

**AGENDA ITEM BRIEFING**

**Submitted by:** Joe Elabd, Ph.D., Vice Chancellor for Research  
The Texas A&M University System

**Subject:** Establishment of the Texas A&M Space Institute

**Proposed Board Action:**

Establish the Texas A&M Space Institute as an organizational unit of The Texas A&M University System (A&M System).

**Background Information:**

A new era of innovation in space exploration and commercial aerospace fields is envisioned by the Texas Legislature for the space economy through the creation of the Texas Space Commission (TSC), the Space Exploration and Aeronautics Research Fund, and the Texas Aerospace Research and Space Economy Consortium (Space Consortium), per House Bill 3447, Regular Session by Representative Greg Bonnen, M.D. '88. The Texas A&M Space Institute will strategically lead the A&M System, Texas A&M University (Texas A&M), and associated agencies' efforts, to accelerate innovation through strategic planning in support of the Space Consortium, consisting of cross-sectoral engagement with the space community at-large. The institute will also support the Texas Research and Space Economy Consortium through the establishment of a Space Consortium that will advance Texas leadership in civil aviation, military aerospace, space economic development and space-related academic research and workforce development. The Texas Legislature appropriated \$200 million for the construction of a new Texas A&M facility adjacent to the NASA Johnson Space Center (JSC), which will house the TSC, the Space Consortium, the Texas Space Aeronautics and Curation Exploratorium (T-Space), and the Texas A&M Space Institute.

Texas currently accounts for 10% of the national space economy, and the potential for leading the competition being exerted by other states requires new strategies and focus on critical new alignments that can be forged by higher education institutions within the aerospace industry.

Texas A&M is a space-grant university with a long history of conducting basic and applied research and workforce development in human space exploration. Interdisciplinary space-related research occurs in more than 12 colleges/schools across Texas A&M, with broad expertise in space-related academic research, and proven leadership in seeking networks of private, government, and academic entities.

This institute will provide a multi-faceted approach to deliver on strategies for development of current and future workforce talent, economic drivers, and innovative and translational research through foundational Texas A&M tenets of academic excellence through transformational education, connectivity to local, state, national and international collaboration and partnerships, and growth of new knowledge to advance the Texas space economy.

**A&M System Funding or Other Financial Implications:**

State and federal funding opportunities are expected to support the Texas A&M Space Institute, including, but not limited to, facilities, equipment, general operations, salaries, and other Space Consortium-led initiatives. Funding will begin in fiscal year 2024.

**Strategic Plan Imperative(s) this Item Advances:**

Approval of this agenda item will advance A&M System Strategic Imperatives #4, #5, and #7, whereas #4: the A&M System will increase its prominence by building a robust and targeted research portfolio; #5: the A&M System will provide services that respond to the needs of the people of Texas and contribute to the strength of the state's economy; and #7: the A&M System will pursue pioneering/progressive opportunities to address national and global challenges.

**THE TEXAS A&M UNIVERSITY SYSTEM**  
Office of the Vice Chancellor for Research

July 25, 2023

Members, Board of Regents  
The Texas A&M University System

Subject: Establishment of the Texas A&M Space Institute

I recommend adoption of the following minute order:

