Alabama Research and Development Enhancement Fund
Quarterly Report
October 2021

shonda.gray@adeca.alabama.gov

Street Address: 401 Adams Avenue, Suite 560
Montgomery, Alabama 36104-4325

Mailing Address: Post Office Box 5690
Montgomery, Alabama 36103-5690

Background

The Alabama Innovation Act (AIA) was established by Legislative Act #2019-404 and became effective June 6, 2019. The Act designated the Alabama Department of Economic and Community Affairs (ADECA) as the state agency to establish and administer the Alabama Research and Development Enhancement Fund (ARDEF) Program.

The purpose of the ARDEF Program is to encourage new and continuing efforts to conduct research and development activities within the state. The Fund is designated to receive appropriations from the legislature, or from the receipt of gifts, grants, or federal funds to be expended for the purpose of increasing employment opportunities and products and services available to the citizens of Alabama.

Overview of 2020 Program Year

Projects Funded Under 2020 Round One Grant Period

Applicant	Amount
Auburn University – Removal of Per- and Polyfluoroalkyl Substances (PFAS) in Water and Landfill Leachate in Alabama	$193,960.00
Auburn University – Knitting Micro-Resolution Mosquito Bite Blocking Textiles	$868,145.00
Auburn University – Advanced Biosensors from Forestry Products and Agricultural Resources	$245,864.77
HudsonAlpha Institute for Biotechnology – Advancing Genomic Health in Community Clinics and Employee Wellness Settings	$969,409.00

Auburn University – Removal of Per- and Polyfluoroalkyl Substances (PFAS) in Water and Landfill Leachate in Alabama

This project aimed to remove and destroy the so-called forever chemicals, per- and polyfluoroalkyl substances (PFAS), from Alabama water and landfill leachate. PFAS have been detected in chemical manufacturing wastes and landfill leachate in Alabama and have caused some serious cases of drinking water contamination in the state. Ongoing health concerns and regulatory development associated with PFAS are threatening the sustainable development of the Alabama economy and business. The goal of this research was to develop an innovative "Concentrate-&-Destroy" technology to cost-effectively remove and degrade PFAS in water and landfill leachate. The new remediation technology will provide the affected industries and water utilities with a powerful remediation means to mitigate the PFAS-related issues, thereby assuring sustainable development of the economy and the wellbeing of Alabama citizens.

In this quarter, we have made progress on analysis and characterization of field PFAS-impacted water and landfill leachate. These tasks revolved around the analysis of PFAS and other water quality parameters in a PFAS-impacted stream, which has been serving as the drinking water source, and a municipal landfill leachate collected from two Alabama sites. The results detected 7 major PFAS in the stream water collected in July 2021 and December 2020, and the PFAS levels were significantly higher than the EPA advisory levels or far exceeded the regulatory levels of various states in the U.S. The results from the leachate analysis confirmed the high

concentrations of various anions and cations (especially organic carbon and chloride) in the landfill leachate. In addition, we have been testing our materials for adsorption and photodegradation of PFAS from the stream water, and the results will be reported in the next quarterly report.

Auburn University – Knitting Micro-Resolution Mosquito Bite Blocking Textiles

Insects transmit crippling diseases to humans. Nearly a half million people die of malaria each year. In Alabama, citizens encounter Dengue and Zika virus invasions as well as a multitude of encephalitis variants. The worse vector-borne diseases are transmitted in the hottest climates like Alabama, and it is uncomfortable to wear the thickest clothing. This project will research different textile and weave patterns to create clothing that is cool in heat and capable of blocking mosquito bites and develop prototypes based on this research. Beyond the prototype phase, research will be done to measure the effectiveness this product will have on the Alabama economy.

