UND National Security Initiative

Description:
Enhancements of the Center for Space Education and Research that expand on existing as well as planned investments from the University and the Colleges of Aerospace, Engineering & Mines, and Arts & Sciences would greatly benefit North Dakota, the region, and the U.S. UND continues its investment in its National Security Initiative (NSI) to expand the university's capacity to pursue, secure, and execute projects with federal agencies including the Department of Defense (DoD) and Department of Homeland Security (DHS). The NSI has generated numerous opportunities in research, training, and education for a broad range of colleges, schools, programs, faculty, and undergraduate and graduate students. The NSI is expected to continue to expand opportunities in these areas for the foreseeable future. The first phase of the NSI focused on space-related activities, building on established expertise in UAS/Autonomy and mobility in the air domain into a cohesive Surface-Air-Space (SAS) domain, integrating ground vehicles, airborne assets, and satellite architectures like the constellation in development by the Space Development Agency (SDA) as well as partner companies.

The second phase of the NSI will continue to align with UND's 6-year planned investment of $7.5M in strategic funding to advance National Security Research activities. This phase will expand the focus of the NSI to address topics that cut across the SAS domain in areas such as Virtual Reality (VR), Cyber Security, High-Speed Optical Communication, and physical spaces to perform meaningful experiments and system testing in a variety of environmental conditions. These resources would position UND, and the state of North Dakota, to effectively support National Security agencies and industries that are actively operating in the state (such as SDA, Grand Forks Air Force Base (GFAFB), North Spark Defense Lab, and the United States Space Force), and to entice additional partners to establish a presence here. The envisioned capabilities support research activities starting with the Vice President of Research & Economic Development, the Research Institute for Autonomous Systems, the John D. Odegard School of Aerospace Sciences (Space Studies, Atmospheric Sciences, and Aviation departments), the College of Engineering and Mines (Electrical Engineering & Computer Science and Mechanical Engineering departments), and the College of Arts & Sciences (Chemistry, Mathematics, Physics & Astrophysics, and Psychology/Human Factors departments).

Expected Outcome:
Expansion of the NSI is designed to increase federal funding from the DoD and DHS. A conservative funding target is an annual increase of $3M in research expenditures from these two agencies, building on a baseline established in FY22 (~$2.5M)—over a 100% increase. The Center will help attract star research faculty and staff in national-security-related fields to include graduate students and post-doctoral researchers. These efforts will drive development of new capabilities that ensure U.S. National Security preeminence, while supporting key partners in the region (industry, the GFAFB, etc.) through technology development and technology transfer/economic development. Enhancement of our innovation ecosystem would further fortify its importance to the nation, especially for SAS (autonomous) systems/capabilities, including key resources (e.g., the GFAFB). While primarily a research initiative, the NSI will substantively refresh academic programs. Enhancement of this center will deliver more educational opportunities online and on-campus with state-of-the-art technology and research labs. It will foster high-tech workforce development in key emerging areas at both undergraduate and graduate levels, increase opportunities for student engagement in hands-on and applied research and training opportunities, and assist with growth and diversification of the ND state economy, especially in the high demand, rapidly growing high-tech sector.

Connection to Existing Program:
This project will continue to support existing and growing programs and research in national-security-related fields in the Colleges of Aerospace, Engineering & Mines, and Arts & Sciences and leverage ongoing strategic investments from the University. The National Security Initiative supports Goal 4 of the UND Strategic Plan (to Enhance Research) and puts an action to the UND Grand Challenges of Autonomous Systems and Big Data. These two Grand Challenges encompass areas of research and education identified by UND as priorities critical to the state and areas in which we are nationally competitive.