**“The Texas A&M Space Institute is hereby established as an organizational unit of The Texas A&M University System.”**

Respectfully submitted,

**[ORIGINAL SIGNED BY]**

Joe Elabd, Ph.D.  
Vice Chancellor for Research

**Approval Recommended:**

**[ORIGINAL SIGNED BY]**

John Sharp  
Chancellor

**Approved for Legal Sufficiency:**

**[ORIGINAL SIGNED BY]**

Ray Bonilla  
General Counsel

**[ORIGINAL SIGNED BY]**

Billy Hamilton  
Deputy Chancellor and  
Chief Financial Officer

**[ORIGINAL SIGNED BY]**

James R. Hallmark, Ph.D.  
Vice Chancellor for Academic Affairs

**The Texas A&M University System**  
Texas A&M Space Institute

**EXECUTIVE SUMMARY**

***1. Rationale for the Creation of the Texas A&M Space Institute***

Texas has been the home to human spaceflight for the last 50 years, with NASA-led programs like Apollo, the Space Shuttle, and the International Space Station. The next 50 years will be different, evolving to a broader space economy, where the NASA-led effort changes into a much more complex set of commercial, university, and national security stakeholders conducting their own missions. These include commercial crew launches like SpaceX and Blue Origin, robotic delivery of cargo and science instruments to the Lunar surface in support of human exploration, and the Artemis missions that will return American astronauts to the Moon. In parallel, other government agencies are monitoring the Lunar surface for national security, as foreign adversaries have ambitious plans of their own. Commercial space transportation in Texas is currently serviced by five spaceports, two Federal Aviation Administration (FAA)-licensed and three privately licensed exclusive use sites.

The aerospace industry in Texas includes \$3.3 billion/year in total wages and directly employs over 138,000 Texas workers at more than 1,700 establishments (<https://businessintexas.com>). The aerospace, aviation, and defense sectors accelerate growth in the Texas economy. The world's top aerospace corporations choose Texas to conduct major aerospace-related operations. SpaceX has a rocket development facility in McGregor and a launch facility in Brownsville. Blue Origin has a launch site in Van Horn. Numerous new companies have sprung to life in the Clear Lake area such as Intuitive Machines, Axiom, and AEGIS Aerospace, alongside traditional aerospace giants like Lockheed Martin, Boeing, Collins and Raytheon. Across the state, aerospace companies like Firefly Aerospace (Cedar Park), Blue Origin (Van Horn) and SpaceX (Boca Chica) have expanded the Texas space exploration footprint. The future of the human space program is destined to grow this economy with the need for new talent, innovative technologies, and capabilities.

NASA's Johnson Space Center (JSC) located in Houston has served as the helm of human spaceflight since 1965. Mission Control in Houston has been vital to every U.S. human spaceflight since the Gemini IV mission in 1965, including the Apollo missions that took humans to the moon up unto today where flight control teams of experienced engineers and technicians are on duty seven days a week – 24 hours a day, 365 days a year – monitoring activities on the International Space Station (ISS). JSC now leads the engineering development of key new systems for the Artemis Program, NASA's return for humans to the Moon, and then the follow-on efforts for humans to Mars.

Texas is well poised to be the leader in each of these future activities, but rising competition dictates that for Texas to remain the leader in human spaceflight for the next 50 years, we must create an environment where all these stakeholders can work together for best outcomes. Recognizing the changing times, NASA is considering new approaches, such as building facilities "outside the gate" where researchers and commercial companies can work with NASA in a more agile and flexible manner. Where the past human spaceflight programs were NASA centric, the new programs must be able to bring many stakeholders together that include industry, academia, NASA and other government agencies. The Texas A&M Space Institute will facilitate these new collaborations.

Texas has in place other key ingredients to maintain and expand its leadership in the new space economy. According to recent studies, Texas is the number one state for aerospace companies in the United States. Texas has a business-friendly climate, is centrally located, and is home to launch capable locations along the Texas coast, in west Texas and the Ellington Space Port. The missing ingredient is a sufficient workforce to fill the new STEM jobs that space will bring to Texas. Recent studies show a doubling of the international space economy in the next 10 years, and for Texas to claim its rightful share of this expansion, new ways to connect the Texas population with higher education and industrial employers are required.

Through strategic planning, the Texas A&M Space Institute will serve as a catalyst for innovative research and technologies and will develop a networked-space community by bringing together cross-sectoral entities from throughout the state, connecting and advancing new discoveries and capabilities, new ideas in space-related education, and workforce development.