A knitting manufacturing lab was set up in Auburn, Alabama. Three machines were imported and installed including a Stoll ADF flatbed knitting machine from Germany, a Lonati circular knitting machine from Italy, and an Agtek threadtwister from Turkey. Training on the machines was completed. The Auburn knitting lab is now fully functional, and we are now designing and knitting sleeve prototypes in-house. During this quarter we trained with the Agtek fiber winder which is capable of twisting novel yarn geometries. As of this quarter we have completed the main objectives of Aim 1 and are now managing our own active knitting lab in Auburn, Alabama. During this quarter we designed, knitted, and tested a total of 35 novel knit prototypes. Importantly, we were able to identify and refine our key hypotheses about knit variables that lead to mosquito bite blocking.

Auburn University – Advanced Biosensors from Forestry Products and Agricultural Resources

The main goal of this project is to utilize Alabama's forestry products and agricultural resources for extracting cellulosic nanomaterials (CNM) by using these nanomaterials in advanced biosensing. As timber production and other agricultural products are essential for the economy in Alabama, these materials are a great resource for obtaining cellulosic nanomaterials. In this work, the Auburn University research team has explored CNMs from three different sources: cotton, soybean hulls, and wood. Irrespective of sources, these nanomaterials demonstrated great potential of being employed in advanced biosensing. Initially, the team has explored antibody-based detection of two emergent water contaminants with surface modified CNC. Successful detection of analytes was achieved. However, antibody-based schemes can be limited by a lack of specificity and antibody expense could overshadow accessibility to this technology. Therefore, while the initial results were a successful initial demonstration of the potential of CNMs in biosensing, the AU research team is planning on a new detection route which will overcome the limitations of antibody-based biosensors. The AU team is using Surface Plasmon Resonance (SPR) in addition to Quartz Crystal Microbalance with Dissipation (QCM-D) to investigate the sensing at a molecular level. Outstanding lab facilities along with the support from ADECA are enabling scientific knowledge contributions and revalorization of agricultural and forestry waste products as biosensors.

HudsonAlpha Institute for Biotechnology – Advancing Genomic Health in Community Clinics and Employee Wellness Settings

Genomic medicine is a form of precision medicine that uses approaches customized to each patient to treat disease and optimize prescription medicine based on a genetic profile. This project will test and develop a genomic health complete delivery system for Alabama patients and physicians at healthcare systems and community hospitals with limited expertise in genomics. This system includes 1) Partnering with Auburn University to develop community-based models for health programs, 2) Refining and optimizing the process including insuring access by rural areas that are underserved, and 3) Developing the health IT infrastructure needed to fully integrate genetic test reporting and education into an electronic health records system. The proposed development of new products and services will result in improved health outcomes for Alabamians, opportunities for employers to increase competitiveness and reduce costs, and modernization of health care in an equitable way for Alabama communities, large and small, regardless of socioeconomic status.

The HudsonAlpha ADECA/ARDEF project will develop and optimize genetic health screening programs with multiple partners around the state of Alabama, including large employers offering genetic testing to their employees. Phase 1 of this project will involve Auburn University and provide 1,000 Auburn employees with pharmacogenetic testing to identify medications that may or may not be optimal for some individuals with genetic factors that influence the metabolism of these medications. Phase 2 will take lessons learned from the Auburn project and deliver similar programs to other entities around the state, in diverse clinical settings. We have made progress in the most recent quarter by continuing to expand pharmacogenetic testing at existing partner sites (Auburn University, Miles College), and establishing new ADECA/ARDEF-funded programs (East Alabama Health), two additional universities (Oakwood University and Drake State), and one corporation in the Huntsville area.

