. **Innovation[X] 2021-2022 Proposal Application**
The School of Innovation and Innovation Partners are calling for proposals for the next round of our Innovation[X] Program, which provides grants that allow multidisciplinary teams of faculty, undergraduates, graduate students, and postdocs to work together to address complex real-world challenges.

Faculty may apply for grants of up to **$20,000** to facilitate year-long projects. The number of grants to be awarded will depend on funding and application levels. Funding begins September 1, 2021.

Additionally, we have partnered with the Mays Innovation Research Center to fund a set of proposals to study the process of innovation itself. Successful proposals for this subset will pursue topics such as, barriers to or preconditions for innovation, the effects of law and policy on innovation, the behavior or psychological requirements for innovation, innovation and health, the social impacts of innovation, international comparisons of innovation, or novel measurements of innovation.

Proposals are due by 11:59 PM on our **newly extended** deadline of **February 22, 2021** and must be submitted using this online form.

NOTE - Only one team leader/faculty member needs to submit a proposal for a given project.

Reminder of Requirements:
- Teams must consist of an interdisciplinary set of faculty members, and must include two (2) faculty members from different colleges/schools.
- Teams must include a multidisciplinary team of 10-20 students, both undergraduate and graduate, from across the university.
- At least 8-10 of these students must be undergraduates.
- The team must include students from at least two (2) different colleges/schools.
- Students must participate in the project for both Fall 2021 and Spring 2022 semesters, with limited exceptions.
- Proposals should demonstrate a team-based approach to a complex problem and include meaningful deliverables.

Please contact Assistant Director Emily Finbow at innovationx@tamu.edu or 979-862-6071 with questions.

. For which tracks would you like your proposal to be considered?

- ○ Track A - Traditional Innovation[X] Project
- ○ Track B - Special Track - "Process of Innovation" Innovation[X] Project
- ◉ Both Track A and Track B

. Project Title

Prototyping Blue-Green Infrastructure as Complex Adaptive Systems for Space Habitats

. *Please provide the following information for the Primary Point of Contact for the Project (Project Leader)*

. Prefix

Dr.

. First Name

Hope Hui

. Last Name

Rising

. Email Address

hope.rising@tamu.edu

. Phone Number

5039620220

. Gender Identity

- ○ Man
- ◉ Woman
- ○ Trans Man
- ○ Trans Woman
- ○ Genderqueer
- ○ Non-Binary/Gender non-conforming
- ○ Not listed above, please specify
- ○ Prefer not to respond

.
Ethnic and Racial Identity

- ○ Hispanic/Latino/a/x
- ○ American Indian or Alaska Native
- ◉ Asian/Pacific Islander/Desi-American
- ○ Black/African American

- White
- Bi-racial / Multi-Racial (please specify):
- Not listed (please specify):
- Prefer not to respond

. Project Information

. Please provide brief background/context for the issue this project seeks to address. (2,000 character maximum)

In 2020, the Earth transitioned from an 11-year cycle of solar minimum to another 11-year cycle of solar maximum. The intensity and frequency of solar activities are going to increase until 2025 during the first half of the solar maximum cycle. This will lead to more sudden stratospheric warmings (SSWs) above the Arctic to destabilize the polar vortex. The resultant arctic blasts can threaten water, food, energy, material, and thermal security in regions unprepared for freezing conditions. In addition, all the ice on Earth can potentially melt at once to increase the sea level by 217 feet when more intense and frequent solar storms impact the Earth. The impacts of solar storms will become more severe because the magnetic field (that protects the Earth from solar radiation) has been weakening at an alarming rate. The rapid reduction of the Earth’s magnetic field suggests that a magnetic polar reversal is overdue. Polar reversal can cause large-scale tidal waves to inundate most of the eastern half of the United States. This can result in widespread contamination of water, land, and air due to underground sewer backing up into basements and streets and flood-induced explosions at nuclear plants, petrochemical refineries, chemical plants, and oil and gas pipelines. Solar storms can also incapacitate global power grids, radio communications, and global positioning systems (GPS) to lead to power outage from weeks to months and the associated interruptions in potable and waste water distribution systems, heating and cooling systems, food refrigeration systems, life-support systems in medical facilities, gas stations, cellphone service, and transportation. It is currently difficult to predict the seasonal variations of solar eruptions and the spatial distributions of their resultant catastrophic terrestrial events until the increased activities can be observed in the sun about a few days before the solar activities take place.