## ***2. General Description of the Texas A&M Space Institute and Its Mission and Goals***

The Texas A&M Space Institute is a multi-faceted research organization focused on leading, servicing and support of an evolving space economy, providing Texas with strategic planning and research accomplishments, workforce development and training, and a holistic approach to broadening statewide engagement and promoting growth in all sectors related to the Texas space economy.

**Vision:** *To maintain and expand Texas as the leader in the new space economy, leveraging existing expertise, capacities, and resources to foster new discoveries, technological developments, health advances, and workforce growth through partnerships across economic sectors within the state and beyond.*

**Mission:** The institute will provide for multisector partnerships that leverage subject matter expertise, existing current and future capacity, new research and technologies, and workforce development that aligns with strategic priorities of the state of Texas.

### **Goals:**

1. Develop a Texas space ecosystem across the academic, commercial, service, private, and government sectors throughout the state of Texas that strengthens the state's leadership in space exploration and civil and commercial aerospace including the Texas spaceport. This goal includes establishment of i) a series of integrated hubs throughout Texas to leverage capacity and resource investment, and ii) a cross-sectoral space consortium that provides a collective approach to advancing space research and workforce development.
2. Support near-term and long-term strategic planning for the Texas space economy through engagement of the Texas Space Commission and the Texas Research and Space Economy Consortium periodically updating the plan to address the rapidly changing competitive landscape.
3. Advance the Texas space research innovation in space exploration and space flight, through leading-edge research infrastructure and funding opportunities to advance interdisciplinary collaborations. Seek federal, state, commercial and private funding to support and grow the space exploration ecosystem within Texas.
4. Establish laboratories for astromaterial curation of post-mission materials and create the world's largest indoor testbeds for the Lunar and Mars surfaces adjacent to JSC.

5. Develop a cross-sectoral collective approach to addressing workforce development through education and training opportunities for students, researchers, and industry professionals to advance their skills and knowledge, new technologies, and public outreach. Through partnership with JSC, provide training to current and future NASA and commercial astronauts.
6. Develop a public relations and outreach strategy to increase the visibility of Texas-based space exploration and to attract federal and other investment in the state related to human space exploration and space flight.
7. Foster a culture of innovation and entrepreneurship through collaboration with industry partners to transfer technology from research to commercialization, identify industry needs for future research, and through the formation of startup companies to lead the commercialization of space.

### ***3. Potential Faculty Associated with the Texas A&M Space Institute and Potential Intrasystem and Other Collaborations***

Over 280 Texas A&M faculty and investigators from more than 12 colleges/schools and at least two associated state agencies (i.e., Texas A&M Engineering Experiment Station and Texas A&M AgriLife Research) are involved in space-related research and the majority work on topics related to space exploration and space flight. Texas A&M is the only university in the nation with four astronauts on the faculty. Scientists and engineers from Texas A&M have participated in all NASA rover missions to Mars with two scientists active on NASA's Perseverance Rover Team. In addition, a retired NASA engineer who previously led robotic construction of the International Space Station and the development of NASA's next rover for the Moon has joined the Texas A&M faculty.

The Texas A&M faculty research expertise is expansive with strength in academic and industry knowledge (Table 1, Texas A&M Research Enterprise Strategic Plan 2023 -2030). Specific areas noted: human space flight, aeronautics, earth and planetary sciences, planetary surface engineering and construction, quantum, manufacturing, materials, AI and Machine learning, situational awareness, cybersecurity, communications, space health and nutrition, and climate, among others. Texas A&M has also invested in several state-of-the-art facilities. Recent workshops organized by the Office of the Vice President for Research (VPR) have resulted in the establishment of faculty-working groups to facilitate team building and collaborations to advance discoveries and leverage resources. The faculty-working groups have been actively engaged in extramural proposal writing, with recent awards from various agencies including the U.S. Air Force, the U.S. Space Force, and the National Reconnaissance Office.