Projects Funded Under 2020 Round Two Grant Period

Applicant	**Amount**
University of Alabama in Huntsville – Alabama Business Resiliency and Sustainability Index and Roadmap	$ 746,104.00
University of Alabama in Huntsville – Rural Employment and the Need for an Alabama Irrigated Acreage Survey, Demand Estimate and Forecast	$ 172,073.00
University of Alabama at Birmingham – A Comprehensive Data Science Software Toolkit to Improve Alabama's Mobility Planning for Serving Businesses and Vulnerable Populations	$ 394,926.00
Auburn University – Design, Fabrication and Testing of Novel Medical Facemasks to Prevent COVID-19	$ 75,374.00
Auburn University – Formaldehyde Paper-based Device (PAD) for a Cost-efficient Detection of Formaldehyde Emissions from Wood Panels	$ 247,142.00
University of Alabama at Birmingham – Commercialization of Small Diameter Artificial Vascular Graft for an Animal Trial	$ 906,458.00
Bashan Institute of Science – Exploring the Use of Cellulose Fibers as Microcapsules for Plant Growth-promoting Bacteria (PGPB) Inoculants	$ 7,500.00

University of Alabama in Huntsville – Alabama Business Resiliency and Sustainability Index and Roadmap

Recent events, such as the global COVID-19 pandemic, are having detrimental impacts on companies throughout Alabama, including the products and services they provide and the citizens they employ. Other impactful events that can occur may include the sudden loss of a major customer or supplier, a natural disaster, or even a diminishing source of skilled labor. The objective of this project is to research potential impacts on businesses and organizations across several business sectors to develop and deploy a comprehensive Resiliency and Sustainability Index and Roadmap (RSIR) model. The RSIR can be further tailored to fit each business sector and individual organization. Additionally, the UAH team will directly support businesses in the customization and implementation of their RSIR along with assistance in developing the ability to execute the roadmap and plan should the need arise.

During this reporting period, progress has been made in three phases of the Reliability and Sustainability Index and Roadmap (RSIR) project:

- Completion of Research Potential Impacts by Sector
- Continue Research and Development of the RSIR
- Draft of the Engagement Process
- Initiate Outreach Strategies

Research is complete for the Potential Impacts by Sector. Numerous resources have been reviewed, including journal articles, books, industry publications, research studies and news articles. Information was then compiled to capture categorizations of disruptive events as well as categorizations of the effects the events have on various types of businesses. There are currently six high-level categories of effects that can be mapped to each of the categories of disruptive events.

Research and Development of the RSIR model is very near complete. The model is constructed around the business systems of an organization and their functions. Each of the categories of effects are not only mapped to the disruptive event types, but also to the business systems and functions they impact. The model will evaluate capabilities a business has in place for both sustainability and resilience. Sustainability is the ability a business has to prepare for, respond to, and recover from a disruptive event. Resilience is the ability a business has to adapt to a changing environment. An assessment will be conducted to evaluate the capabilities of the practices in place in each of these areas and generate a score. The model is constructed to allow a drill-down investigation into the score to identify opportunities for improvement and allow for cross-cutting the results to look at components of the score by business system, disruptive event type, or even capabilities related to typical key performance indicators, such as quality, cost and delivery.

The Engagement Process is also near complete. The Engagement Process defines how the companies will be engaged in the assessment process and what will be accomplished in each of the three phases of the engagement. The first phase will capture general information about the company that can be used to tailor the RSIR model to only those components relative to the company and the sector in which they reside. The second phase consists of the detailed assessment and results in the RSIR score and roadmap to improvement. The third phase engages

the business in one-on-one support to implement improved practices that will increase their resilience.

The Outreach strategy has been drafted and initiated. As the model nears completion, outreach material is being developed to engage business and industry, as well as leverage economic development organizations. White papers are drafted to serve as both educational and marketing of the RSIR purpose and availability.

University of Alabama in Huntsville – Rural Employment and the Need for an Alabama Irrigated Acreage Survey, Demand Estimate and Forecast

As irrigated agriculture develops in our rural communities, it is imperative Alabama has the tools and data needed to ensure water resources are available for sustainable economic development. The goals of this project are to update the existing manual center pivot irrigation survey completed by UAH for the years to include 2017 and 2019 and develop a state-specific machine-learning framework from multiple sources of remote sensing products to efficiently and semi-autonomously identify the irrigated areas in Alabama to include all irrigated land such as golf courses and other irrigation system types beyond just center pivots.

