

BIENNIAL REPORT

1 JULY 2018 – 30 JUNE 2020

RESEARCH & SCIENTIFIC SOLUTIONS

ARMED FOR THE FUTURE



NATIONAL STRATEGIC RESEARCH INSTITUTE
at the University of Nebraska



Dillion Cunningham (left), NSRI director of special projects, and Jacob Ferry (right), deputy director of plans and programs for NSRI field operations and training, collect surface samples aboard a C-17 Globemaster III aircraft 6 April 2020 at the Nebraska National Guard air base in Lincoln, Neb.
Courtesy of Senior Master Sgt. Shannon Nielsen, Nebraska National Guard.

EXCELLENCE. RESPONSIVENESS. TEAMWORK.

In April 2020, scientists from the National Strategic Research Institute (NSRI) at University of Nebraska (NU) joined with active-duty, reserve and Air National Guard personnel to execute particle and airflow testing of six aircraft. The project aimed to eliminate the risk of COVID-19 spread to aircrew if infected personnel were brought on board.

"It usually takes months and months to plan an experiment like this. We executed it with two weeks' notice," said Dillon Cunningham, NSRI director of special projects. "It was definitely an extreme turnaround for everyone involved."

The first set of airflow tests were conducted on the KC-135 Stratotanker, C-17 Globemaster III and C-130J Hercules aircraft, followed by tests on the KC-46 Pegasus, KC-10 Extender and C-5M Super Galaxy aircraft.

The scientists from multiple disciplines used a new method of dispersing aerosol DNA tag beads, a concept Dr. Joshua Santarpia, NSRI research director for CWMD programs, invented two years before.

After the beads were released, multiple tests were performed in the air and on the ground. The scientists taped off and numbered small areas of the aircraft's floor to capture surface samples.

"Basically, we run multiple tasks on an airframe to understand if bead one, released at the rear of the aircraft, made it up to the front; or if bead two, released in the middle of the plane, made it up to the front of the aircraft," Cunningham said. "We can look at their spread in real time to make sure they are representative of a particular size of interest relative to the spread of different potential infectious substances."

There wasn't a single person on the joint-operations, interdisciplinary team that week who didn't play a critical role in the success of the mission.

Maj. Dave Sustello, U.S. Air Force Air Mobility Command Test and Evaluation Squadron operations officer, commended NSRI and all the entities that took part for contributing to protecting the health of the mobility force.

"This was world-class support," Sustello said. "Anything and everything we've asked for they've been able to provide, and I'm seeing that Nebraska work ethic shine through."

Excellence, responsiveness, teamwork — that is what NSRI is all about.

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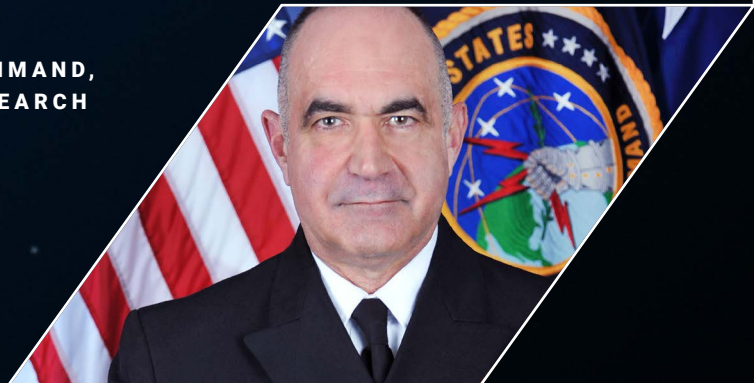
"It has been an honor and a privilege for the University of Nebraska to consistently deliver innovative solutions to the Department of Defense since the inception of the National Strategic Research Institute in 2012. We have built tremendous relationships with a wide range of government sponsors and remain a committed partner across a broad scope of capabilities for national security. Our researchers and students have tremendous opportunities to support those who wear the cloth of our nation and bring forward insights to keep us looking to the possibilities of the future."

TED CARTER

PRESIDENT, UNIVERSITY OF NEBRASKA



"As the sponsor of the NSRI, the United States Strategic Command and its 150,000 military and civilian force are proud of their accomplishments, and we look forward to what they will offer this command and the nation in the future. Deterrence is a multi-domain effort and the outstanding faculty, staff and students at the University of Nebraska are consistently providing the tools necessary to keep our nation and our allies safe."

ADM. CHARLES RICHARDCOMMANDER, U.S. STRATEGIC COMMAND,
NSRI UNIVERSITY AFFILIATED RESEARCH
CENTER SPONSOR

MESSAGE FROM THE EXECUTIVE DIRECTOR

LT. GEN. (RET.) ROBERT HINSON

I am 50 years into my career, a career spent directly serving our country in the U.S. Air Force and in support roles to the Department of Defense, and I honestly can say that 2020 is as significant as any year I have seen to date. I know I'm not alone in that assessment.

While I'm sure your mind immediately tracks to the concerns and challenges of COVID-19 — as it should until there is a vaccine to combat this deadly virus — I assure you that it only represents one of the evolving threats that our sponsors must be prepared for every day. The insights and research opportunities of the last two years covered by this report are just the tip of the iceberg in illustrating the critical work we have continued to perform.

Through the National Strategic Research Institute at the University of Nebraska, I have witnessed an unwavering sense of purpose, a resolute desire to perform to the highest potential and a keen intellect, sparked by urgency and broadened by action. I am proud to lead this eminent group of professionals who continually impress me with their dedication and ability to deliver solutions to difficult problems.