A recent tabulation shows over 300 active space-related projects at Texas A&M with an average of \$25 million per year for the last five years. This includes competitive awards from NASA and other government agencies, as well as grants from the commercial space industry. The proposed institute will harness this existing ecosystem for space research as a starting point. In addition, there is significant interest and expertise in space exploration at other A&M System universities including Prairie View A&M University and Texas A&M University-Corpus Christi. The proposed institute will engage broadly, leverage expertise, and foster collaborations across Texas A&M colleges/schools and A&M System universities as well as its state agencies to accomplish its mission and goals.

### ***4. Potential Activities***

1. **Research and Development:** The institute will seek funding and conduct research in areas that advance the Texas strategic plan and foster innovations that address challenges which impede advancing space exploration and space flight. This could involve both fundamental and applied research aimed at developing new technologies that can be commercialized.
2. **Cross-sectoral Collaboration:** The institute will partner across economic sectors to develop new technologies and products, provide access to research expertise and facilities, and offer workforce development and training programs.
3. **Workforce Development and Education:** The institute will emphasize the growth of the Texas workforce to meet current and future demands through the Space Consortium. It is important to bring together all industry sectors to strengthen education and training programs throughout Texas to develop the skills and knowledge needed for careers in the space and support efforts on Earth.
4. **Outreach and Community Engagement:** The institute will engage with the local community and stakeholders to raise awareness of the importance of Texas leadership in space exploration and its role in advancing this domain. This could involve public lectures, conferences and other events aimed at promoting science and technology education.

**Special Projects:** Through additional funding sources, the institute would deliver special projects that advance space exploration and the Texas Space Economy Priorities. The initial project is the construction of a Texas A&M facility (Figure 1) adjacent to JSC in the Clear Lake area. The Texas Legislature recently passed legislation to fund this facility. JSC has facilitated NASA issuing an “Announcement for Proposal” (AFP) of 270 acres on the western side of its campus for external (partner) development in 2023. Texas A&M intends to bid on access to 32 acres along Saturn Lane, adjacent to Rocket Park and at the entrance to JSC. The Texas Legislature directed Texas A&M to design, build and operate a new facility that will be the center piece of this new collaboration between industry, academia, and multiple government (local, state, and federal) agencies. Owned and operated by Texas A&M, it is anticipated that the facility will house the Texas A&M Space Institute, the Texas Space Commission, Texas Space Consortium (TSC), and the Texas Space Aeronautics and Curation Exploratorium (T-Space) to include labs, shops, classrooms, meeting rooms, control rooms and dedicated spaces for astromaterial curation and sample research. The facility will also include two large extraterrestrial testbeds, one emulating the Martian surface and the other emulating the Lunar surface.

Such special projects will be identified and implemented in support of efforts identified in the strategic plan as additional funding becomes available through the TSC and other sources. Examples of future high priority targets include expanding and digitally connecting from the facility to A&M System facilities and regional hubs, including the Texas A&M System RELLIS Campus, development of spaceflight prototypes for use in the terrestrial testbeds, and development of regional hubs within the state network.

## ***5. Impact on Education and Training of Students***

Education and training of students is a fundamental element of the institute to ensure that a knowledgeable and skilled workforce exists to meet the current and future needs of Texas space economy priorities. A trained workforce requires a variety of knowledge and skilled individuals. The challenge is attracting, recruiting and retaining individuals interested in the space-related economy as well as the retooling of the existing workforce to meet new technologies and

opportunities. This requires a coordinated partnership across sectors that the Texas A&M Space Institute will facilitate with commercial, academic, non-profit, federal agencies and public-school systems.

As part of the cross-sectoral Space Consortium efforts, the institute will map-out existing educational programs throughout the state with an emphasis on space-related economy components. Understanding the current expertise will allow the development of robust educational/training programs in space-related fields to meet the workforce needs. Examples include environmental factors, habitability, human factors and behavioral performance, exploration medical capabilities, human health countermeasures, human physiology, space food systems, space radiation, extravehicular activity (EVA), robotics and artificial gravity countermeasures. A robust and on-going research program, housed in Texas, is a necessary component to maintaining Texas as the home of space exploration and the new space-related economy ecosystem. This will require future investment in both university and technical programs throughout the state.