Infrastructure Project	Description	Estimated Cost
Satellite and Space Debris Tracking	A series of antennas would be installed and used to collect data to track satellites and space debris. This facility would allow for both student projects and faculty research, including the analysis of satellite and space object data, development of advanced tracking software, and development and testing of new antennas and sensors.	2,000,000
High-Speed Laser for Optical Comms.	Ultrafast, powerful, high-speed lasers will be acquired and installed in Witmer Hall and the Tech Accelerator. This will position UND to respond to Department of Defense, including United States Space Force (USSF), opportunities--many of which are focused on optical communications. It will also expand partnership opportunities with commercial entities. Another benefit is it will enable research with materials that are otherwise unavailable, leveraging recent investments in the nanofoundry.	5,000,000
Molecular Beam Epitaxy	Molecular Beam Epitaxy is the state-of-the-art methodology for constructing single crystals with precisely controlled composition. Its principal use is for the development of semiconductor devices on the nanoscale. Because the device operates under ultrahigh vacuum conditions, high purity, defect-free devices can be built that are inaccessible by other means. This allows access to unique materials and devices, including organic semiconductors and various quantum materials (including quantum wells and superlattices); MBEs are used in the search for high temperature superconductors and artificially layered magnetic materials. DARPA has identified 3D heterogeneously integrated (3DHI) technologies as the key objective to enable disruptive microsystems of tomorrow. It further states that without this technology, the US will fall behind in artificial intelligence, autonomous systems and robotics, and networked sensing.	2,000,000
Digital Engineering and Virtual Reality - DREAM Laboratory	This investment will create the Digital Realism in Engineering and the Applied Metaverse (DREAM) and establish UND as the institutional lead. The partnership consists of four major academic and industry collaborators: UND, NVIDIA Corp., Lenovo USA, and the Ohio Supercomputing Center (OSC). DREAM will expand existing UND-based Artificial Intelligence (AI) and Virtual Reality (VR) projects. This growing UND research capacity addresses clear needs of national defense labs to reproduce reality as high-fidelity virtual spaces (aka Digital Twins). Such Metaverse environments allow for the integration of human physical training into virtual combat spaces while simultaneously providing the capability to generate synthetic data for use in training digital bots for real-world military missions via AI and Machine Learning (ML) algorithms.	6,500,000
Cybersecurity Research Infrastructure	This investment will create a stand-alone network with infrastructure to enable researchers to test cybersecurity tools and techniques on a production-like environment. This system will also allow advanced system integration for cybersecurity research on development platforms to create networks and tools for future cyber security techniques. This tool will support established research activities and lead to more research opportunities from federal agencies and private sector corporate partners.	2,000,000
Cyber Range	This investment will create a cloud-based cross-disciplinary training tool that training students to manage cyber security attacks in a variety of scenarios. It is a very immersive experience provide performance-based learning and assessment, an environment for teams to work together to improve teamwork, and simulate on-the-job experiences related to Security Operations (SecOps) and Development Operations (DevOps).	1,000,000
3D Rocket Laboratory	This would create a laboratory for designing, fabricating, and testing novel 3D rocket engine designs, injectors, and turbopumps. This includes novel materials for improved heat transfer and performance at high temperatures and would enable testing of materials that could be utilized in Lunar and Martian missions.	1,500,000
Autonomous System Environment Development and Test Facility	UND has a long history of research excellence in autonomous systems, particularly with Unmanned Aircraft Systems. Collaborators across the campus have coalesced around this topic with significant success in generating external partnerships and ongoing funding. As autonomous systems take up increasing tasks, it is critical to increase reliability and the ability to operate in a variety of conditions, including wind, rain, fog, dust, and so forth. The design of robust autonomous systems that are resilient to these conditions is a critical need, as is the need to test existing and proposed autonomous systems in these environments. This effort aims to establish a common area in which researchers from across campus can work to design, develop, fabricate, and test robust and reliable autonomous systems in the harsh environments that they will experience in practice. We propose to renovate an existing facility to house fabrication and testing labs for small to medium sized autonomous systems, office space for data processing, autonomous algorithm development, cybersecurity research, and public policy research. This facility will also house a full environmental testing facility that can subject autonomous systems to environmental conditions in a controlled way.	18,500,000
Controlled Environment Field-Testing Facility	This would create an indoor, GPS-enabled, testing facility for systems (e.g., drones, autonomous ground vehicles, etc.). Such a facility enables testing in a controlled environment that mitigates all safety concerns regarding non-participants and significantly improves testing capabilities during inclement weather. It also supports testing with GPS (as opposed to most facilities that block GPS), which is critical for many systems. Such a facility would enable testing of both ground and airborne systems.	6,500,000

