions to share 30% of the cost of the entire project, not including personnel costs. Therefore, the investment of TRIF funds as the cost-sharing component to NSF MRI grants generates an immediate return on investment of no less than 2:1. In addition, the acquisition and/or development of such major instrumentation (which, in many cases, would be too costly for the university to acquire) enhances intra- and inter-institutional collaborations,

increases our institutional research capacity, provides training opportunities for students and post-docs that make them more valuable in the Arizona workforce, and helps our faculty to be more competitive overall in continuing to identify and secure external project support from the NSF and other federal agencies.

**Research Equipment Acquisition:** The TRIF Research Equipment Acquisition Program (REAP) catalyzes the advancement of research at NAU by providing funds to purchase equipment that extends current research and research training capacity in both laboratory and field investigations and assists investigators in competing for external funding. Faculty are required to demonstrate that equipment will be shared by no fewer than three independent research programs that are aligned with TRIF FY17-FY21 research initiatives and that the research conducted with the equipment will be supported by external grant funding. Equipment purchased under this program has a lower acquisition or development cost ($10K - $100K) than equipment that can be acquired or developed under the NSF MRI program.

**Operational Support for University Research Core Facilities:** University Research Core Facilities (URCFs) support the TRIF research mission by providing a centralized location and cross-campus access to sophisticated and highly specialized major equipment, instrumentation, and services. For example, the microscopy and histology equipment in the Imaging and Histology Core Facility contributes to analysis and characterization of biomaterials, microbes, and human and animal cells and tissues; the Environmental Genetics and Genomics Laboratory provides high throughput genetics and genomics analysis of human, animal, and microbial DNA; and the Advanced Human Performance Laboratory supports basic and applied research on elite athletic training and evaluation, personal bionics and wearable robotics, rehabilitation, and assessment of human performance. The goals of NAU's URCFs are to maximize productivity and quality of NAU-sponsored research and to foster research-intensive learning environments for state-of-the-art student training. Increases in productivity will be measured in papers published, grant proposals submitted and grant awards obtained. TRIF support contributes to maintenance agreements and service contracts for major equipment so that reasonable fee rate schedules can be maintained. This supplementary support protects NAU's TRIF investments in major research equipment, and incentivizes faculty to use such equipment, and to commit time and effort toward obtaining external funding for research and major equipment acquisition.

### 3.3 Initiative budget table (see Appendix Table 2B)

### 3.4 Plan for sustainability

**3.4.1 Anticipated funding sources for ongoing support.** Researchers supported through the iHealth initiative have been successful in garnering external funding and will continue to seek external support from the following agencies:

National Institutes of Health
National Science Foundation
Arizona Department of Agriculture
Arizona Department of Health Services

| | |
|---|---|
| US Department of Agriculture | Battelle Memorial Institute |
| Department of Homeland Security | Flinn Foundation |
| Defense Threat Reduction Agency | Alfred P. Sloan Foundation |
| American Chemical Society | Andrew W. Mellon Foundation |
| American Lung Association | American College of Sports Medicine |

### 3.4.2 Timeline for transitioning away from TRIF support

Sustainability of initiatives and programs funded by TRIF has been a major strength of NAU's TRIF programs. Over the past 15 years of the TRIF program, NAU's research funding from external sources has increased significantly, with federal funds accounting for the majority of this increase. This has been the strategy of all of NAU's TRIF research investments. Because of the uncertainty of the continuation of the TRIF program beyond FY2021, NAU is making primarily short-term and one-time investments with TRIF funds during this final five-year period. For example, investments in new faculty support is commonly only provided for 2-3 years, after which time the faculty member is expected to fund his/her research program with external grants. Therefore, these investments do not require longer-term sustaining. Likewise, investments in post-doctoral research scholars ordinarily take the form of a two-year commitment intended to prepare the scholars for a professional research career and to assist NAU faculty in carrying out preliminary work so that their proposals for external grants will be more competitive. TRIF-funded competitive research grants are short-term in nature (18-months or less) and are intended to provide seed funding so that again, faculty can be more competitive for extramural funding.

We expect that our success at increasing external support of research at NAU will continue. As a result, sustainability of center support, which will be tapered down to minimal levels during this five-year period, will be made with university funds through increased recovery of indirect costs generated by the extramural funding. In the same way we anticipate that TRIF support of our Technology Transfer program will be replaced by a combination of institutional support (through increased indirect costs) and by royalties and other Intellectual Property income.

# Section 4: National Security Systems (NSS)

# 4. National Security Systems (NSS)

## 4.1 Investment description/rationale/justification

Cybersecurity is a major concern in 21st Century society. Hacking has become a sort of 'anti-industry' driven by a myriad of motivations that can be political, social, economic, religious, or even personal. In 2014, the Center for Strategic and International Studies published a report that estimated the annual cost to the global economy from cybercrime at between $US 375-500 billion. Moreover, in the United States, studies suggest that losses from cybercrime could cost as many as 200,000 jobs annually. (Net Losses: Estimating the Global Cost of Cybercrime, Center for Strategic and International Studies, 2014, http://www.mcafee.com/us/resources/reports/rp-economic-impact-cybercrime2.pdf). Banking, health care, energy, travel, and manufacturing are just some of the industries that require increasingly more secure means of protecting data and thwarting deliberate attempts to disrupt computer networks, ever more sophisticated approaches to safeguarding computing systems operations, and a more cyber-savvy workforce. We see this growing need as a core national security priority in the coming decade.

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

Cybersecurity for information and communications systems, reconfigurable computing, remote sensing, and the internet are areas of major concern for industry operations, institutional protection of data, computer-to-computer communications, and other related applications. Every higher education institution and every technology oriented industry will need to develop ever more sophisticated approaches to computing systems operations, computing applications, data protection, and computing systems workforce development. We see this growing need—to address information and computing—as a core national security priority in the coming decade.

Northern Arizona University is contributing significant investments to its new School for Informatics, Computing and Cyber Systems (SICCS) with its four emphases: cyber security, cyber-physical systems (network design, ubiquitous computing, sensor systems, smart cities, etc.), reconfigurable computing, and data science. These 21st century challenges have strong industry applications industry demand. This Initiative will also generate a significant number of technology innovations that will lead new IP, patents, and licensing opportunities. Additionally, this initiative will help train an advanced professional workforce in areas critical to Arizona's future economy.

### 4.1.2 Discussion of mission, goals, values, and vision

**Mission:** Northern Arizona University's National Security Systems initiative leverages research, discovery and training to develop and disseminate innovative and secure application of informatics, computing and cyber systems. **Vision:** Northern Arizona University is a national leader in developing new technologies in

computing and cybersystems and in training a critical sector of the knowledge-based economy. **Values:** Northern Arizona University brings a core set of values for achieving this vision:

- A commitment to the use of rigorous scientific research methodology and investment in technical and infrastructure befitting an institution that is expanding its abilities to respond to 21st Century challenges in computing technology.
- A responsibility to promote and translate important discoveries through technology innovations around computing systems.
- A belief that interdisciplinary teams will best address today's technical security and economic development challenges.
- A conviction that computing and cyber-system security is a crucial aspect of the university's research endeavors to maintain and grow the economic future for the state's citizens.
- A commitment to training a highly skilled professional workforce in a key national security area for Arizona.

**Goals:** Our specific goals under NSS include:

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

### 4.1.3 Description of programmatic investments

Northern Arizona University will make two major programmatic investments through the NSS initiative: *Cybersolutions* and *iCore (Informatics and Computing Research)*. Both of these programs will be delivered through NAU's new School of Informatics, Computing and Cyber Systems (SICCS).

*Cybersolutions* addresses key challenges for secure computing. The most obvious challenge is the need for cybersecurity and encryption that cannot be easily defeated. Novel approaches will include both software designs and embedded encryption in hardware. Reconfigurable computing represents major challenges for cybersecurity because of the need for computing programs that are adaptable and often less secure (e.g., machine learning). Cyber-physical systems will require security to ensure that computers talking to other computers are not corrupted and

harm entire systems of machine-to-machine communications. The same concern can be extended to remote sensing data and smart infrastructure systems (smart cities, smart buildings, and even smart cars).

*iCORE* is a program drawing in researchers working with very large datasets, machine learning, remote sensing, IoT (Internet of Things), and/or reconfigurable computing. That cohort would cover Health, Astronomy, Environment & Ecology, Biology, Mechanical Sciences, Bio-engineering, Forestry, Earth Sciences, Psychology, Linguistics, and possibly Sociology and Humanities. The key element to *iCORE* is building transdisciplinary projects around computing applications and secure computing. Collaborative projects, proposals, and working groups involve, at minimum, a disciplinary faculty person (both Centers and Department faculty) and a SICCS faculty or affiliate (skilled at writing code). The strong focus on interdisciplinarity will offer opportunities for technical innovations, economic development, and workforce training.