Initial efforts will start with the identification of current existing degrees and certificates offered within the A&M System related to human space exploration. In addition, the institute will identify current and future opportunities to work with local high schools and community colleges to promote STEM education and encourage more students to pursue careers in space. By doing so, the institute can help build a pipeline of talent that is important for the industry's growth and competitiveness. Educational and training requirements will be mapped to delivery of the Texas strategic plan.

Through anticipated corporate partners, the institute can offer internships, co-op programs, and other educational opportunities for students to gain hands-on experience in the space industry. This can help students develop the practical skills and knowledge necessary to succeed in the industry and provide them with networking opportunities that can help secure future employment. Access to nearby JSC laboratories and the unique Texas A&M facility will allow university researchers new approaches, techniques, components, and devices for cutting-edge development and discovery and provide hands-on opportunities to promote STEM education and outreach.

## ***6. Resource Requirements***

The Texas A&M Space Institute will require a variety of resources to achieve its goals, including:

**Funding:** The institute will require significant funding to carry out research, technology development, workforce development, consortium development and educational program development. This could come from a variety of sources – partnerships with the state of Texas, federal and state grants, commercial, academic, foundation and/or private donations.

**Facilities:** The institute will be housed at the Texas A&M University facility adjacent to the JSC in Clear Lake using the \$200 million recently appropriated to Texas A&M by the Texas Legislature for this purpose. Negotiations are in place to arrange access for JSC to be a primary user of a portion at this facility for research, training, and other activities.

**Faculty and Staff:** The institute will require a cross-sectorial team of experienced administrators, researchers, educators, and support staff to oversee its various programs and initiatives. This could include professors, postdoctoral researchers, engineers, administrative personnel, and outreach specialists.



**Space Consortium:** The space consortium will include entities across sectors of the Texas space community to leverage existing capacities, new discoveries through research, proposal development, workforce development, outreach, and other opportunities at this institute.

**Industry Partnerships:** The institute will need to establish partnerships with the members of the space community including commercial, technologic and services companies, technology firms, and other industry players to facilitate collaborations, joint research, and workforce development initiatives. Industrial users of the Texas A&M facility will pay for services and access in the facility.

## ***7. Sources and Future Expectations of Financial Support***

The Texas Legislature has secured \$350 million for the Texas Space Commission, with \$150 million to the Space Exploration and Aeronautics Research Fund, and \$200 million for Texas A&M to work with JSC to construct a building that will be for mission training, research, and the curation of astronautical materials. In addition to state funding, the institute affiliated research faculty and staff will engage in proposal writing to secure additional funding from federal, industry, and other external sources.

Additional revenue may be leveraged from workforce development related activities, such as delivery of short courses and workshops to industry and government entities and issuance of continuing education certificates.

## ***8. Governance and Advisory Structure***

A&M System Vice Chancellor for National Laboratories and National Security Strategic Initiatives will provide administration of the Texas A&M Space Institute. The administration and organizational strategy of the institute will be structured such that it subscribes to A&M System Policy *11.02, Creation of Centers and Institutes*. The institute will have a director, who will report to the Vice Chancellor for National Laboratories and National Security Strategic Initiatives and the Vice Chancellor for Research. The primary report will be the Vice Chancellor for National Laboratories and National Security Strategic Initiatives.

The director will additionally be supported with input by an External Advisory Committee and an Internal Oversight Committee. The External Advisory Committee will be comprised of leaders in the space community from the commercial, service, academic, government and private sectors. The external committee will provide guidance concerning alignment of goals with state and national priorities, state-of-the-art innovation and technological, challenges to be addressed, funding opportunities and potential partnerships and insight into risk cost benefit, security and certification issues. The Internal Oversight Committee will be composed of administrators and subject matter experts from Texas A&M. The internal oversight committee will (i) provide input concerning the alignment of deliverables with institute, university and system priorities, and the scope and budget of deliverables, (ii) develop the strategic vision for the institute, and (iii) contribute to outreach across communities and economic sectors.