. What are the goals for this project? (5,000 character maximum)

As space weather events result in increasingly more space-like adverse living conditions on Earth, there is a pressing need to build our capacities to evacuate timely and relocate proactively to circumvent the impacts of these events. The invention of artificial gravity has drastically upscaled space habitats to enable 9000 to a million people to be relocated from space weather impact zones at once to space planetary surface habitats deployed in flood-resilient locations on Earth and in the outer space. However, mass productions of large space habitats have been cost-prohibitive because space habitats have often required external resources and mechanical systems to provide water, food, energy, materials, and environmental control without harmful growth of microorganisms for astronauts and space equipment. Space habitats cannot become environmentally, economically, and socially viable long-term life support systems for widespread applications until an effective landscape approach can be developed to integrate microorganisms into ecosystem service providers (ESPs) to create self-sustaining and cost-effective water, food, energy, material, and microclimate systems. Our first project goal is to develop a modular landscape approach that maximizes system- and component-level production of natural (NESs) and cultural ecosystem services (CESs) from microbial ESPs as building blocks of a space habitat. The objectives for the first project goal are to identify parameters of ESPs to be optimized to effectively 1) transform domestic wastewater into reusable water, nutrient, energy, food, and materials (NESs); 2) maintain a healthy microbiome (NES); 3) facilitate thermal comfort (CES); and 4) increase inhabitants’ attachment to and willingness to finance and maintain these ESPs (CESs). Compared to centralized infrastructure, decentralized infrastructure is more suitable for space habitats due to its scalability and more fail-safe nature. Yet, the intense maintenance needs of decentralized landscape infrastructure require private financing and stewardship associated with users’ functional, emotional, and cognitive dependence on ESPs as loci of place attachment. The project will target the following four microbial ESPs as potential building blocks of space habitats: 1) blue modules (microbial fuel cells (MFC) in wastewater); 2) green modules (rhizodeposition-based MFCs); 3) blue-green modules (MFCs with wetland plants partially submerged by wastewater); and 4) green-blue modules (MFCs both within the elevated growing medium and the subsurface wastewater with exposed wetland plant roots). The bio-electricity from MFCs can help power a fan to move the warmer ambient air into the cooler subsurface chamber to help keep relative humidity (RH) above the chamber below 60% to minimize harmful growth of microorganisms. The subsurface chamber condensates the incoming warmer air into reusable water to provide water to humans, protein-rich plants, and algae for fish to offset the loss of water to evapotranspiration while keeping RH in the chamber cavity between 70% and 80% for growing fungal mycelium as a source of 3D-printable material. For the green and green-blue modules, the heat produced by MFCs helps minimize surface moisture buildup on soil, plants, and other surfaces to mitigate microbial growth while making air from green and green-blue modules warmer and dryer compared to the blue and blue-green modules with greater evaporative cooling effects. Our second project goal is to make space habitat design science actionable with and for society to accelerate humanity’s preparedness for extreme space weather events and readiness for interplanetary migration. The objectives of the second project goals are to 1) provide hands-on education on space habitat design to students; 2) design space habitats through interdisciplinary collaboration; 3) develop a proof of concept; and 4) collect and leverage pilot data for broader impacts and external funding. For objectives one and two, we will issue a call for participation in a space habitat design challenge to invite faculty and students from around the campus to participate in three three-hour geodesign games each semester. The results of the literature review from project goal one will be used to inform the briefing materials and game cards used by the geodesign games. For objectives three and four, the project faculty team will work with 10 undergraduate student leaders with the most relevant backgrounds among the design game participants, applicants from the Aggie Research Program, and the student networks affiliated with our faculty team leaders and members. The faculty team will also identify relevant thesis and dissertation topics for interested graduate students to pursue. The select group of undergraduate and graduate students will work with the faculty team to develop a prototype demo and collect pilot data in support of applications and proposals for external funding.