### 4.2 Expected Outcomes as a result of TRIF investments

Researchers supported by the TRIF iHealth initiative will continue to discover new knowledge and disseminate that knowledge through scientific publications, public seminars, undergraduate and graduate students trained. Researchers will leverage TRIF support with external funding to further their scientific and translational objectives. Researchers will continue to participate in a range of professional engagements including offerings of short courses, conferences, workshops, and preparation of white papers and technical reports. Researchers will seek opportunities to translate their research into economically productive innovations with commercial applications.

#### 4.2.1 Specific and realistic goals that are clearly measureable

**4.2.1.1 Return on investment.** Investments in NAU's National Security Systems initiative will enhance researchers' ability to successfully compete for external funding. Although NAU does not have past experience investing TRIF funds in the National Security Systems initiative, our past performance with respect to financial impact of overall TRIF research investments supports an optimistic projection. During the period FY12 through FY15, NAU leveraged an average 35% return on investment across all research investments. We expect to meet or exceed this level of return across all research initiatives during this business plan cycle.

**4.2.1.2 Technology transfer.** Northern Arizona University's programs under National Security Systems are anticipated to generate a significant volume of intellectual property with high commercial potential. The goal of current and planned research and development in cybersecurity is the development of inherently secure platforms by pushing security from the software to the hardware level, exploiting the complex physical properties of nanomaterials, and building new types of firewalls for optical communications. Collaboration with Arizona State University and The University of Arizona

promises to expedite NAU's cybersecurity research program, and we anticipate early and prolific outcomes from this work.

**4.2.1.3 Industry engagement (outreach, partnerships, collaboration).** The National Security Systems initiative will partner with cybersecurity and related defense and technology industries to generate both software and hardware applications for more secure cyber systems operations. We will pursue internship placements for our students with multiple companies, generating a strong workforce for Arizona's economy.

**4.2.1.4 Workforce contributions.** The TRIF investment in National Security Systems will dramatically increase the number and breadth of cutting-edge research and technology development experiences to undergraduate students, PhD students, and research scientists at NAU. Furthermore, we anticipate that our partnerships with Arizona companies will result in student internships at these companies. Collectively, these opportunities will help prepare the Arizona workforce for a knowledge-based economy.

**4.2.1.5 Educational outreach.** Through the National Security Systems initiative, Northern Arizona University will partner with industry and with its sister institutions to provide students with advanced development experiences in computing and cybersystems. In addition, Northern Arizona University has recently formalized an agreement with Diné College that will increase collaboration between the institutions and generate research opportunities for Diné students in computer science and engineering programs. Diné students may be able to participate in NSS-supported programs, short-courses, seminars and symposia through the School of Informatics, Computing and Cybersystems. NAU is committed to working with Diné College to develop joint admission and 2+2 programs, dual enrollment agreements, integrated academic degree progression plans, faculty exchanges, and collaborative research and scholarly activities among professors and students.

**4.2.1.6 Government Agency/Community Engagement (outreach, partnerships, collaboration).** Investments under NSS will allow NAU faculty to be much more competitive in securing federal grants and subcontracts with federal contractors. NAU's partnerships with industry are anticipated to increase as we aggressively pursue collaborations under federal grants and contracts. We will also partner with young companies in the new Flagstaff Business Accelerator.

### 4.2.2 Annual metrics table of expected outcomes and timeline for achievement

**NORTHERN ARIZONA UNIVERSITY**
National Security Systems

| PERFORMANCE MEASURES | Projected FY17 | Projected FY18 | Projected FY19 | Projected FY20 | Projected FY21 |
|---|---|---|---|---|---|
| **TRIF EXPENDITURES** | | | | | |
| Total | 2,935,577 | 2,977,363 | 2,903,950 | 1,207,561 | 886,798 |
| **FINANCIAL IMPACT OF TRIF INVESTMENT** | | | | | |
| Sponsored Awards | 4,403,366 | 4,466,045 | 4,355,925 | 1,811,342 | 1,330,197 |
| Gifts & Other Sources | 220,168 | 223,302 | 217,796 | 90,567 | 66,510 |
| Intellectual Property Income | 8,333 | 18,750 | 23,438 | 46,875 | 35,156 |
| **TOTAL** | **4,631,867** | **4,708,097** | **4,597,159** | **1,948,784** | **1,431,863** |
| **TECHNOLOGY TRANSFER ACTIVITY** | | | | | |
| Invention Disclosures Transacted | 4 | 5 | 5 | 6 | 7 |
| US Patents Issued | 0 | 0 | 1 | 2 | 2 |
| Licenses and Options Executed | 1 | 2 | 1 | 2 | 1 |
| Startup Companies | 0 | 0 | 1 | 0 | 1 |
| **WORKFORCE CONTRIBUTION** | | | | | |
| Postdoctoral Appointees | 2 | 4 | 5 | 5 | 4 |
| Graduate Students | 6 | 10 | 10 | 10 | 15 |
| Undergraduate Students | 10 | 20 | 20 | 25 | 25 |

## 4.3 Initiative Structure

### 4.3.1 Organizational structure

Northern Arizona University's Vice President for Research (VPR) oversees the implementation of all TRIF-supported research initiatives. The Associate Vice President for Research (AVPR) and the Executive Director (ED) of the Office of the VPR jointly manage the four TRIF-supported initiatives; they advise and report directly to the Vice President. They are supported by an internal advisory committee of faculty (two for each initiative) directors of research centers in bioscience, health, and engineering and individual faculty in Departments carrying out key research projects that support the mission and goals of the four initiatives. TRIF budgetary oversight is provided by the Vice President's office and by the NAU Office of Budget and Planning. Research centers that receive support through the TRIF program report to the Deans of Colleges (currently, all such centers are organized under the College of Engineering, Forestry and Natural Sciences).

NAU Innovations, the university's technology transfer program, resides within the Office of the Vice President for Research. NAU Innovations has an Advisory Board that includes (but is not controlled by) university representatives and members from

the Phoenix and Tucson areas with expertise in technology transfer and experience commercializing emerging technologies and creating start-up companies.

### 4.3.2 Advisory Board

Northern Arizona University has assembled a TRIF Research Advisory Board comprising leaders from across the state whose perspective will help to shape the university's view of its strategic opportunities and priorities. Members of this Advisory Board were chosen from such areas as economic development, banking, aerospace, biotechnology, philanthropy and astronomy. The group will meet annually with the NAU President and Vice President for Research to review overall direction and the productivity of the TRIF investments in research, to provide perspective on the most strategic directions for future investment and to advise the university on sustainability of programs beyond TRIF support.

### 4.3.3 Infrastructure

The National Security Systems initiative is supported by multiple research centers and multiple departments with active researchers. The initiative is further supported by appropriate lab resources, computing resources, and research core facilities. Academic departments support this initiative with graduate programs through which PhD students are trained and mentored to become active contributors to the state's economic development.

### 4.3.4 Description of investment mechanisms

Northern Arizona University is making a number of targeted short-term and one-time investments across all TRIF initiatives under this five-year Plan.

**High-Performance Computing:** Under the NSS initiative NAU will make investments to increase high performance computing (HPC) capacity, including expanded bandwidth capacity from Southern to Northern Arizona and Internet 2 access. Monsoon, NAU's computer cluster, provides high-speed data transmission and high capacity computing that allows faculty researchers to run bigger data analysis projects and have them completed in a reasonable amount of time. Monsoon is ideal for data-rich research in areas such as biology, climate science, genetics and astronomy, and all four of NAU's TRIF initiatives will benefit from this investment.

**New Faculty Start-up Resources:** Northern Arizona University recognizes that, in order to increase the overall economic impact of its research enterprise, we need to facilitate the research success of our faculty. One way we are doing this is by providing the financial resources that all new faculty need to succeed—to start and grow a new research program (for faculty just starting their careers) or to transfer and grow an established research program (for faculty coming to NAU from other academic institutions). Investing TRIF funds to support new faculty enables the university to provide competitive salaries and start-up packages to attract the best, most productive researchers whose work addresses NAU strategic research

priorities. Such support is limited to two or three years, after which time faculty are expected to support their research through external grants.