During the third quarter, the team finished preliminary estimation of irrigated areas for 2017. A total of 2,069 Center Pivots were found totaling 135,847 irrigated acres. This was a 293 Pivot increase, and 14,453 irrigated acres increase from 2015. The UAH team has produced a preliminary data product of irrigation areas based on the Random Forest algorithm which shows promise over that of existing satellite remote sensing datasets. The preliminary products for 2019 will be used to aid in the pivot mapping exercise. The UAH and Auburn teams conducted an update meeting, and the TerrSet Land Change Modeler will be utilized to aid in the projection of irrigation land use.

The UAH and Auburn teams will continue to conduct the irrigation surveys and will expect to make progress on the 2019 survey in the next quarter. Outputs from the machine learning model will continue to be improved and evaluated against baseline Random Forest Runs and the manual pivot estimations. The TerrSet model will be constructed to include an irrigated ag land class for projections.

University of Alabama at Birmingham – A Comprehensive Data Science Software Toolkit to Improve Alabama's Mobility Planning for Serving Businesses and Vulnerable Populations

This project focuses on the development of a comprehensive data science software toolkit to support transportation planning for Alabama's businesses and vulnerable populations. Research activities include: (i) use of transportation user surveys and open data source collection to build a web-based data portal for mobility analysis in Alabama; (ii) development of agent-based urban transportation simulation models, and employment of machine learning techniques for transportation forecasts; and (iii) use of the developed tools to study scenarios that address pressing mobility needs in Alabama. Examples include (1) building a COVID-19 simulator to explore how various business reopening strategies affect the population's mobility and hence the virus spread; and (2) studying the impact of shared mobility services such as Uber/Lyft/Via, Zyp BikeShare stations and dockless electric scooters on local traffic congestion, transit use; and accessibility and mobility of vulnerable populations. The project will provide helpful

recommendations to transportation policy makers about transportation initiatives that can help Alabamians, including economically and physically disadvantaged ones, to gain access to jobs and critical amenities in an equitable and efficient manner.

During the reporting period of July to September 2021, the team completed the transportation simulation for studying the impact of micromobility services (i.e., e-scooters) on traffic operations. We used the UAB campus for a case study because the City of Birmingham has recently launched a pilot program to partner with two companies, Veo and Gotcha, to introduce e-scooter services, and we have access to a rich set of fine-grained datasets on travel demand and services around the UAB campus. To complete this task, we modified MATSim's carsharing module to support the mode of e-scooters, and we designed a proper scoring function to allow MATSim to select the proper travel mode among alternative modes. We also designed effective algorithms to generate realistic population day-plans for the simulated transportation network, including traffic generated by students attending classes, traffic generated by employees going to work, and background traffic where travelers are just passing through UAB. Our simulation results show that deploying e-scooters around the UAB campus does clearly reduce the car traffic and increase the traffic speed especially in peak hours. A demo video of our simulation with e-scooters can be found at https://youtu.be/zh_mHQ6ck4U.

Auburn University – Design, Fabrication and Testing of Novel Medical Facemasks to Prevent COVID-19

This research will focus on design, fabrication and testing of novel medical face masks to reduce and prevent spread of coronavirus COVID-19. Various woven, knitted and nonwoven fabrics and their combinations will be examined to be used in surgical face masks and N95 respirators. Computer aided design (CAD) of fabrics will be generated and virtually tested. After choosing the right fabrics based on these computer tests, prototypes of Surgical Face Mask Level 1 and N95 respirator will be produced. These masks will be tested against the ASTM (formerly known as American Society for Testing and Materials), Food and Drug Administration (FDA) and National Institute for Occupational Safety and Health (NIOSH) standards. Upon passing the tests, the technology and know-how that is developed will be used either in a start-up company or will be licensed to an existing U.S. commercial textile company to mass produce masks and respirators for public use in the next phase.