UND Space Education and Research Infrastructure

ND Senate: Appropriations-Education and Environment Division
29 March 2023

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National Security Initiative (NSI) Overview

Grand Challenge

- Strategic investment/opportunity areas

Personnel

- Strong, integrated team from across campus
- Assoc. Vice President for Research
- Adding Director and 8 faculty

Core Capabilities

- Space, Autonomy/Counterautonomy, Materials (inc. Micro/Nano), Quantum Tech., Rare Earth Elements

Strategic Partnerships

- Grand Forks Air Force Base, Grand Sky, Northern Plains UAS Test Site, Industry

Serve those who serve

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NSI Focus Impacts

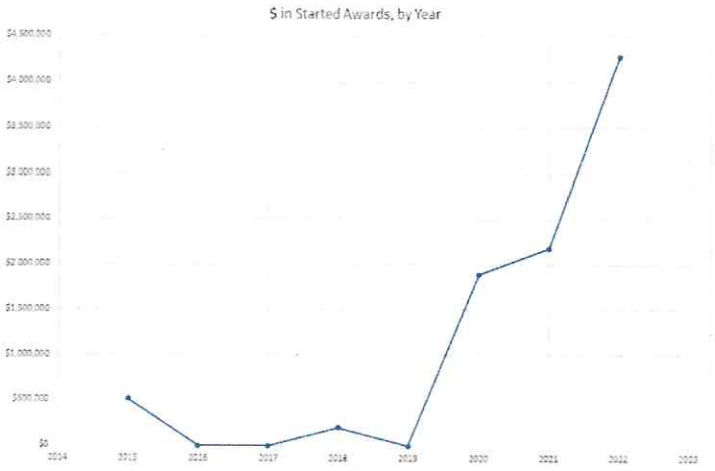
$ in started awards for Dept. of Defense

- Dept. Homeland Security and EERC efforts not in chart

Impact of focus on NSI

- Do not have estimates for Space Education and Research Infrastructure investment impact yet
- In progress

Potential $50M-100M yr^{-1}



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Big Picture (Complementary Capabilities)

Digital Engineering:
Digital Engineering and Virtual Reality DREAM Laboratory

Advanced Materials:
Nanofoundry
Molecular Beam Epitaxy
3D Rocket Laboratory

Prototyping & Testing:
Autonomous System Environment Development and Test Facility & Controlled Environment Field-Testing Facility

Communications:
Laser/Optical Comms.

System Security:
Cybersecurity Research Infrastructure & Cyber Range

Tracking:
Satellite and Space Debris Tracking

Current & Potential Collaborations

Dept. of Defense
US Space Command
US Space Force
Space Dev. Agency
NRO
DARPA
AFRL/NRL/ARL
AFOSR
AFWERX
Grand Forks AFB
DHS
NASA
FAA
NPUASTS

Grand Sky
Northrop Grumman
General Atomics
Iridium
General Dynamics
Space-X
Airbus
Quantinuum

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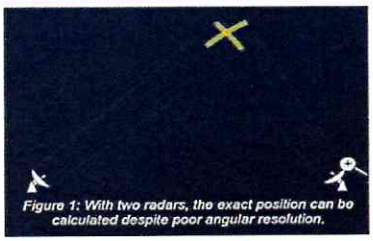
Satellite and Space Debris Tracking

Space debris is a growing problem

Placement of active RADAR on the roof of academic buildings allow us to detect and track debris

Development of novel machine learning/deep learning models can identify small and distant objects



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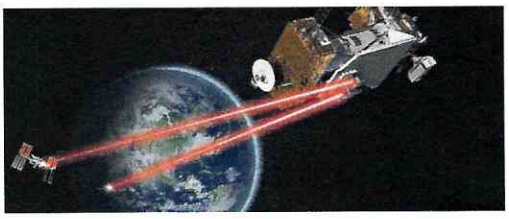
High-Speed Laser for Optical Communications

Consistent message from Space Force and other potential space research partners:

- Need fast, reliable, secure communication with high transmission rates in space
- Laser (optical) communications
- Communication spacecraft-spacecraft; spacecraft-aircraft; spacecraft-ground