**Support for Post-doctoral Research Scholars:** Post-doctoral Research Scholars ("Post-docs") play a key role in university research programs. They manage research projects on behalf of their faculty mentors, train graduate and undergraduate students, and write grant proposals and scholarly articles—all while developing the professional networks and skills necessary to succeed in their chosen field. Since 75% of Post-docs do not enter academia, the vast majority of Post-docs are developing the skills needed to land jobs in industry and not-for-profit institutions (*Fonseca-Kelly, Darwin, Operario, Finger and Baucum. 2010. The Role of Post-docs, PIs and Institutions in Training Future Scientists, http://www.asbmb.org/asbmtoday/asbmbtoday_article.aspx?id=9198*)

Between FY17 and FY21, we will invest TRIF funds to hire up to twenty-five (25) Post-docs (for 2-3 year appointments) who will bring new technical capacities and/or expertise (that does not currently exist at NAU) to expand current research and research training capacities across all initiative areas. Post-docs funded in this manner are extremely productive as they are able to work across all of the faculty researcher's projects, unlike Post-docs that are funded on a specific externally-funded research project. In addition, these Post-docs write grant proposals and enable the faculty researcher to write and submit more grant proposals than s/he would otherwise be able to produce. The hiring of Post-docs is expected to increase inter-institutional collaboration between NAU and their PhD-granting institutions; a second potential link may be created between NAU and the academic institution, company or other organization to which the Post-docs go at the end of the 2-3 year NAU Post-doctoral appointment.

**Competitive Research and Development Grants:** Under Northern Arizona University's Research Development Grants (RDG) Program, we will invest TRIF funds by providing small grants ($10K - $25K) for planning activities that help to build and solidify interdisciplinary and inter-institutional collaborations for sponsored research opportunities, and to support the generation of preliminary data that can be used to develop competitive research proposals. Faculty researchers are required to demonstrate that they will submit a research proposal to an external sponsor (requesting at least $100,000 in direct costs) as a result of the work conducted under the RDG grant.

**Technology Transfer:** NAU Innovations, the university's technology transfer unit, catalyzes discovery and manages the transfer of research outcomes from Northern Arizona University to the private sector for the benefit of Arizona and the world. Through NAU Innovations, the university provides resources and technical assistance to faculty researchers from the earliest stages of discovery and development, helping to both generate and disseminate cutting-edge innovations that can compete in the 21st Century marketplace. We will invest TRIF funds to support NAU Innovations across all research initiatives.

**Enhancing institutional capacity in sponsored projects administration:** Key to NAU's ability to leverage TRIF funding across all TRIF research initiatives is our ability to significantly increase the number of research proposals submitted to external sponsors and to enhance our ability to manage awards efficiently and effectively. To this end, NAU has recently reorganized its Office of Sponsored Projects (OSP)—the unit responsible for assisting faculty researchers in preparing and submitting external grant proposals and in managing the funds awarded by the external sponsors. We will make a small investment of TRIF funds in FY17 to support the hiring and training of new OSP staff. In FY18 and beyond, increased indirect costs recovered from externally-funded research projects will support these costs.

**Research Equipment Acquisition:** The TRIF Research Equipment Acquisition Program (REAP) catalyzes the advancement of research at NAU by providing funds to purchase equipment that extends current research and research training capacity in both laboratory and field investigations and assists investigators in competing for external funding. Faculty are required to demonstrate that equipment will be shared by no fewer than three independent research programs that are aligned with TRIF FY17-FY21 research initiatives and that the research conducted with the equipment will be supported by external grant funding. Equipment purchased under this program has a lower acquisition or development cost ($10K - $100K) than equipment that can be acquired or developed under the NSF MRI program.

### 4.4 Initiative budget table (see Appendix Table 2C)

### 4.5 Plan for sustainability

**4.5.1** Researchers supported through the National Security Systems initiative will solicit external funding from the following agencies:

Department of Defense
National Institute of Standards And Technology
SBIR/STTR Programs
National Science Foundation
National Security Agency
Homeland Security
Defense Threat Reduction Agency

#### 4.5.2 Timeline for transitioning away from TRIF support

Sustainability of initiatives and programs funded by TRIF has been a major strength of NAU's TRIF programs. Over the past 15 years of the TRIF program, NAU's research funding from external sources has increased significantly, with federal funds accounting for the majority of this increase. This has been the strategy of all of NAU's TRIF research investments. Because of the uncertainty of the continuation of the TRIF program beyond FY2021, NAU is making primarily short-term and one-time investments with TRIF funds during this final five-year period. For example, investments in new faculty support is commonly only provided for 2-3 years, after which time the faculty member is expected to fund his/her research program with external grants. Therefore, these investments do not require longer-term sustaining. Likewise, investments in post-doctoral research scholars ordinarily take the form of a two-year commitment intended to prepare the scholars for a

professional research career and to assist NAU faculty in carrying out preliminary work so that their proposals for external grants will be more competitive. TRIF-funded competitive research grants are short-term in nature (18-months or less) and are intended to provide seed funding so that again, faculty can be more competitive for extramural funding.

We expect that our success at increasing external support of research at NAU will continue. As a result, sustainability of Center support, which will be tapered down to minimal levels during this five-year period, will be made with university funds through increased recovery of indirect costs generated by the extramural funding. In the same way we anticipate that TRIF support of our Technology Transfer program will be replaced by a combination of institutional support (through increased indirect costs) and by royalties and other Intellectual Property income.

# Section 5: Exploring Planetary Systems

# 5. Exploring Planetary Systems

## 5.1 Investment description/rationale/justification

People throughout the United States and the world identify Arizona with astronomy and planetary science. Our state is home to the largest collection of telescopes—as well as the largest number of people—in the United States that explore our planetary system and other distant planetary systems. Furthermore, some of the most important astronomical discoveries and technological breakthroughs of the last 100 years were made by Arizona astronomers and planetary scientists. The erstwhile planet, Pluto, was discovered by an astronomer at Lowell Observatory in Flagstaff. The citizens of Arizona draw a sense of inspiration and pride from the scientific discoveries and technological breakthroughs made by Arizona astronomers and planetary scientists.

Through TRIF investment in the Exploring Planetary Systems research initiative, Northern Arizona University is generating outcomes that contribute to the intellectual and economic development of the state. Specifically, we are pursuing the scientific discoveries and cutting-edge technology developments that will (a) train undergraduate and graduate students for a knowledge based work force in Arizona, (b) transfer new knowledge and technology to Arizona companies to improve their economic competitiveness, and (c) continue to increase external funding to support our mission.

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

Astronomy, planetary science, and space science are major players in the economy of Arizona. The total investment in capital facilities in Arizona related to these fields exceeds $1 billion[1]. The annual grants and contracts awarded to institutions in Arizona related to these sciences exceeds $200 million, equivalent to the grants and contracts awarded to institutions in Arizona by the National Institutes of Health[1]. More than 2,000 Arizonans are employed in jobs related to astronomy, planetary science, and space science with a payroll of approximately $84 million[1]. Research conducted by Arizona universities accounts for 18% of all university-based Astronomy research in the United States.[1]

TRIF investment in *Exploring Planetary Systems* will further strengthen Arizona's stature as a worldwide leader in astronomy and planetary science research, and it will allow us to develop unique and cutting-edge programs in Solar System origins, Mars, and exoplanet research. TRIF investment will allow us to develop the infrastructure to build low-cost, high-quality instruments for shoe-boxed sized spacecraft (CubeSats), and fly a complete spacecraft mission. Such work will require us to partner with Arizona companies and should result in entrepreneurial activity. The investment will allow us to maintain or even expand upon our access to cutting-edge telescopes such as the Discovery Channel Telescope, FRoST, and ATLAS. This

[1]Arizona Arts, Sciences, and Technology Academy Report, 2008.

telescope access is essential for dramatically increasing the grant funding in astronomy and planetary science coming to northern Arizona. Our grant funding is very important for training undergraduate students and graduate students for the skills needed for astronomy and planetary science jobs in Arizona and across the nation.

### 5.1.2 Discussion of mission, goals, values and vision

**Mission:** Through the Exploring Planetary Systems initiative, NAU discovers new ways of exploring space, contributing to a new understanding of our place in the universe. **Vision:** Arizona is internationally known for having some of the best facilities in the world to study our own and other planetary systems, and for doing cutting-edge science that expands the frontiers of knowledge in space exploration. **Values:** The core set of values that NAU brings to bear to achieve this vision:

- A commitment to rigorous scientific research methods.
- A responsibility to train undergraduate and graduate students.
- A commitment to transfer new knowledge to Arizona industries to improve their competitive and generate economic activity.