Several new versions of the mask have been developed. 25 samples of the final version (Version 5) were sent to a third-party independent testing lab in Michigan for performance testing including virus filtration. The results have been received which are satisfactory. Fluid flow simulation of the mask has been started using computer aided simulation with lasers. Antibacterial spray coating has been ordered which will be applied to the mask. A website has been established for the project: https://www.safemaskalabama.com. This website contains further information about the project activities for public use.

Auburn University – Formaldehyde Paper-Based Device (PAD) for a Cost-Efficient Detection of Formaldehyde Emissions from Wood Panels

Formaldehyde emission can be toxic to people depending on the time of exposure coupled with formaldehyde concentration. This level of exposure is generally not high in forest products because companies that make indoor products currently measure formaldehyde through quality control techniques. Companies also use safe adhesives ("glues") by partnering with their

suppliers. Nevertheless, these companies are regulated to federal standards such as the California Air Resources Board (CARB) to ensure this safety. To assist with the more expensive and laborious methods in CARB, this project endeavors to create a relatively cheap paper-based sensor that changes color based on formaldehyde exposure. Such a product can help to reinforce the safety of our forest products while maintaining the jobs of our many Alabamians.

The project entitled "Formaldehyde paper-based device (PAD) for a cost-efficient detection of formaldehyde emissions from wood panels" focuses on the development of a prototype of a paper-based device (PAD) for measuring formaldehyde concentration in air. The ultimate goal for the project is to develop an easy, rapid, accurate analytical tool for the determination of formaldehyde in air, at concentration levels below 1 ppm.

The progress of the research work performed during the second quarter of 2021 meets the goals described in the project's timeline. The main results are listed below:

- New methods for applying the color probes on the surface of functional fibers have been tested. The selected method allows us to produce larger number of samples with a uniform and consistent color.
- A percentage of color change on each paper sample (PAD) after being exposed to a known concentration of formaldehyde in air can be obtained by image analysis of the sample using Fiji Software. The data is being analyzed and reproducibility is being tested.
- A provisional patent application to protect the invention has been signed (Provisional Application No.: 63/252,916. Title: “Paper-based Formaldehyde sensor (PFS)”. File Date: October 6, 2021. AU IP No.: 2020-053-01).

University of Alabama at Birmingham – Commercialization of Small Diameter Artificial Vascular Graft for an Animal Trial

The goal of the project is to finalize the development of an artificial vascular graft for surgical implantation. The graft has relevance to the current COVID-19 pandemic in that numerous patients are reporting kidney infections and blood clots. UAB has been working on this project since 2007 and has reached a point where funds are needed for an animal trial. Once this graft has been validated through this process, we plan to market it to a biomedical implant company to set up a division in Alabama or to establish a spin off company for the production and distribution. This graft has the potential for an estimated $50 million in annual sales based on conservative estimates of the number of surgical interventions that could use the implant in an unmet market and lead to a number of jobs for highly skilled workers in the State of Alabama.

Progress continues on our development of the small diameter artificial graft for dialysis patients. We have received all the major equipment requested and are setting up and testing it now. A test of our current implementation of the graft has been made by our surgical team and found it to be performing well in terms of suturing and ability to sustain blood flow. We are continuing to develop the graft in preparation of our first longer term implantation.

Bashan Institute of Science – Exploring the Use of Cellulose Fibers as Microcapsules for Plant Growth-Promoting Bacteria (PGPB) Inoculants

Inoculation of plants with plant growth-promoting bacteria (PGPB) that enhance the yield of crops and growth performance of environmental plants is an old practice. Two main factors control the success of inoculation—effectiveness of the bacteria and application technology. If the suspensions of bacteria are inoculated into the soil without a proper carrier, the bacteria population declines rapidly. These unprotected inoculated bacteria must compete with the often better-adapted native microflora and withstand predation by soil microfauna. Consequently, a major role of formulation of bioinoculants is to provide a more suitable microenvironment, combined with physical protection for a prolonged period to prevent a rapid decline of introduced bacteria. This project explores the feasibility of using cellulose fibers as carriers, to improve survival and enhance the PGPB viability. During the third quarter we assessed different concentrations of cellulose fiber, that will successfully carry the biggest number of bacteria.