. What are anticipated outcomes from this project? (e.g., publications, website, app, data collection for further research/grant) (2,000 characters maximum)

The students recruited by the faculty team will work with the faculty within their subject areas as the main advisors and other faculty as secondary advisors. The faculty and student team will generate literature review publications, build one prototype demo, and collect pilot data to support external funding proposals. Project goal one will result in two literature review publications on optimizing the microbial ESPs as components and systems to maximize the production of NESs and CESs. Specifically, the publications are intended to 1) inform the design of future controlled greenhouse and field experiments to maximize the production of NESs; and 2) identify hypotheses of component and network configurations that maximize space habitats' production of CESs, such as microclimatic and social performances. Project goal two will lead to a third publication on the effectiveness of the space habitat design games as open innovation systems that facilitate the inflows and outflows of ideas and information within and across the design, automation, microbial, engineering, and ecological components of the project. The manuscript will also evaluate the extent to which within-team disciplinary diversity contributes to the between-team coherence of outcomes to help converge team outcomes into consensus-based frameworks with fewer geodesign games. The evaluation will be submitted as pilot data for external funding proposals on testing design games as complex adaptive decision-making systems for solving complex problems. Finally, the team will develop a prototype demo and collect pilot data to demonstrate technical and financial feasibility for future funding proposals. The invited student leaders will also submit an application for the EPA People, Prosperity, and Planet (P3) Student Competition with a plan to develop the demo into a more refined prototype for implementation in a real-world setting.

. Is this proposed project an extension of existing work or a new endeavor? (1,200 character maximum)

This project is a new endeavor as it relates to integrating relevant work by the faculty. Rising has conducted visual preference surveys and discovered that water reuse motivated users' willing to finance and maintain blue-green infrastructure in the public realm. Rising are prototyping blue and green modules in a greenhouse. Dvorak has tested blue-green modules as rooftop field experiments. De Figueiredo and Han conducted a pilot lab experiment for testing the efficacy of microbial fuel cells in treating wastewater and producing bioenergy. The closed-loop microclimate system that Rising and Brown have been investigating can be made possible by integrating microbial fuel cells with blue-green infrastructure prototypes. Gu conducted plant experiments with aeroponics, which Rising, Brown, and Majji identified as a critical long-term space nutrition component. Pinchak investigated applications of microbial fuel cells in cultivating synergistic microbial communities to enable integration of animals into the space habitats. Each faculty will continue to deepen their expertise while developing links across expertise areas to create synergistic research outcomes.

. Is Institutional Review Board (IRB) approval required for this project?

Yes. Institutional Review Board approval will be required because the second half of each space habitat design game will prompt participants to complete a survey to generate evaluation scores for each team outcome. The evaluation scores will be used to distill components of a consensus-based framework for team outcomes. Additionally, there will be an intake survey that seeks to understand the level of expertise possessed by each participant in each of the relevant subject areas to facilitate intentional teaming based on maximizing and minimizing the disciplinary diversity of each team. The two teaming approaches create comparison groups for testing the hypothesis that higher intrateam disciplinary diversity leads to higher inter-team decision-making efficacy as indicated by higher coherence of team outcomes and thus fewer design games required to distill a consensus-based framework from team outcomes.

. *Team Participants*

. Please list all Team Leaders below (including yourself), including Prefix, Name, Title, and Department/School.

Dr. Hope Hui Rising, Assistant Professor, Landscape Architecture & Urban Planning. Dr. Manoranjan Majji, Assistant Professor, Aerospace Engineering Dr. Arum Han, Professor, Electrical & Computer Engineering Dr. Paul de Figueiredo, Associate Professor, Microbial Pathogenesis & Immunology

. Do any of the team leaders listed above have plans for a sabbatical or other extended leave away from campus during the 2021-22 academic year? Note: Selecting "yes" will not automatically disqualify a team, but rather will indicate that we need to have a discussion with your team about the nature of the planned leave in relation to the project.

No

. Please list all Team Contributors below, including Name, Title, and Department/School. *Please exclude anyone you already listed as a Team Leader.*

Robert Brown, Professor, Landscape Architecture & Urban Planning Mengmeng Gu, Professor, Horticultural Sciences & AgriLife Extension Bruce Dvorak, Associate Professor, Landscape Architecture & Urban Planning William Pinchak, Professor, Ecosystem Science & Management & AgriLife at Vernon

. Do you plan to assign someone other than a faculty leader as a “project manager” for your team (i.e., a graduate student, postdoc, staff person)?