**Goals:** Our specific goals include the following:

- Double external research funding in astronomy and planetary science.
- Partner with Arizona companies to develop instrumentation for shoe-box-sized spacecraft (CubeSats).
- Fly a CubeSat to an extraterrestrial object (e.g., an asteroid).
- Expand partnerships with private observatories (e.g., Lowell Observatory, FRoST, ATLAS).
- Build and/or operate small telescopes (e.g. FRoST and ATLAS) to detect potentially hazardous near-Earth asteroids. Such work is among the best funded in astronomy and of the most important to the preservation of our society.
- Continue to operate and expand the capabilities of the Astrophysical Ice Laboratory on the NAU campus. The one-of-a-kind lab simulates the icy surfaces of Kuiper belt objects, like Pluto.

### 5.1.3 Description of programmatic investments

Northern Arizona University's investments in Exploring Planetary Systems will be made through three programs:

**Solar System Origins:** NAU faculty members and their students use an armada of cutting-edge telescopes equipped with state-of-the-art imaging systems to study the ancient building blocks of planets left over from the formation of the Solar System. They are detecting and characterizing the physical and chemical properties of rocky asteroids that could potentially impact the Earth. They are looking for the elusive "Planet Nine", a large and undiscovered ninth planet in the most distant

regions of the Solar System. They are characterizing the physical and chemical properties of the small and faint, icy Kuiper belt objects, such as Pluto, at the edge of the Solar System to better understand the evolution of the Solar System. Faculty members are simulating the surface environment of Pluto in a laboratory on campus to help interpret data from the New Horizons spacecraft that flew by Pluto.

**Mars:** NAU faculty members use spacecraft data to study the geology of Mars as well as hunt for water and life on its surface. Faculty members and their students direct the path and daily tasks of the NASA Curiosity Rover on the surface of Mars from the NAU campus; they build flight instruments for spacecraft bound for Mars; and they analyze data taken by spacecraft on the surface and orbiting Mars.

**Exoplanets:** NAU faculty and their students study planets orbiting around distant stars. They use telescopes and computer simulations to characterize the physical and chemical properties of these planets. Their goal is to identify which of the thousands of known exoplanets are the best candidates to harbor life and so are worthy of additional observations for the eventual detection of an Earth-like atmosphere, the chemical signature of photosynthesis in an atmosphere, or perhaps even the signature of a civilization in the atmosphere.

## 5.2 Expected Outcomes as a result of TRIF investments

Researchers supported by the Exploring Planetary Systems initiative will continue to discover new knowledge and disseminate that knowledge through scientific publications, public seminars, undergraduate and graduate students trained. Researchers will leverage TRIF support with external funding to further their scientific and translational objectives. Researchers will continue to participate in a range of professional engagements including offerings of short courses, conferences, workshops, and preparation of white papers and technical reports. Researchers will seek opportunities to translate their research into economically productive innovations with commercial applications.

### 5.2.1 Specific and realistic goals that are clearly measureable

**5.2.1.1 Return on investment.** We anticipate the primary return on the TRIF investment in *Exploring Planetary Systems* will be a significant increase in NASA and NSF funding for astronomy and planetary science research coming to NAU. At present, about approximately $1M in NASA and NSF grants come to the Department of Physics and Astronomy per year. We project the TRIF investment will at least double the federal grants in astronomy and planetary science coming to NAU per year.

**5.2.1.2 Technology transfer.** A major component of the Exploring Planetary Systems initiative will be the development of new instruments for use in CubeSats. We anticipate that this work will generate patentable intellectual property.

**5.2.1.3 Industry engagement (outreach, partnerships, collaboration).** We envision partnering with companies like Arizona Space Technologies (in Phoenix) to

develop the electronics for CubeSat instruments and Quantum Spatial (in Oregon) to field-test our CubeSat instruments. We will pursue internship placements for our students with both of these companies; the latter has already agreed to host NAU students.

**5.2.1.4 Workforce contributions.** The TRIF investment in Exploring Planetary Systems will dramatically increase the number and breadth of cutting-edge research and technology development experiences to undergraduate students, PhD students, and research scientists at NAU. Furthermore, we anticipate that our partnerships with Arizona companies will result in student internships at these companies. Collectively, these opportunities will help prepare the Arizona workforce for a knowledge-based economy.

**5.2.1.5 Educational outreach.** TRIF investments will result in more faculty members and post-doctoral researchers who will supervise more undergraduate and PhD students on cutting-edge research topics.

**5.2.1.6 Government Agency/Community Engagement (outreach, partnerships, collaboration).** The TRIF investment will allow NAU faculty to be much more competitive in securing federal grants from NASA and NSF. It will also result in more collaboration between NAU and local scientific institutions, i.e. Lowell Observatory, the United States Naval Observatory, and the United States Geological Survey Astrogeology Branch.

### 5.2.2 Annual metrics table of expected outcomes and timeline for achievement

**NORTHERN ARIZONA UNIVERSITY**
Exploring Planetary Systems

| PERFORMANCE MEASURES | Projected FY17 | Projected FY18 | Projected FY19 | Projected FY20 | Projected FY21 |
|---|---|---|---|---|---|
| **TRIF EXPENDITURES** | | | | | |
| Total | 215,526 | 1,414,168 | 1,562,207 | 1,979,689 | 2,557,438 |
| **FINANCIAL IMPACT OF TRIF INVESTMENT** | | | | | |
| Sponsored Awards | 323,289 | 2,121,252 | 2,343,311 | 2,969,534 | 3,836,157 |
| Gifts & Other Sources | 16,164 | 106,063 | 117,166 | 148,477 | 191,808 |
| Intellectual Property Income | 0 | 0 | 0 | 23,438 | 35,156 |
| **TOTAL** | **339,453** | **2,227,315** | **2,460,476** | **3,141,448** | **4,063,121** |
| | | | | | |
| **TECHNOLOGY TRANSFER ACTIVITY** | | | | | |
| Invention Disclosures Transacted | 1 | 1 | 1 | 2 | 2 |
| US Patents Issued | 0 | 0 | 0 | 2 | 2 |
| Licenses and Options Executed | 0 | 0 | 0 | 1 | 1 |
| Startup Companies | 0 | 0 | 0 | 0 | 0 |
| **WORKFORCE CONTRIBUTION** | | | | | |
| Postdoctoral Appointees | 2 | 4 | 5 | 5 | 4 |
| Graduate Students | 6 | 10 | 10 | 10 | 15 |
| Undergraduate Students | 35 | 35 | 50 | 50 | 50 |

## 5.3 Initiative Structure

### 5.3.1 Organizational structure

Northern Arizona University's Vice President for Research (VPR) oversees the implementation of all TRIF-supported research initiatives. The Associate Vice President for Research (AVPR) and the Executive Director (ED) of the Office of the VPR jointly manage the four TRIF-supported initiatives; they advise and report directly to the Vice President. They are supported by an internal advisory committee of faculty (two for each initiative) directors of research centers in bioscience, health, and engineering and individual faculty in Departments carrying out key research projects that support the mission and goals of the four initiatives. TRIF budgetary oversight is provided by the Vice President's office and by the NAU Office of Budget and Planning. Research centers that receive support through the TRIF program report to the Deans of Colleges (currently, all such centers are organized under the College of Engineering, Forestry and Natural Sciences).

NAU Innovations, the university's technology transfer program, resides within the Office of the Vice President for Research. NAU Innovations has an Advisory Board that includes (but is not controlled by) university representatives and members from the Phoenix and Tucson areas with expertise in technology transfer and experience commercializing emerging technologies and creating start-up companies.

### 5.3.2 Advisory Board

Northern Arizona University has assembled a TRIF Research Advisory Board comprising leaders from across the state whose perspective will help to shape the university's view of its strategic opportunities and priorities. Members of this Advisory Board were chosen from such areas as economic development, banking, aerospace, biotechnology, philanthropy and astronomy. The group will meet annually with the NAU President and Vice President for Research to review overall direction and the productivity of the TRIF investments in research, to provide perspective on the most strategic directions for future investment and to advise the university on sustainability of programs beyond TRIF support.

### 5.3.3 Infrastructure

The Exploring Planetary Systems initiative is supported by multiple departmental interactions with active researchers. The initiative is further supported by astronomy observatories in Northern Arizona and multiple astronomy partnerships in other parts of the state. Within NAU, the initiative is supported by appropriate lab resources, computing resources, and research core facilities. PhD students are trained and mentored to become active contributors to the state's economic development.

### 5.3.4 Description of investment mechanisms

Northern Arizona University is making a number of targeted short-term and one-time investments across all TRIF initiatives under this five-year Plan.

**New Faculty Start-up Resources:** Northern Arizona University recognizes that, in order to increase the overall economic impact of its research enterprise, we need to facilitate the research success of our faculty. One way we are doing this is by providing the financial resources that all new faculty need to succeed—to start and grow a new research program (for faculty just starting their careers) or to transfer and grow an established research program (for faculty coming to NAU from other academic institutions). Investing TRIF funds to support new faculty enables the university to provide competitive salaries and start-up packages to attract the best, most productive researchers whose work addresses NAU strategic research priorities. Such support is limited to two or three years, after which time faculty are expected to support their research through external grants.