## ***9. Mechanisms for Periodic Review***

The institute Director will be responsible for preparing annual progress reports to present to the Vice Chancellor for National Laboratories and National Security Strategic Initiatives. Reports will

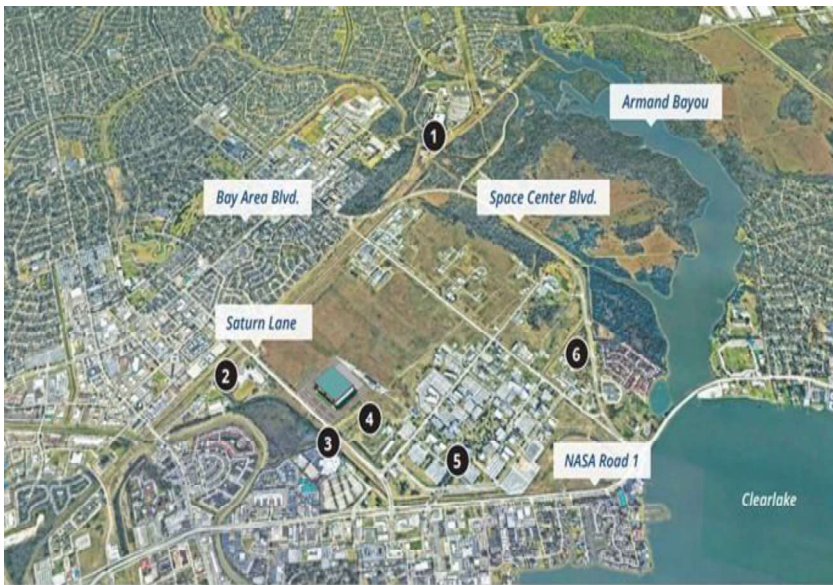
also be shared with the Vice Chancellor for Research, the Vice Chancellor and Dean of Engineering, the Vice President for Research, Texas A&M, the Senior Vice President of Texas A&M Health, and the Vice Chancellor and Dean for Agriculture and Life Sciences for comment. The institute will be evaluated by the Vice Chancellor for National Laboratories and National Security Strategic Initiatives annually. A formal review of the institute will be completed every five years per Texas A&M System Policy 11.02. The External Advisory Board will meet annually, at a minimum, and the Internal Advisory Committees will meet quarterly, at a minimum.

The annual report will summarize the following aspects of the institute:

- Significant Accomplishments
- Financials
- External and Internal Advisory Committee summaries
- Research activities, including input (grants, contracts, etc.) and output (publications, reports, etc.) metrics
- Workforce development and Outreach activities
- Industry relationships summary
- Research Security and Compliance Review
- Goals for the upcoming year