- (●) Yes
- ( ) No
- ( ) Not sure yet

. What would be the ideal composition of team members for this project? What majors, disciplines, skills, backgrounds, or perspectives would you like to have on the team? (2,000 characters maximum)

The ideal team will be composed of sufficient faculty and student expertise around design, automation, microbial, engineering, and ecological systems as focus areas to be integrated. The design group will have majors from the College of Architecture, including Architecture, Landscape Architecture, Urban Planning, Construction Sciences, and Visualization. The engineering group will have majors from the College of Engineering, including Electrical and Computer Engineering, Civil Engineering, Mechanical Engineering, Biological Engineering. The design and engineering groups will focus on reshaping their disciplines to function synergistically with microbial ecosystem service providers to contribute to a self-regulating microclimate system within a closed-loop context. The microbial group will investigate strategies for minimizing harms from microbial activities and for maximizing the NESs coproduced by blue-green infrastructure modules and microbes through analyzing the microbial activities in water, air, and soil. The ecological group will study the synergistic interactions of microbes with ecological systems to influence the wellbeing of humans, plants, and animals to provide water, food, energy, material, and energy security. The automation group will integrate all elements from the design, engineering, microbial, and ecological groups into a complex adaptive system through automating feedback loops between groups to respond to weather station data and microclimatic sensors.

. Will your team also include any external organizations or individuals as either partners, clients, study subjects, beneficiaries of the work, etc.?

The space habitat design games enable NASA, the space tourism industry, and clean and green tech industries to cocreate space habitat designs with faculty and students to ensure the prototypes being developed meet user needs and market expectations. The outcomes of the space habitat design game and the prototype developed will inform the student leaders’ application for the EPA’s P3 – People, Prosperity, and the Planet Competition to continue to develop the prototype for a real-world application. The project builds upon Dr. Majji’s existing work on AgRover for precision agriculture applications using instruments developed by Dr. Kumar from the El Paso Campus. The prototype demo from the project will help expand the capacity of the AgRover beyond soil-based precision agriculture to optimize food security with water, energy, material, and microclimatic security to benefit the community partners and projects associated with the Texas A&M AgriLife Extensions in El Paso and Vernon. The AgRover will also help improve the effectiveness of livestock research with cattle, sheet, goats, and rabbits at various AgriLife Research locations and the San Angelo Center at the Prairie View A&M University. The space habitat design game toolkits will be made available for download by any K-12 or college teachers interested in providing hands-on education to their students. The space habitat designs generated from the games will be exhibited nationally by the Landscape Architecture Foundation. The exhibit will help expand the Green New Deal with Blue New Deal and Space New Deal to enhance our capacities to adapt the impacts of more extreme space weather events. The space habitat designs will also be shared with the Congress to inform and catalyze actions from the RENEW Civilian Conservation Corps Act. These actions are intended to repropose Civilian Conservation Corps into residential campuses for job training in industries related to capacity-building for climate adaptation. The project outcomes will help inform a job training program for the Civilian Conservation Corps around the production and operation of space transit and planetary surface habitats as mobility modes and destinations for emergency evacuation and proactive relocation to enable as many terrestrial communities to circumvent the impacts of extreme space weather events. Finally, the space habitat designs will be shared with NASA and the Space Tourism Society to expedite the establishment of as many space transit and planetary surface habitats on Earth as possible through space tourism as a possible financing mechanism for building our capacities for interplanetary migration. This will enable more proving grounds for space habitats to be established as space tourism destinations to rapidly increase the carrying capacities of a network of resilient destinations to accommodate as many climate refugees as possible during extreme terrestrial and space weather events.

. Travel

. Does your proposal include travel for students beyond Bryan/College Station?

- ○ Yes
- ◉ No
- ○ Not sure yet

. Where would the team travel?

N/A

. When do you anticipate that this travel would take place? (e.g., Fall 2021, Spring 2022, some other academic break, TBD)

N/A

. Do you expect that all students selected for the team would be able to travel, or just a select number?

No

. Collaboration with Students

. Ideally, how many undergraduate students would you select to participate on this team? (Numeric responses only, please)

10

. Ideally, how many graduate students would you select to participate on this team?

5

. Ideally, how many professional or doctoral students would you select to participate on this team?