**Support for Post-doctoral Research Scholars:** Post-doctoral Research Scholars ("Post-docs") play a key role in university research programs. They manage research projects on behalf of their faculty mentors, train graduate and undergraduate students, and write grant proposals and scholarly articles—all while developing the professional networks and skills necessary to succeed in their chosen field. Since 75% of Post-docs do not enter academia, the vast majority of Post-docs are developing the skills needed to land jobs in industry and not-for-profit institutions (*Fonseca-Kelly, Darwin, Operario, Finger and Baucum. 2010. The Role of Post-docs, PIs and Institutions in Training Future Scientists,* *http://www.asbmb.org/asbmtoday/asbmbtoday_article.aspx?id=9198*).

Between FY17 and FY21, we will invest TRIF funds to hire up to twenty-five (25) Post-docs (for 2-3 year appointments) who will bring new technical capacities and/or expertise to expand current research and research training capacities across all initiative areas. Post-docs funded in this manner are extremely productive as they are able to work across all of the faculty researcher's projects, unlike Post-docs that are funded on a specific externally-funded research project. In addition, these Post-docs write grant proposals and enable the faculty researcher to write and submit more grant proposals than s/he would otherwise be able to produce. The hiring of Post-docs is expected to increase inter-institutional collaboration between NAU and their prior PhD-granting institutions; a second potential link may be created between NAU and the academic institution, company or other organization to which the Post-docs go at the end of the 2-3 year NAU Post-doctoral appointment.

**Competitive Research and Development Grants:** Under Northern Arizona University's Research Development Grants (RDG) Program, we will invest TRIF funds by providing small grants ($10K - $25K) for planning activities that help to build and solidify interdisciplinary and inter-institutional collaborations for sponsored research opportunities, and to support the generation of preliminary data that can be used to develop competitive research proposals. Faculty researchers are required to demonstrate that they will submit a research proposal to an external sponsor (requesting at least $100,000 in direct costs) as a result of the work conducted under the RDG grant.

**Technology Transfer:** NAU Innovations, the university's technology transfer unit, catalyzes discovery and manages the transfer of research outcomes from Northern Arizona University to the private sector for the benefit of Arizona and the world. In the case of the *Exploring Planetary Systems* initiative, NAU will develop high quality instrumentation for CubeSats that will be used by companies in Arizona and around the world for such applications as Earth imaging (e.g., for disaster relief and avoidance, cropland tracking), flight testing space hardware and conducting experiments in the atmosphere and in space. There is a growing trend toward the use of Cubesats in research, Through NAU Innovations, the university provides resources and technical assistance to faculty researchers from the earliest stages of discovery and development, helping to generate and disseminate cutting-edge innovations that can compete in the 21st century marketplace. We will invest TRIF funds to support NAU Innovations across all research initiatives.

**Enhancing institutional capacity in sponsored projects administration:** Key to NAU's ability to leverage TRIF funding across all TRIF research initiatives is our ability to significantly increase the number of research proposals submitted to external sponsors and to enhance our ability to manage awards efficiently and effectively. To this end, NAU has recently reorganized its Office of Sponsored Projects (OSP)—the unit responsible for assisting faculty researchers in preparing and submitting external grant proposals and in managing the funds awarded by the external sponsors. We will make a small investment of TRIF funds in FY17 to support the hiring and training of new OSP staff. In FY18 and beyond, increased indirect costs recovered from externally-funded research projects will support these costs.

**MRI Matching Funds:** The National Science Foundation (NSF) provides large grants ($100,000 to $4 million) to universities for the acquisition or development of Major Research Instrumentation through the MRI program. Northern Arizona University submits two to three proposals (the limit) to this program every year in such areas as Astronomy, Biological Sciences, Chemistry and Mechanical Engineering. Under the *Exploring Planetary Systems* initiative, NAU would submit a proposal requesting approximately $750,000 to build an optics/cleanroom necessary for the development of CubeSat instrumentation. This NSF program requires awardee institutions to share 30% of the cost of the entire project. Therefore, the investment of TRIF funds as the cost-sharing component to NSF MRI grants generates an immediate return on investment of no less than 2:1. In addition, the acquisition and/or development of such major instrumentation (which, in many cases, would be too costly for the university to acquire) enhances intra- and inter-institutional collaborations, increases our institutional research capacity, provides training opportunities for students and post-docs that make them more valuable in the Arizona workforce, and helps our faculty to be more competitive overall for continuing external project support from the NSF and other federal agencies.

**Research Equipment Acquisition:** The TRIF Research Equipment Acquisition Program (REAP) catalyzes the advancement of research at NAU by providing funds to purchase equipment that extends current research and research training capacity in both laboratory and field investigations and assists investigators in competing for external funding. Faculty are required to demonstrate that equipment will be shared by no fewer than three independent research programs that are aligned with TRIF FY17-FY21 research initiatives and that the research conducted with the equipment will be supported by external grant funding. Equipment purchased under this program has a lower acquisition or development cost ($10K - $100K) than equipment that can be acquired or developed under the NSF MRI program. Equipment needed for an optics/cleanroom could be acquired under this program.

**Operational Support for University Research Core Facilities:** University Research Core Facilities (URCFs) support the TRIF research mission by providing a centralized location and cross-campus access to sophisticated and highly specialized major equipment, instrumentation, and services. For example, the scanning and transmission electron microscopes in the Imaging and Histology Core Facility, and the mass spectrometers in the Analytical Research Core Facility contribute to research directed at analyzing the physical and chemical properties of asteroids and other planetary objects. In order to be competitive for external grants and to do the most advanced research, faculty and students need access to these state-of-the-art facilities. The goals of NAU's URCFs are to maximize productivity and quality of NAU-sponsored research and to foster research-intensive learning environments for state-of-the-art student training. Increases in productivity will be measured in papers published, grant proposals submitted and grant awards obtained. TRIF support contributes to maintenance agreements and service contracts for major equipment so that reasonable fee rate schedules can be maintained. This supplementary support protects NAU's TRIF investments in major research equipment, and incentivizes faculty to use such equipment, and to commit time and effort toward obtaining external funding for research and major equipment acquisition.

## 5.4 Initiative budget table (see Appendix Table 2D)

## 5.5 Plan for sustainability

### 5.5.1 Anticipated funding sources for ongoing support

TRIF investment in Exploring Planetary Systems will enable us to develop the necessary infrastructure and partnerships with industry to build high-quality low cost instruments for CubeSats. Such infrastructure and a reputation for building such instruments will make our proposals much more competitive for funding from NASA programs such as:

- SIMPLEX – Small Innovative Missions for Planetary Exploration (i.e. interplanetary CubeSats).

- PICASSO – Planetary Instrument Concepts for the Advancement of Solar System Observations (take an idea from concept to lab instrument).
- MaTISSE – Maturation of Instruments for Solar System Exploration (take a lab instrument to a proto-flight instrument).
- PSTAR – Planetary Science Technology through Analog Research (field test instruments).
- Earth Observing Programs - Once we have instruments and technologies, these funding opportunities can be pursued. This set of topics is very well funded, and would be a new research area for NAU to grow into.

Continued partnership with Lowell Observatory in the Discovery Channel Telescope and the development of new small telescopes (FRoST and ATLAS) will make faculty more competitive for funding from NASA programs such as:

- SSO – Solar System Observations (observations of Kuiper belt objects with Discovery Channel Telescope).
- NEOO – Near Earth Object Observations (observations of near-Earth asteroids with Discovery Channel Telescope, FRoST, and ATLAS).
- SSW – Solar System Workings (simulation of icy Kuiper belt object surfaces in NAU astrophysical ice lab).

Many of our research programs require us to write separate proposals for telescope time and funding. By purchasing nights on telescopes, we guarantee ourselves time on telescopes, which makes our funding proposals to NASA and NSF much stronger.

Finally, post-doc and graduate research assistant support allows us to greatly amplify the amount of research we produce, again making our funding proposals much more competitive.

### 5.5.2 Timeline for transitioning away from TRIF support

TRIF support for this initiative is designed to provide strong consistent funding support across the five years of the fourth cycle of TRIF investments. In the final two years, in the event that TRIF is not re-funded, the specifically dedicated funds will be tapered down to provide realistic flexibility and more one-time, one-year funding of projects.