## APPENDICES

**Figure 1) Proposed Facility in Clear Lake Area**



1. UH Clearlake  
2. CCISD SC Intermediate

3. Space Center Houston  
4. Rocket Park

5. NASA JSC Building 1  
6. JSC Rockyard

**Table 1 Research Capacities reflected in the Texas A&M Research Enterprise Strategic Plan, 2023 – 2030**

Strategic Research Themes	Strategic Research Sub-Themes	Examples of Research Areas of Strength/Opportunity within Texas A&M
<b>Community, Culture, and Economic Resilience</b>	<b>Arts Ecosystem and Culture</b>	Impact of arts on health & wellbeing, education and economy, community transformation and healing, adaptation to social, economic and technological challenges, public humanities, cultural heritage, historic creative activity, civics education, creative production and performance, use of new media and technologies in arts, and tourism
	<b>Human Development and Social Dynamics</b>	Human resource development, change management, resilience, leadership development, social dynamics, policy, human factors, bioethics, education disparities
	<b>Workforce and Future of Work</b>	Workforce development, future of work, cultures of work, policy, inclusive workforce
	<b>Artificial Intelligence, Learning, and Autonomy</b>	Machine learning, deep learning, human-machine interactions, sensors, robotics, computer vision, ethics/policy, technology adoption
<b>Emerging Technologies and Innovations</b>	<b>Biotechnology and Biomanufacturing</b>	Synthetic biology, genomics, gene editing, genetic medicines and RNA/DNA vaccines, biomanufacturing
	<b>Data, Visualization, and Information Technologies</b>	Digital twins, computing platforms, visualization, AR/VR technology, LED production stages, communicating with the future, policy
	<b>Microelectronics and Semiconductors</b>	Analog and mixed signal circuits, artificial intelligence hardware, biosensors, brain- inspired computing, integrated photonics, intelligent and cognitive EM sensors, MEMS sensors and actuators, memristors and emergent memory devices, metrology, molecular computing, neuromorphic materials, radiation-hardened electronics, secure edge computing, 5G/6G technology, workforce development
	<b>Quantum Science and Technology</b>	Quantum sensing, quantum biology, quantum communications, quantum computing
<b>Health and Quality of Life</b>	<b>Diagnostics, Treatments, Intervention, and Cures</b>	Biomedical devices, diagnostic technologies, precision medicine, genetics/genomics, toxicology/environmental health, neuroscience, infectious diseases, zoonotic/emerging diseases, digital health, telehealth, cancer therapeutics/vaccines, cardiovascular diseases, communication and adoption, clinical trials, governance
	<b>Disease Prevention and Health Promotion</b>	Risk and protective factors, food-nutrition-health link, prevention of chronic diseases, stress management, vaccine development, emissions-energy-health interactions, health communication, hospitality and recreation
	<b>Health Disparities and Community Health</b>	Rural and community health, racial/ethnic/socioeconomic health disparities, women’s health and gender differences, military and operational medicine, humanitarian assistance/disaster response, health resilience, global health security, governance

<b>National Security</b>	<b>Biodefense and Biosecurity</b>	Detection/forecasting, rapid response/contamination, pandemic response, one health, rapid therapy/vaccine development, applied biosafety/bio-risk mitigation, environmental surveillance, manufacturing, supply chain
	<b>Cybersecurity</b>	Cybersecurity assessment, human dimensions, cyber modeling, privacy versus security, governance
	<b>Nuclear Security</b>	Arms control, nuclear terrorism, risk analysis, nuclear forensics, nuclear nonproliferation, nuclear power, policy
	<b>Advanced National Security Technologies</b>	Directed energy; hypersonic technology; ballistics; encryption; systems engineering; materials for extreme environments; policy
	<b>Human Space Flight</b>	Human factors and behavioral performance, human health countermeasures, space radiation, exploration medical capability, research operations and integration, food/nutrition, space humanities
<b>Space Exploration</b>	<b>Space Engineering and Construction</b>	Aerospace power and energy storage; robotics, sensors, and autonomous systems; robotics space flight; materials and manufacturing; space food systems
	<b>Earth and Planetary Sciences</b>	Earth science, astrophysics, astrobiology, planetary science, exoplanets, space domain awareness, remote communications, asteroid detection and deflection
	<b>Climate Resilience and Mitigation</b>	Climate resilience/mitigation, coastal resiliency, blue economy, carbon capture, environmental ethics/humanities, policy
<b>Sustainability and Environment</b>	<b>Energy Transition/Clean Energy</b>	Biomass/renewables, nuclear reactors, hydrogen economy, smart grid/infrastructure of the future, electrification, decarbonization, energy storage, critical materials, simulations of scenarios of energy of the future, response, training, policy
	<b>Food-Energy-Water (FEW) Nexus</b>	Development and application of integrated tools/platforms to inform the decision- making process for FEW resilience, assessment of the sustainability of FEW systems, water quality decision support system, FEW and health, food security, clean water, response, training, policy