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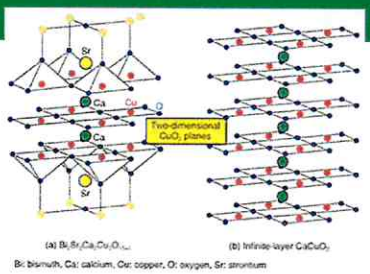
Molecular Beam Epitaxy

Create complex 2D and 3D semiconducting devices on the nanoscale

Ultrahigh vacuum allows fabrication of devices that are not possible by any other means

According to the Defense Advanced Research Projects Agency, such devices are essential for next-generation advances in artificial intelligence, autonomous systems and robots, and networked sensing



(a) $Bi_2Sr_2Ca_2Cu_3O_{10+x}$ (b) Infinite-layer $CaCuO_2$

Bi: bismuth, Ca: calcium, Cu: copper, O: oxygen, Sr: strontium

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Digital Engineering & Virtual Reality: DREAM Laboratory

The Partnership for **D**igital **R**ealism in **E**ngineering and the **A**pplied **M**etaverse (**DREAM**)

Partners: NVIDIA, Lenovo, Ohio Supercomputing Center

- NVIDIA/Lenovo OVX Double-Pod
- New/upgraded servers/cluster to support data processing
- Data Center power/cooling/infrastructure upgrade
- DGX Pod
- Upgraded display workstations, VR headsets, VR treadmills, motion capture

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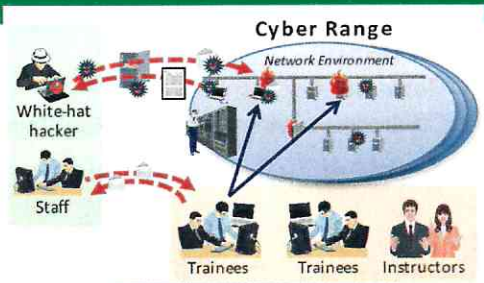
Cyber Security Training & Research

Cyber Range

- Cloud-based resource to train cyber professionals to: Create and test different strategies, Master skills and techniques, Strengthen execution

Cyber Research Infrastructure

- Computational and stand-alone Network resources to develop novel and effective approaches to solve cyber security problems



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3D-Printed Rocket Components Lab

Will allow us to design, fabricate, and/or test:

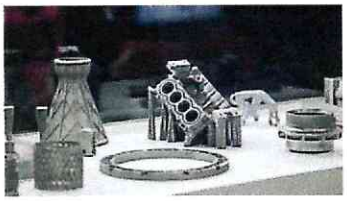
- Novel 3D-printed rocket engine designs, injectors and turbopumps
- Engine material coatings for improved heat transfer
- Lunar and Martian metals for 3D-printed motors
- High-temperature performance of nanodevices

Will experiment with liquid and solid rocket boosters

Potential to partner with Grand Sky

Development of the Space Workforce

Currently 85 students in the UND Advanced Rocketry Club



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Autonomous System Environment Development & Test Facility

Critical needs

- Rapid development
- Controlled environmental testing (rain, fog, snow, etc.)

Op. Context ↔ **Simulation** ↔ **Laboratory** ↔ **Field Testing**

Autonomous systems development factory

Integrated capability & controlled environment accelerate realization

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Controlled Environment Field-Testing Facility

- Inflatable Dome for Space Station/Lunar/Mars Habitat and UAS Testing
- **Allows Communication and GPS Reception**
- Year-Round Availability
- **Revenue Generating (Commercial UAS, Sports, Events)**

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Progress with Previous Funding

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Nanofoundry & Advanced UAV/Satellite Materials Lab

Nanofoundry

Renovation of 1,000 sq. ft. facility with cleanroom is well under way

Will soon launch a search for a full-time technician (funded by UND)

We are working to foster collaborations with industry partners

Raith (E-Beam) is planning a story about our investment. In the context of the CHIPS act, they think that our story will inspire other institutions

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Advanced UAV & Satellite Material Lab

$1 million in instruments have been ordered, including a thermogravimetric analyzer, gas chromatogram – mass spectrometer, electron microscope, particle size analyzer, etc.