Sustainability of initiatives and programs funded by TRIF has been a major strength of NAU's TRIF programs. Over the past 15 years of the TRIF program, NAU's research funding from external sources has increased significantly, with federal funds accounting for the majority of this increase. This has been the strategy of all of NAU's TRIF research investments. Because of the uncertainty of the continuation of the TRIF program beyond FY2021, NAU is making primarily short-term and one-time investments with TRIF funds during this final five-year period. For example, investments in new faculty support is commonly only provided for 2-3 years, after which time the faculty member is expected to fund his/her research program with external grants. Therefore, these investments do not require longer-term sustaining. Likewise, investments in post-doctoral research scholars ordinarily take

the form of a two-year commitment intended to prepare the scholars for a professional research career and to assist NAU faculty in carrying out preliminary work so that their proposals for external grants will be more competitive. TRIF-funded competitive research grants are short-term in nature (18-months or less) and are intended to provide seed funding so that again, faculty can be more competitive for extramural funding.

We expect that our success at increasing external support of research at NAU will continue. As a result, sustainability of Center support, which will be tapered down to minimal levels during this five-year period, will be made with university funds through increased recovery of indirect costs generated by the extramural funding. In the same way we anticipate that TRIF support of our Technology Transfer program will be replaced by a combination of institutional support (through increased indirect costs) and by royalties and other Intellectual Property income.

# Section 6: Access and Workforce Development

# 6 Access and Workforce Development

## 6.1 Investment description/rationale/justification

Increasing the number of college graduates is essential to Arizona's economic vitality and competitive position in today's rapidly changing environment. College graduates earn more, pay more in taxes, and depend less on social services. According to a recent report by College Success Arizona, the state lags behind the national average of adults with college degrees and has a high population of adults who have enrolled in postsecondary education, but never finished their degree. Arizona is also home to a high percentage of first-generation students who need additional support and guidance in making a decision to pursue and persist in a degree program.

However, increasing the number of Arizona adults with bachelor's degrees to the levels needed cannot be accomplished by increasing the numbers of traditional age college-going students alone. NAU's Extended Campuses serves a primarily adult population with an average age of 39, with the primary goal of degree completion. While a high productivity rate is important to the university's financial stability, it is also important to the state's economic development and future outlook.

NAU has a strong history of success in providing affordable pathways to degrees through innovative degree completion and delivery options, even in remote, rural communities. In particular, non-traditional students, including a high percentage of under-represented populations, have achieved a higher education degree and career success through the university's flexible, alternative learning models that have evolved over the years to address the needs and demands of its students.

As Arizona's current and future employers demand a skilled workforce, Northern Arizona University's Access and Workforce Development (A/WD) initiative will address the needs of employers and their current and future employees in the areas of Education and Health Sciences in response to the 2025 ABOR Enterprise Plan. The projects within the NAU A/WD initiative are closely aligned, sharing staffing and employing continuous improvement strategies to increase efficiencies. The initiative includes the development and delivery of courses and degree programs to support workforce development and the use of technologies to increase student achievement and accelerate student progress through degree completion.

To achieve these goals of Access/Workforce Development, Extended Campuses has collaborated successfully with the e-Learning Center, which also supports academic programs on the Flagstaff Mountain Campus.

Online education at NAU continues to grow. The vast majority of students take at least one online course in their college career. It is a tenet of Access/Workforce Development that, for many students, attending traditional classroom courses at the same time every week, in a location that costs valuable time and money to travel to, is unrealistic. Online is their only option. Increasingly, online delivery will be the primary way to reach nontraditional students at an affordable cost while maintaining quality.

NAU's significant investment in Competency-Based Education (CBE) through its Personalized Learning programs presents a bright future for access and workforce development. As more program options become available and our business processes and technical solutions evolve, Personalized Learning will meet the educational needs of an expanding population of place- and time-bound students seeking a low-cost, self-paced path to a college degree.

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

The A/WD business plan addresses three of the four goals and their objectives of the 2025 ABOR Enterprise Plan:

- Drive Student Educational Success and Learning
- Advance Educational Attainment within Arizona
- Impact Arizona

Accordingly Northern Arizona University has identified the following areas for the TRIF A/WD initiative:

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

### 6.1.2 Discussion of mission, goals, values, and vision

NAU is a recognized national leader in online and distance education by providing access to higher education to students throughout Arizona for over three decades. The Arizona Board of Regents has recognized this in approving the university's mission:

**Goals:** Develop and provide curricular and educational opportunities that ensure the successful achievement of 2025 completion goals, and resonate with student and workforce needs in communities across the state.

**Mission**: Provide an outstanding undergraduate residential education strengthened by research, graduate and professional programs, and sophisticated methods of distance delivery.

**Vision:** The Extended Campuses of Northern Arizona University delivers a respected, affordable university education to students wherever they want to learn. Through its statewide community campuses, extensive online options, innovative

programs and passion for student success, Extended Campuses empowers busy people to advance in their careers and make a difference in their communities throughout Arizona.

The e-Learning Center aligns with this vision in that it improves access to higher education and creates efficiencies by cultivating the highest course quality and by developing faculty technological fluency.

The **Values** of Extended Campuses are articulated with goals outlined in the University's Strategic Plan: Student Access, Progress, and Affordability; Innovative, Effective, and Accountable Practices. The e-Learning Center is a unit within the Office of the Provost and thus also closely aligned with the university's strategic plan. The Center facilitates research on and provides support for engaging, effective, and efficient implementations of innovative pedagogy and education technologies in all modes of instructional delivery.

### 6.1.3 Description of programmatic investments

Access and Affordability. NAU has longstanding community college partnerships that provide students across the state with access to an affordable, quality higher education experience. By co-locating NAU facilities on community college campuses, students and communities can better achieve important workforce development goals in their hometowns, especially in high-demand fields like education and health sciences.

Through these partnerships, students can take lower division classes at the community college and then transfer into NAU to finish their four-year degree. These relationships have been further strengthened by education options like the 90/30 degree programs that allow students to transfer 90 hours of classes from a community college at a lower cost and complete the bachelor's degree in just 30 credit hours from NAU.

Northern Arizona University's tuition and fees are among the most affordable in the state and region. This is reflected in a number of offerings for traditional and non-traditional students. For example, the cost for students enrolled in NAU's Personalized Learning program is $3,000 per six-month subscription ($6,000 per year) which includes all fees, materials, and textbooks. NAU must provide increasingly flexible high-quality programs and services to remain competitive and ensure affordable access to Arizona citizens. Consequently, the A/WD initiative will increase NAU's capacity for delivering successful courses online and in the classroom away from Flagstaff.

Educational Access for Place- and Time-Bound Students. The A/WD initiative is focused on providing programs, curricula and courses delivered on the Web, hybrid and in-person to serve all NAU students with a special focus on place-bound and time-bound students. Course offerings are designed to meet the needs of education and health professions students while allowing them to remain in their communities as they engage in clinical placements or practicums in school districts. The initiative is committed to providing exemplary student services, including success coaching,

advising, and assistance in-person at more than 20 offices around the state or at a distance through chat, Web access and toll-free telephone.

Off-Campus Program Options. Off-campus education continues to play an important role in the mission and financial well-being of the university, allowing not only for flexible options for students, but also for the institution to respond to emerging opportunities across the state. Northern Arizona University now offers over 100 program options away from the Flagstaff campus. The A/WD initiative will continue to advance Northern Arizona University reputation as an e-learning leader. Funds will support new and on-going research to apply cognitive learning principles to implement effective, efficient, and engaging uses of learning technologies. As technologies evolve, funds will support faculty, staff, and student engagement in designing and supporting the next generation learning environment.

### 6.2 Expected Outcomes as a result of TRIF investments

NAU has delivered consistent, positive outcomes through past TRIF A/WD initiatives. Extended Campuses has recruited hundreds of students, whether transfers from community colleges, K-12 educators, or other community business members from both the for-profit and not-for-profit sector. Outcomes for the current proposal include an estimated 2,000 Arizonans who will be awarded college degrees in education and health sciences, enhanced coaching and mentoring of students to improve retention and completion rates enhanced coaching and mentoring of students, and the continued growth of overall student engagement and enrollment.

In addition, our cutting-edge work with Competency-Based Education has allowed NAU to develop singular experience and expertise in the complexities of offering non-term-based CBE programs without being able to rely on an existing technical architecture to support it. Our expertise in awarding Title IV funding to students enrolled in CBE programs is at the forefront of higher education. Our innovative technical solutions in support of these accomplishments further enhances the teaching/learning experience by providing state of the art solutions designed to meet our quality and delivery standards of excellence.