5

. How will you facilitate collaborative inquiry on the team? How often and in what format will the team meet? How will you divide tasks? How you will ensure effective management of the project (e.g., appoint a student as a project manager, assign that role to a faculty leader, etc.)? (2,500 character maximum)

We will select a minimum of 10 undergraduate students with two in each focus area group as student leaders that will participate in all six space habitat design games. The undergraduate student leaders will work closely with the faculty team to conduct literature reviews, build a prototype demo, collect pilot data, and develop external funding proposals. We will encourage at least 10 graduate student leaders, two from each focus group, to attend the space habitat design games to inspire them to take on relevant topics for their capstone projects, theses, and dissertations under the guidance of their respective faculty team advisors. The two undergraduate and graduate leaders for each focus area group will conduct one design game with faculty and students from similar disciplines after each space habitat design game to facilitate vertical integration that deepens each focus area. They will bring the results of the vertical integration back to the subsequent space habitat design game to facilitate horizontal integration with student leaders and faculty from other focus area groups. All student leaders and project faculty will attend all six design games to coordinate their efforts from various focus area groups. There will be two undergraduate student workers (10 hours per week) co-managing the design and participation aspects of the projects with Dr. Rising. Another two undergraduate student worker (10 hours per week) will co-manage the technical and system integration aspects of the project with Dr. Majii respectively. In addition, there will be a total of six or two undergraduate leaders from the each of the following three colleges: College of Medicine, College of Engineering, and College of Agriculture and Life Sciences. Each undergraduate student leader will receive a scholarship of $200 to attend six design games as a team leader. They will be supervised by faculty from their respective disciplines. These undergraduate student leaders and graduate students interested in space habitat as a research topic for their graduate study requirements will be recruited by the project faculty from each college to amplify the impacts of this project. Additional students will be recruited through the call for participation in the space habitat design games and the Aggie Research Program and managed by the student leaders and project faculty. They will also participate in the design games and may elect to continue to work on the project beyond the design games.

. What might students gain from their participation (e.g., conducting research directly with subjects, contributing to publications, using language skills)? What unique and differentiated learning opportunities would be available for graduate students? (2,500 character maximum)

The participating students will gain hands-on education on different aspects of space habitat design through the design games, including closed-loop systems, the nexus of food, energy, and water, microclimatic design, and the interactions between microbiomes, water, plants, animals, and humans. In addition, they will contribute to publications and proposals and develop teamwork and leadership skills in interdisciplinary settings. Specifically, the students will learn how to situate discipline-specific research topics within the context of convergent research using complex adaptive system as a framework. They will learn how their home discipline makes decisions and interacts with other disciplines to result in the emergence of interdisciplinary synergies that are greater than the sum of individual disciplines. The students will also develop their capacities to bridge convergent with translational research to help solve complex wicked problems. For the graduate students, they will be exposed to a wide range of skills brought by the faculty team, including human energy budget modeling, experimental designs for controlled lab research and field research, microbial analysis of water, soil, and air, prototyping microbial fuel cell modules, measuring NESs and CESs, quantifying the environmental impacts of plant components, and developing adaptive systems with computer vision, smart sensors, robotics, machine learning, and integration with the weather stations and microclimatic data.

. *Timeline and Budget*

. Identify the timeline for the project, including start, completion and major project milestones.

NOTE - You may use the text box or upload a table or file in the next question.

September, 2021 - Literature Review + Recruiting Design Game Participants + Design Game One (09/11/2021) October, 2021 - Literature Review + Design Game Two (10/16/2021) + Demo Design Development November, 2021 - Manuscript Writing + Design Game Three (11/13/2021) + Demo Design Development December, 2021 - Manuscript Writing + Demo Design Development January, 2022 - Manuscript Submission + Design Game Four (01/15/2022) + Demo Prototyping February, 2022 - Proposal Writing + Design Game Five (02/12/2022) + Demo Prototyping March, 2022 - Proposal Writing + Design Game Six (03/12/2022) + Pilot Data Collection from Demo April, 2022 - Proposal Writing + Pilot Data Collection from Demo + Project Reporting

. Timeline Upload (if needed)

Innovation_Grant_Timeline.docx
18.7KB

application/vnd.openxmlformats-officedocument.wordprocessingml.document

. Total Budget Request (numeric response only, please). As a reminder, the maximum amount that can be requested is **$20,000.**

$20,000

. You may upload a budget table here encompassing the categories below, or you may complete the fields below through this form as applicable.