Lab renovations are in the design phase

These instruments, along with several existing instruments, will be operated as a cost center and made available for use by industry partners

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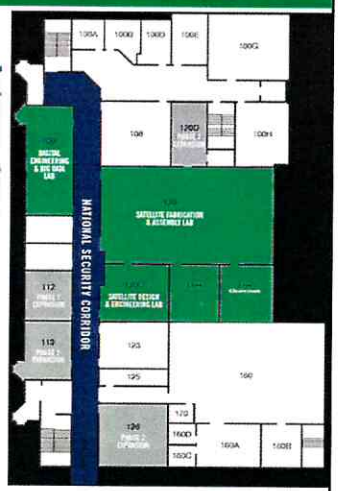
National Security Corridor

Harrington Hall (1st floor)

- Satellite Subsystem Development Lab
- Cleanroom Assembly
- Satellite Assembly & Test
- Digital Engineering & Big Data Lab



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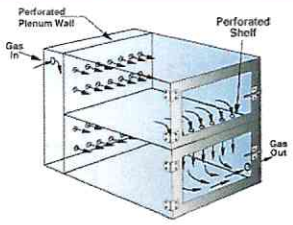
Satellite Component Assembly & Cleanroom

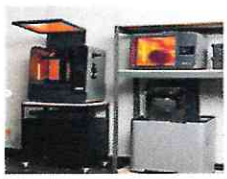
Cleanroom

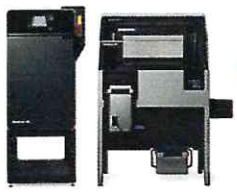
- HEPA air handling, Vestibule, Nitrogen purge cabinet

Satellite Component Design

- Component fabrication, PCB fabrication equipment, Precision 3D printers, Solder/rework stations







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Final Satellite Assembly & Test

Components

Space Systems Fabrication, Assembly, & Testing

- Thermal/vacuum chamber
- Shaker table
- Laser cutter
- Water cutter
- Anechoic chamber
- Millimeter wave antenna chamber

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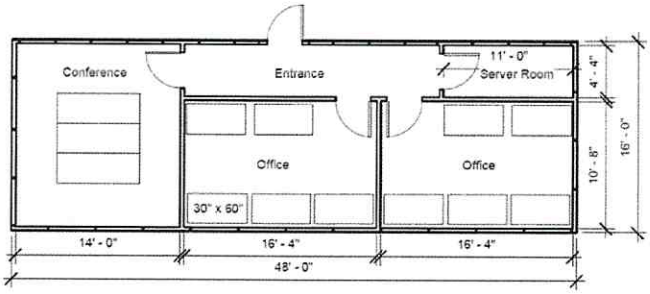
Secure Compartmental Information Facility (SCIF)

Secure rooms for classified discussions/research



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National Security Corridor Update

Most equipment has been purchased/ready for installation

- Some pieces of equipment are not yet delivered but expected late spring

SCIF: Have an estimate. Expected to complete late summer

Renovation of Harrington Hall will begin late February. Expected to conclude late summer

Companies and government organizations are excited about the National Security Corridor and are ready to partner with us—examples include:

- National Reconnaissance Office
- Northrop Grumman
- Packet Digital

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Space Operations Update

Space Operations Center/Classroom in Robin Hall - 95%

Satellite Communications and Tracking

- Odegard Hall Roof
- Network connected

Small Sat Build/Launch

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Expenditures Update

	Estimated Cost	Expenses posted	Encumbrances	Committed	Total
Satellite Operation Center	1,000,000	116,322	0	883,678	1,000,000
Digital Engineering and Big Data	300,000	168,070	557,675	52,238	777,983
Satellite Design and Engineering Lab	300,000	172,809	97,000	30,191	300,000
Satellite Fabrication and Assembly Lab, including Clean Room	2,400,000	120,871	2,508,684		2,629,555
Advanced UAV and Satellite Material Lab	5,700,000	2,006,073	5,084,901	401,488	7,492,462
Neutral Buoyancy Tank	1,200,000				0
Sensitive Compartmented Information Facility (SCIF)	1,500,000			600,000	600,000
Satellite and Space Debris Tracking	900,000				0
Laboratory Configuration	1,200,000			1,200,000	1,200,000
	*14,500,000	2,584,145	8,248,260	3,167,595	14,000,000

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