#### 6.2.1 Specific and realistic goals that are clearly measureable

**6.2.1.1 Return on investment.** The U.S. Census Bureau states that a baccalaureate college graduate earns an average of $26,000 more per year than a high-school graduate.[2] First degrees and advanced academic training have an immense lifetime impact for the individual and add to the state tax base. Estimates for this difference over a lifetime equates to the bachelor's degree recipient earning an average of $1.1 million more than a high-school graduate. Given that it costs on average of about $15,000 (state general

[2] U.S. Census Bureau. (2012) "Table 232. Mean Earnings by Highest Degree Earned Government Printing Office. Retrieved from: http://www.census.gov/library/publications/2011/compendia/statab/131ed/education.html): 2009." Statistical Abstract of the United States: 2012 (131th Edition). Washington, DC: U.S.

fund and student tuition combined) per year to educate an undergraduate, the lifetime ROI to the student is $1.1 million on a university investment of $60,000. Based on the number of Northern Arizona University graduates from programs supported by TRIF A/WD funding over the last ten years, it is estimated that the 4,000 graduates from the current funding request will earn $100 million more in 2022 directly attributable to their degrees.

These investments in education and their return are notable in many ways, especially in small, rural communities where education and opportunity can be limited. NAU's presence makes a higher education possible, increasing opportunity, raising the educational attainment level, and helping advance overall productivity and life quality—improving education, health, and fostering economic development.

**6.2.1.2 Technology transfer.** Not applicable.

**6.2.1.3 Industry engagement (outreach, partnerships, collaboration).** NAU reaches out to individual students and to employers, whether they are industry, business, non-profit, government or schools, to recruit students and for both formative and summative evaluation of degree programs. EC has a team of over 20 outreach recruiters across the state interfacing with local industry to discover needs and develop pathways to degree attainment.

**6.2.1.4 Workforce contributions.** Within the five years of this initiative it is conservatively estimated that 4,000 new or advance-trained workers in Arizona will have benefited from the TRIF A/WD initiative by continuing their post-secondary education. It is estimated that 2,000 students will complete degrees or certificate programs within this time.

**6.2.1.5 Educational outreach.** Extended Campuses has outreach staff deployed across the state at community college campuses and at locations where contacts through business and industry are essential to building strong communities. Recruitment for education, health sciences and the new competency-based nursing programs is focused on Arizona residents and based on community need.

**6.2.1.6 Government Agency/Community Engagement (outreach, partnerships, collaboration).** Northern Arizona University has strengthened existing partnerships with community colleges throughout the state through joint admission to ensure that community college students can easily and seamlessly complete NAU bachelor's options. The 2NAU transfers have increased an average of 20% year over year in the last 5 years.

NAU recently entered into a new agreement with the City of Tempe to provide degree completion to a cohort of city employees at both the bachelor's and graduate level. Opportunities for degree completion in the upcoming competency-based RN to BSN program are currently under discussion with the potential partners. In the summer of 2016 the Nursing

program currently delivered in Tucson will move onto the Pima Community College West campus, further enhancing the partnership and providing shared learning resources and strengthening the student pathway to a bachelor's degree.

The roles of outreach recruiters statewide have become more proactive, focusing on acquisition of prospective student leads, conversion from a prospect to an enrolled student, and retention of current students. Outreach to businesses, organizations and community colleges has intensified. New agreements with the U.S. Customs and Border Patrol and out-of-state community colleges (e.g., Pikes Peak Community College) provide new pathways for students.

Marketing to prospective students is changing to include a variety of marketing and communications approaches to raise awareness of NAU, as well as the importance of a degree. The university will use traditional outreach via radio, out-of-house, and direct mail, and has most recently incorporated more aggressive digital outreach that includes targeted approaches to lead generation, websites are maximizing search engine optimization strategies and responsive techniques, and a social media marketing focus informally connected with prospective students.

#### 6.2.2 Annual metrics table of expected outcomes and timeline for achievement

(See Page 64)

### 6.3 Initiative Structure

#### 6.3.1 Organizational structure

Programmatic oversight for A/WD is in the Extended Campuses division with the Vice President for Extended Campuses who is directly responsible for all activities. By integrating the initiative into ongoing Extended Campuses operations, sustainability is ensured. For FY17 the Extended Campuses enterprise has a proposed budget across all funding sources of approximately of $37M, including $3.6M in TRIF dollars.

In close collaboration with Extended Campuses, the e-Learning Center provides expert learning design, educational graphics and creative design, learning technology implementation and services, and training support for all faculty members at NAU, regardless of location. Instructional Designers in the e-Learning Center are participating in the construction of new competency-based course architectures and thus developing the skillsets and knowledge base of the institution that will allow NAU to expand competency-based education program offerings.

### 6.3.2 Advisory Board

These are well-established programs under the direct oversight of vice presidential areas at Northern Arizona University. The Arizona Board of Regents and legislature provide final oversight.

### 6.3.3 Infrastructure

Extended Campuses supports a broad range of academic programs and functional areas, all with the end goal of student access, support, and success away from the Flagstaff campus. Funding for EC comes from state and locally retained tuition dollars, as well as TRIF.

### 6.3.4 Description of investment mechanisms

Educational Delivery to Place-bound Students. Northern Arizona University will continue to support targeted A/WD programs through this five-year plan in education and health sciences. TRIF funds program delivery, especially in rural communities, where student cohorts are smaller, and the investments have a significant and persistent positive impact on the community overall.

Competency-Based Education. An expansion to the A/WD initiative is the *Personalized Learning* (PL) program in nursing. NAU is the first state university to offer competency-based education, having launched three bachelor's degrees in 2013. Because of NAU's strong history of success in distance and online education, the expansion into competency-based programming was a logical progression to complement the changing needs of online students. The Personalized Learning RN-BSN program is projected to enroll 150 students in its first year when it launches in FY17 and quickly meet the needs of the nursing sector. Once the enrollments in the program provide adequate tuition revenues for financial sustainability, the program will move away from TRIF dollars. With the RN-BSN program launched, the Master of Science in Nursing is a graduate degree that has potential for the Personalized Learning model.

## 6.4 Initiative budget table (see Appendix Table 2E)

## 6.5 Plan for sustainability

### 6.5.1 Anticipated funding sources for ongoing support

Continued enrollment growth and tuition revenue from Competency-Based Education (CBE) programs presents a viable alternative to TRIF funding in the future. Key to this transition will be institutional self-sufficiency in developing additional online and CBE programs. By using open-source learning management systems and deploying the technical expertise of NAU faculty and the e-Learning Center, NAU will be in a strong position to develop additional, high-demand programs.

### 6.6.2 Timeline for transitioning away from TRIF support

TRIF support for this initiative is designed to provide consistent support for programs that will transition to other funding sources through growth in enrollment. TRIF funding for programs at NAU in Prescott Valley and online programs in Business Administration will be funded through State support dollars as well as locally retained tuition. The competency-based program in Nursing will launch in FY17. Once this program is self-sufficient, estimated in the fourth year, TRIF funding will be redirected to start new high-need workforce development degree programs, including, when feasible, new CBE programs.

The eLearning Center will continue to be funded by TRIF to support existing programs and new program development. Long term, the eLearning Center will be part of the next iteration of a comprehensive provost-level initiative to support teaching and learning for all faculty teaching and designing effective and efficient student learning experiences regardless of delivery mode or location.

**NORTHERN ARIZONA UNIVERSITY**

**Access and Workforce Development**

| PERFORMANCE MEASURES | Projected FY17 | Projected FY18 | Projected FY19 | Projected FY20 | Projected FY21 |
|---|---|---|---|---|---|
| **TRIF EXPENDITURES** | | | | | |
| Total | $ 5,010,000 | $ 5,061,000 | $ 5,112,000 | $ 5,163,000 | $ 5,214,000 |
| **FINANCIAL IMPACT OF TRIF INVESTMENT** | | | | | |
| Annual Impact of Graduates on Economy[1] | $ 5,174,000 | $ 7,279,220 | $ 9,389,097 | $ 11,503,769 | $ 13,623,383 |
| Degree/Certificate Programs Offered [2] | 75 | 77 | 79 | 81 | 83 |
| Business/Nonprofit Collaborations [3] | 160 | 175 | 190 | 205 | 220 |
| Number of Students Served by A/WD [4] | 4,000 | 4,400 | 4,840 | 5,324 | 5,856 |
| **WORKFORCE CONTRIBUTION** | | | | | |
| Web/Hybrid/Enhanced Courses Developed[5] | 150 | 160 | 170 | 180 | 190 |
| Faculty Developing Courses[6] | 370 | 400 | 430 | 460 | 490 |
| Increase in Student Technology Literacy[7] | 4,300 | 4,425 | 4,550 | 4,675 | 4,800 |
| Individual Faculty Trained in Teaching Technologies[8] | 250 | 275 | 300 | 325 | 350 |
| Faculty Support Incidents Resolved[9] | 17,000 | 17,250 | 17,500 | 17,775 | 18,000 |
| Faculty using Adaptive Courseware | 5 | 10 | 15 | 25 | 40 |

Proposed metrics and goals. Actual numbers will be reported annually

[1] Estimated based on U. S. Census Bureau Data for annual increase in earnings by a baccalaureate-trained worker compared to high school degree

[2] Number of degrees supported by A/WD funding

[3] Organizations (business, industry, nonprofits, school districts) with formal/informal relationships with NAU related to TRIF A/WD activities

[4] Number of students completing a course with significant or advanced technical fluency skills.