Overview of 2022 Program Year

Projects Funded Under 2022 Grant Period

Applicant	**Amount**
The University of Alabama – Innovative Wood-Concrete Composite Structural Elements for Resilient Modular Building and Transportation Structures	$341,679.00
Auburn University – Advanced Liquid Transportation Fuels from Co-Liquefaction of Forest Biomass and Waste Plastics	$727,677.00
Auburn University – Novel Biotechnology that Converts Agricultural and Municipal Waste into Bioplastics	$294,008.00
HudsonAlpha Institute for Biotechnology – Next Generation Crops for a Diverse Alabama Agricultural Economy	$968,365.00
The University of Alabama in Huntsville – Versatile Training to Provide an Agile, Advanced Manufacturing Workforce in Alabama	$603,206.00
Auburn University – Polymer Smart Machines	$268,353.00
University of North Alabama – Surface Plasmon Resonance-based Biosensors	$10,353.33
Auburn University – Novel and Sustainable Feed Binder from Soybean Hulls	$300,432.00
The University of Alabama at Birmingham– Amputation	$700,000.00
The University of Alabama at Birmingham – Pneumococcal Vaccine	$635,926.67

The University of Alabama – Innovative Wood-Concrete Composite Structural Elements for Resilient Modular Building and Transportation Structures

This research project focuses on the development of innovative materials and construction techniques that can help improve the sustainability and resilience of Alabama building and transportation infrastructure. The overall research goal of this project is to develop innovative hybrid structural building elements using fiber reinforced concrete, laminated wood materials (traditional lumber and/or bamboo) and characterize their performance under several loading

conditions. As part of this research, we will develop two types of hybrid elements and perform large-scale testing of these elements whereby they will be subjected to mechanical and impact loading (representing expected debris impact during a tornado event). We will also investigate the acoustic and thermal performance of these elements to understand their energy efficiency for building applications. The novel and validated structural elements can provide opportunities to attract new industries and supply chains related to prefabricated building systems.

Auburn University – Advanced Liquid Transportation Fuels from Co-Liquefaction of Forest Biomass and Waste Plastics

The main goal of this project is to advance economic development in Alabama (and the nation) through reinvigoration of our natural resource-based industries and to establish new industries based on advanced liquid fuels from woody biomass grown in the state and the waste plastics collected from our local cities. Woody biomass prevalent in Alabama will be co-liquefied with waste plastics using a pyrolysis technology, which will then be subjected to hydrogen treatment to produce jet- and diesel- fuels. The funding from the Alabama Innovation Fund will be used to overcome technical barriers faced in converting woody biomass to biofuels and waste plastics recycling. The research will be focused on developing: (i) a process that would require lower capital and operating cost for biomass liquefaction; (ii) catalysts for the production of jet- and diesel-fuels; and (iii) a pathway for recycling waste plastics for the production of liquid fuels along with woody biomass. The team will leverage existing infrastructure and expertise at the Center for Bioenergy and Bioproducts at Auburn University.

Auburn University – Novel Biotechnology that Converts Agricultural and Municipal Waste into Bioplastics

Alabama is one of the top agricultural producing states in the U.S., with annual agricultural exports exceeding $1 billion. As a result, there is a significant amount of organic wastes produced in the state, and Alabama ranks 14th among all states in terms of biogas generation potential from organic waste through anaerobic digestion (AD). These organic wastes represent an underutilized renewable feedstock for biofuel and biochemical production. This project aims at researching and assessing the economic feasibility of converting organic wastes into bioplastics. Specifically, the project will develop and optimize a prototype of a patent pending biotechnology that enables the conversion of organic wastes into bioplastics, and to assess its technical and economic feasibility at scale through techno-economic analysis (TEA). In the proposed technology, a microalgae-methanotroph coculture will be cultivated in a novel patent-pending circulation coculture biofilm photobioreactor (CCBP) to convert biogas (both methane and carbon dioxide) derived from organic wastes into microbial biomass while simultaneously recover chemicals from AD effluent to produce treated clean water. The produced mixed microbial biomass can be economically processed to produce high-value bioplastics that are in rising demand. The project will advance the progress of the patent pending biotechnology towards commercialization, which has potential to create many new jobs in the State of Alabama.