For each item listed below or on your budget table upload, please enter both dollar amount and any relevant notes/justification.

Innovation_Grant_Budget.docx
28.7KB
application/vnd.openxmlformats-officedocument.wordprocessingml.document

. GRADUATE OR RESEARCH ASSISTANTSHIP (PHD) *(Suggested range: $15-18/hour; note: RAships for students in graduate school should include costs for tuition remission and fees)*

. RESEARCH ASSISTANTSHIP *(Suggested range: $12-15/hour)*

. INSTRUCTION (Teaching) - PHD STUDENT

. POST-DOCTORAL OR STAFF EFFORT

. UNDERGRADUATE STUDENT STIPEND OR WORK STUDY *(Suggested range: $11-14/hour)*

. INSTRUCTIONAL, RESEARCH OR OFFICE SUPPLIES

. COMPUTERS AND MINOR EQUIPMENT

. TRAVEL - DOMESTIC

. TRAVEL - INTERNATIONAL

. CONTRACT WORK

. MEETINGS - BUSINESS

. OTHER - MISC.

. Please briefly note below any other sources of project funds. *(Projects that match or leverage additional funds are strongly encouraged. Please note any such funds, awarded or proposed, here so that we understand the comprehensive outlay for the project.)*

An expanded scope has been proposed for the X-Grant large team funding opportunities (up to 1.5 million for three years) to fund controlled greenhouse and field experiments on the roofs of Langford Buildings and in AgriLife rangelands across the state using 24 prototypes for each of the four modules. The X-Grant project will also use the pilot data from the indoor and outdoor experiments to evaluate the microclimatic and social performances of alternative space habitat component and system configurations generated by design games and literature reviews using human energy budget modeling and visual preference surveys. The X-Grant did not have the space habitat design games and the evaluation of design games as possible modes of interactions for generating innovative team outcomes that are greater than the sum of the parts. The X-Grant will also be used fund graduate students while the Innovation Grant will be used to fund undergraduate students.

. Please name a Unit/Business Manager who could administer funds for project, if requested. Include their name, email address, and phone number:

Kevin Gustavus from the College of Architecture could administer funds for the project. Kevin can be reached by email at kgustavus@arch.tamu.edu or by phone at 979.845.4971

Location Data

Location: (37.420501708984, -88.887901306152)

Source: GeoIP Estimation

Timeline: The tasks and associated timing of the proposed project are as follows:

September, 2021 - Literature Review + Recruiting Design Game Participants + Design Game One (09/11/2021)

October, 2021 - Literature Review + Design Game Two (10/16/2021) + Demo Design Development

November, 2021 - Manuscript Writing + Design Game Three (11/13/2021) + Demo Design Development

December, 2021 - Manuscript Writing + Demo Design Development

January, 2022 - Manuscript Submission + Design Game Four (01/15/2022) + Demo Prototyping

February, 2022 - Proposal Writing + Design Game Five (02/12/2022) + Demo Prototyping

March, 2022 - Proposal Writing + Design Game Six (03/12/2022) + Pilot Data Collection from Demo

April, 2022 - Proposal Writing + Pilot Data Collection from Demo + Project Reporting

Budget Items	Subtotal
Undergraduate Work Study (Design)	$7,200 ($12/hr * 10 hrs * 2 semesters * 2 students)
Undergraduate Work Study (Automation)	$7,200 ($12/hr * 10 hrs * 2 semesters * 2 students)
Undergraduate Student Scholarships*	$1,200 ($200/student * 6 students)
Undergraduate Work Study Subtotal	***$15,600***
Material Costs for Prototype Demo	$4,400
Research Supply Subtotal	***$4,400***
Project Total	**$20,000**

*The student leader scholarships will be used to compensate six undergraduate students selected by the faculty team to lead the students in the Microbial, Engineering, and Ecological Groups during the six three-hour Space Habitat Design Games. The hourly rate is approximately $11.11. The six student leaders will provide the four undergraduate work study students from the Design and Automation Groups their input on literature reviews, the prototype demo, and the application for the EPA P3 Competition.