[5] Includes Web, hybrid, IT-enhanced, redesigns and quality review process compliance.

[6]Number of faculty participating in course development, design and redesign.

[7]Number of students completing a course with significant or advanced technical fluency skills.

[8]Number of faculty completing core eLearning training.

[9]The number of faculty eLearning help desk problems resolved

# APPENDIX

**Table 1: All Initiatives**

# Northern Arizona University

TECHNOLOGY AND RESEARCH INITIATIVE FUND (TRIF)

| FINANCIAL SUMMARY | Budget FY 17 | Budget FY 18 | Budget FY 19 | Budget FY 20 | Budget FY 21 |
|---|---|---|---|---|---|
| **REVENUE** | | | | | |
| TRIF Revenue | 13,659,200 | 14,459,200 | 15,259,200 | 16,059,200 | 16,859,200 |
| **TOTAL** | **13,659,200** | **14,459,200** | **15,259,200** | **16,059,200** | **16,859,200** |
| **EXPENDITURES** | | | | | |
| OPERATING BUDGET | 11,883,200 | 12,435,200 | 12,665,200 | 13,008,200 | 13,487,200 |
| CAPITAL BUDGET | 1,776,000 | 2,024,000 | 2,594,000 | 3,051,000 | 3,372,000 |
| **TOTAL** | **13,659,200** | **14,459,200** | **15,259,200** | **16,059,200** | **16,859,200** |
| **SUMMARY BY INITIATIVE** | | | | | |
| AWD | 4,510,000 | 4,556,000 | 4,602,000 | 4,648,000 | 4,694,000 |
| AZUN | 500,000 | 505,000 | 510,000 | 515,000 | 520,000 |
| Water, Environmental and Energy Solutions | 2,100,733 | 1,348,167 | 2,267,503 | 2,738,905 | 3,369,423 |
| Improving Health | 1,949,827 | 2,275,585 | 2,191,793 | 3,201,053 | 3,220,755 |
| National Security Systems | 4,376,957 | 3,465,588 | 3,394,525 | 2,335,607 | 1,377,873 |
| Space | 221,683 | 2,308,860 | 2,293,378 | 2,620,635 | 3,677,149 |
| **TOTAL** | **13,659,200** | **14,459,200** | **15,259,200** | **16,059,200** | **16,859,200** |

**Table 2A: Water, Environmental and Energy Solutions**

# Northern Arizona University

TECHNOLOGY AND RESEARCH INITIATIVE FUND (TRIF)
WATER, ENVIRONMENTAL, AND ENERGY SOLUTIONS

| FINANCIAL SUMMARY | Budget FY 17 | Budget FY 18 | Budget FY 19 | Budget FY 20 | Budget FY 21 |
|---|---|---|---|---|---|
| **REVENUE** | | | | | |
| TRIF Revenue | 2,100,733 | 1,348,167 | 1,536,332 | 2,738,905 | 2,249,712 |
| **TOTAL** | 2,100,733 | 1,348,167 | 1,536,332 | 2,738,905 | 2,249,712 |
| **EXPENDITURES** | | | | | |
| OPERATING BUDGET | 2,100,733 | 1,348,167 | 1,536,332 | 2,738,905 | 2,249,712 |
| CAPITAL BUDGET | - | - | 731,171 | - | 1,119,711 |
| **TOTAL** | **2,100,733** | **1,348,167** | **2,267,503** | **2,738,905** | **3,369,423** |

**Table 2B: Improving Health**

# Northern Arizona University

TECHNOLOGY AND RESEARCH INITIATIVE FUND (TRIF)
IMPROVING HEALTH

| FINANCIAL SUMMARY | Budget FY 17 | Budget FY 18 | Budget FY 19 | Budget FY 20 | Budget FY 21 |
|---|---|---|---|---|---|
| **REVENUE** | | | | | |
| TRIF Revenue | 1,621,364 | 1,634,502 | 1,550,710 | 1,919,045 | 2,579,252 |
| **TOTAL** | 1,621,364 | 1,634,502 | 1,550,710 | 1,919,045 | 2,579,252 |
| **EXPENDITURES** | | | | | |
| OPERATING BUDGET | 1,621,364 | 1,634,502 | 1,550,710 | 1,919,045 | 2,579,252 |
| CAPITAL BUDGET | 328,463 | 641,083 | 641,083 | 1,282,009 | 641,503 |
| **TOTAL** | **1,949,827** | **2,275,585** | **2,191,793** | **3,201,053** | **3,220,755** |

**Table 2C: National Security Systems**

# Northern Arizona University

TECHNOLOGY AND RESEARCH INITIATIVE FUND (TRIF)
NATIONAL SECURITY SYSTEMS

| FINANCIAL SUMMARY | Budget FY 17 | Budget FY 18 | Budget FY 19 | Budget FY 20 | Budget FY 21 |
|---|---|---|---|---|---|
| **REVENUE** | | | | | |
| TRIF Revenue | 2,935,577 | 2,977,363 | 2,903,950 | 1,207,561 | 886,798 |
| **TOTAL** | 2,935,577 | 2,977,363 | 2,903,950 | 1,207,561 | 886,798 |
| **EXPENDITURES** | | | | | |
| OPERATING BUDGET | 2,935,577 | 2,977,363 | 2,903,950 | 1,207,561 | 886,798 |
| CAPITAL BUDGET | 1,441,380 | 488,225 | 490,575 | 1,128,046 | 491,075 |
| **TOTAL** | **4,376,957** | **3,465,588** | **3,394,525** | **2,335,607** | **1,377,873** |

**Table 2D: Exploring Planetary Systems**

# Northern Arizona University

TECHNOLOGY AND RESEARCH INITIATIVE FUND (TRIF)
EXPLORING PLANETARY SYSTEMS

| FINANCIAL SUMMARY | Budget FY 17 | Budget FY 18 | Budget FY 19 | Budget FY 20 | Budget FY 21 |
|---|---|---|---|---|---|
| **REVENUE** | | | | | |
| TRIF Revenue | 215,526 | 1,414,168 | 1,562,207 | 1,979,689 | 2,557,438 |
| **TOTAL** | 215,526 | 1,414,168 | 1,562,207 | 1,979,689 | 2,557,438 |
| **EXPENDITURES** | | | | | |
| OPERATING BUDGET | 215,526 | 1,414,168 | 1,562,207 | 1,979,689 | 2,557,438 |
| CAPITAL BUDGET | 6,157 | 894,692 | 731,171 | 640,946 | 1,119,711 |
| **TOTAL** | **221,683** | **2,308,860** | **2,293,378** | **2,620,635** | **3,677,149** |

**Table 2E: Access and Workforce Development**

# Northern Arizona University

TECHNOLOGY AND RESEARCH INITIATIVE FUND (TRIF)

**Access and Workforce Development/Arizona Universities Network**

| FINANCIAL SUMMARY | Budget FY 17 | Budget FY 18 | Budget FY 19 | Budget FY 20 | Budget FY 21 |
|---|---|---|---|---|---|
| **REVENUE** | | | | | |
| TRIF Revenue | 5,010,000 | 5,061,000 | 5,112,000 | 5,163,000 | 5,214,000 |
| **TOTAL** | **5,010,000** | **5,061,000** | **5,112,000** | **5,163,000** | **5,214,000** |
| **EXPENDITURES** | | | | | |
| OPERATING BUDGET | 5,010,000 | 5,061,000 | 5,112,000 | 5,163,000 | 5,214,000 |
| CAPITAL BUDGET | - | - | - | - | - |
| **TOTAL** | **5,010,000** | **5,061,000** | **5,112,000** | **5,163,000** | **5,214,000** |
| **SUMMARY BY INITIATIVE** | | | | | |
| AWD | 4,510,000 | 4,556,000 | 4,602,000 | 4,648,000 | 4,694,000 |
| AZUN | 500,000 | 505,000 | 510,000 | 515,000 | 520,000 |
| **TOTAL** | **5,010,000** | **5,061,000** | **5,112,000** | **5,163,000** | **5,214,000** |