HudsonAlpha Institute for Biotechnology – Next Generation Crops for a Diverse Alabama Agricultural Economy

The HudsonAlpha ADECA/ARDEF project, in collaboration with Auburn University Crop, Soil and Environmental Science and Pathology Departments, and Alabama A&M Winfred Thomas Agricultural Research Station will develop a pilot pipeline to import and test new crop varieties that could be deployed by Alabama farmers. We will connect the advanced agronomy crop research at Alabama Land Grant Institutions to the advanced plant genetic and genomic science expertise at HudsonAlpha. For two crops, barley and beans, the team will bring in diverse germplasm, plant and evaluate cultivars to advance in additional trials. Barley will be tested as an overwinter crop for a spring harvest in Northern and Southern Alabama and dry beans will be tested as a summer crop in North Alabama. The team will evaluate disease, environmental, and weed pressure and other important agronomic traits for a crop to be successful in our challenging farming climate. As part of the goals, the partners will focus on increasing economic awareness of local barley and beans, connecting into existing educational and career development frameworks, and partnering with end users for brewing and food applications to increase the value of these Alabama crops. As this project develops, the teams will work with local farmers who are interested in planting alternative crops and engage stakeholders in workshops to discuss the science of next generation crop development to expand partnerships and apply this strategy to more crops useful for Alabama. With this newly developed research and collaborative infrastructure to bring in additional crop options, we can take control of the future of Alabama farming by optimizing the genetics and germplasm for Alabama, train new scientists in advanced plant science, open up new economic development in agriscience, and expand the current impact of local food and beverage industries.

The University of Alabama in Huntsville – Versatile Training to Provide an Agile, Advanced Manufacturing Workforce in Alabama

The overall goal of the proposed institutional collaboration is to assist in the transition of Alabama from a low-labor-cost manufacturing state to a leader in the research and development of next generation manufacturing sciences. To meet this goal, our primary objective is to expedite trans-disciplinarily, inter-disciplinarily, and multi-disciplinarily training of Alabama students for entering the industrial and government workforces and contributing to the implementation and advancement of the emerging manufacturing technology through Additive Manufacturing. Resources from this grant will expand our Additive Manufacturing Laboratories thereby enhancing and expanding our education and research capabilities. This collaborative environment will provide our students with the skills necessary to support research and development activities within industry and government.

Auburn University – Polymer Smart Machines

This project aims to research and develop the foundational building blocks of polymechatronics, which will enable the realization of 3D printable polymer smart machines. The research and development includes designing, fabricating, modeling, and characterizing piezopolymer versions of traditional mechanical and electrical building blocks such as actuators, sensors, energy harvesters, energy storers, and analog & digital circuit elements. Conventional 3D printed structures do not actuate or compute. However, if successful, the proposed project will lead to the first 3D printable smart machines that can actuate and compute without the need of externally-manufactured actuators and circuits. Compared to traditional devices, polymer smart

machines are expected to be orders less expensive, easier to manufacture, biocompatible, recyclable, use less energy, operate over a larger range of temperatures, offer new functionalities, and be more environmentally friendly. Such attributes are expected to enable a wide spectrum of novel mechatronic components and products for consumers.

University of North Alabama – Surface Plasmon Resonance-based Biosensors

Biosensors are devices that convert a biological response into an electrical signal; and, they are increasingly prevalent across multiple industries including (i) food industry to check and verify the quality of the vegetables, fruits and meat, (ii) medicine and health industry to diagnose biological samples for diseases, ailments etc., and (iii) monitor safety industry to identify harmful chemicals. The current state of biosensors' sensitivity is often limited to minute concentrations of the molecules/agents under testing, usually in the range of 5 ng/mL. Due to this limitation, the biosensor output may lead to a failed detection and/or recognition that might cause harm to life.

A novel technique will be used to enhance the sensitivity of the biosensors based on the principle of surface plasmon resonance (SPR). Numerical investigations have suggested that this novel technique can improve the sensitivity by at least 5-fold, which facilitates easier detection of biomolecules in concentrations not possible using other biosensors. Upon building and successful testing of the SPR sensor system with regular glucose samples, the plan is to detect cow milk allergy agent and Staphylococcal enterotoxin B (SEB), which are important biomolecule agents in the food industry. The proposed biosensor setup can also be used for medical diagnostics.

Auburn University – Novel and Sustainable Feed Binder from Soybean Hulls

The goal of this project is to establish a low cost, high value, and novel compound feed binder from soybean hulls (SBH), a co-product of soybean processing for oil and meal production. The specific objectives of this project are twofold: 1) to scale-up feed binder production to around 1.5 kg/hour and optimize process conditions for production; and 2) to scale-up shrimp feeding trials simulating shrimp farming operations at a commercial shrimp operation in West Alabama. Successful completion of this project will establish a high value and novel compound feed binder platform using 100% soy hulls that is ready for commercial scale productions and applications with significant economic and environmental benefits: it will significantly enhance competitive advantage of shrimp farmers in Alabama by reducing their feed costs. This will in turn improve employment opportunities in seafood farming and processing sector, making more local seafood and services available to the citizens of Alabama. In addition, it will also significantly improve water quality by reducing leached nutrients.

University of Alabama at Birmingham – Amputation

Approximately 1.6 million people live with an amputation within the U.S., and amputation cases are expected to rise to approximately 3.6 million by 2050. 185,000 people have an amputation each year in the U.S., with a significant increase noted associated with COVID-19 infection. The conventional technology is unable to adapt to the dynamic residual limb as it atrophies over time and swells with heat or weight gain. Percutaneous osseointegrated prostheses (POP) are a promising development for the limb-prosthesis interface involving the direct skeletal attachment of the prosthetic device. Alongside the promising benefits of POP, significant risks are

present at the bone-implant interface including superficial and deep infection, inflammation, insufficient osseointegration, lack of vascularization, and implant loosening. The main goal of this project is to develop the multifunctional nanomatrix coating on POP that can be clinically translated for improved osseointegration of prosthetics, and other types of orthopedic and dental implants in order to help promote healing and prevent infection.

University of Alabama at Birmingham – Pneumococcal Vaccine

Streptococcus pneumoniae is a leading cause of bacterial pneumonia and meningitis, resulting in more than 2 million pneumococcal infections and more than 6,000 deaths each year in the United States. Mortality rates are high especially in very young, elderly, and immunocompromised individuals. In Alabama, invasive *Streptococcus pneumoniae* represents a special concern to the State's aging population, as well as in the rural and economically deprived communities with limited access to routine health care. The currently available pneumococcal vaccines in clinic, *e.g.*, PPV23 and PCV13, have limitations. For example, PPV23 is not effective in children younger than two years old, the elderly, and immunocompromised individuals; and while PCV13 is effective for children, it has limited serotype coverage (fewer than PPV23) and requires an inconvenient four-dose immunization schedule for infants and young children. Moreover, none of these clinical vaccines provide effective protection against *S. pneumoniae* serotype 3 (ST3), a significant cause of morbidity and mortality worldwide. In this project, we will develop enhanced PPV23 and PCV13 vaccines which can provide increased protection with reduced number of immunizations. The enhancement will be achieved by employing the potent new vaccine adjuvants recently discovered in the Principal Investigator's laboratory at UAB. Success of this project will benefit the citizens of Alabama and have broader positive impacts on global health as well.