For NSRI, moving toward our mission most recently has meant pursuing focus and clarity, a task we embarked on in 2019 — a goal which the intensity of 2020 has confirmed. As U.S. Strategic Command's University Affiliated Research Center (UARC), designated by the Department of Defense, we are charged with and fully committed to helping our sponsor fulfill their mission requirements.

This year the University of Nebraska was awarded its third USSTRATCOM IDIQ contract through NSRI, an award of \$92 million to bring our institute's total contract and grant awards to \$298 million since 2012. This continued commitment by USSTRATCOM, as our UARC sponsor, demonstrates our ability to deliver at the highest levels. As we have refined our focus, we have not compromised what has made us great — the expertise more than 40 customers have relied upon across the DOD.

In 2020, our dangerous world presents many serious threats to our freedom and way of life. Those threats and the world itself have become much more complex, and all defense domains will continue to be challenged in the years



ahead. Hand-in-hand with our sponsor and other defense partners, NSRI and the University of Nebraska remain poised to enable research and support deterrence of, preparedness for and response to national security threats across multiple domains.

Our institute combines a rapid-response ability and genuine teamwork with leading-edge chemical, biological, radiological, nuclear and explosive technical expertise — a combination that offers both practical tools to support the warfighter and thought leadership to assist those who make the highest level defense decisions for our nation. We have demonstrated this capacity, for example, through our timely response to U.S. Transportation Command in testing their capacity for transporting infected patients on six different airframe types in just six days in April 2020 as well as our contributions to extremely high-level nuclear policy engagements. And so much more as highlighted in this report.

Our success in these efforts has been entirely dependent on the grit, intellectual capacity and resourcefulness of our people. Since 1 July 2018, we have significantly expanded the bench of our leadership team with the addition of Dr. Neal Woollen, senior research strategy officer, Dr. Christopher Yeaw, research director of nuclear programs, Dr. Josh Santarpia, research director

for CWMD programs, and Maj. Gen. (Ret.) Rick Evans, deputy executive director. In total, our leadership team now touts more than 275 years of direct DOD or DOD-support experience.

Looking forward, we will continue our investment in people. We recently launched an independent research and development initiative to catalyze continued innovation for the Department of Defense from the University of Nebraska. We also refined our student intern opportunities to ensure the highest-level experiences for the highest-caliber students. We continue to convene academic experts who are driven to provide USSTRATCOM with actionable insights across the 21st century deterrence landscape.

From deliverables to capabilities to talent, NSRI is built to last well beyond our decade mark of 2022. On the occasion of the release of this biennial report, we recommit ourselves to serving as an enduring resource for the Department of Defense, a conduit through which the University of Nebraska delivers support in the form of the finest national defense and deterrence minds and resources. Our aim as a trusted agent working alongside USSTRATCOM, and other DOD agency decision-makers is to support and protect the warfighters and first responders who protect us all.

IT ALL STARTS WITH THE THREAT

As the United States' mindset around deterrence continues to evolve given the changing international landscape, the National Strategic Research Institute (NSRI) at the University of Nebraska (NU) has evolved as well, refining its focus while remaining broad in its scope.

Long gone are the days of bi-polar Cold War competition that gave rise to predictable patterns of engagement and crisis. Rapidly receding also are the days in which the greatest threats to the United States came from radical non-state terrorist groups. The re-emergence of great-power multipolar competition, after a century of dormancy, confronts the United States with new complexities amidst the modern spectrum of conflict, from murky gray-zone opportunism to ultra-high-intensity warfare.

The domains of competition are multiplying, the speed of conflict is increasing exponentially, the extent of contested engagement is rapidly expanding and novel nuclear, chemical and biological threats are emerging worldwide. But bringing to bear all instruments of national power across multiple strategic fronts is a skill our country has mastered in the past.

This integration has been the foundation of NSRI operations since its inception in 2012. It's imperative to understand that the threats

of today are nothing like they've ever been before and nothing like what is to come. It is that honest and realistic viewpoint that has pushed the institute to be a convenor, a catalyst for the points of innovation that occur where disciplines, experts, ideas and people collide.

This integrated approach is also the foundation for the evolving mission of NSRI: tackling some of the toughest, highest-priority challenges facing our nation's defense. NSRI works across the threat spectrum — chemical, biological, radiological, nuclear and explosive — to help ensure that these capabilities and threats are top of mind for leading researchers across the country.

As the only University Affiliated Research Center (UARC) sponsored by a combatant command, U.S. Strategic Command, NSRI at the University of Nebraska is well-positioned to understand the complex structures of the Department of Defense (DOD) and to connect and leverage these structures for effectiveness and efficiency.

This understanding of a broad picture of defense and deterrence is critical for the protection of the nation — and our allies — both today and in the future.

UNDERSTANDING OUR PURPOSE

It would be impossible to list all the ways NSRI addresses 21st century threats to our nation's security. Here are examples that provide a glimpse into the world-class work being performed by the NSRI team with collaborators across the federal government and the University of Nebraska.

Discover Solutions To Known Unknowns

THREAT: Grave challenges are being presented to U.S. national security by the rapid expansion, diversification and modernization of the nuclear forces of our great-power competitors.

SOLUTION: NSRI is providing extremely time-sensitive research on future arms control options, expanding and deepening the U.S. government's access to technical, analytic and policy expertise for treaty architectures, core principles, national security implications, new technologies in support of treaty verification, and foreign nuclear threat and treaty compliance assessments. A leading NSRI researcher was a special advisor to the head of delegation at an international engagement on warheads and doctrine.

► nsri.nebraska.edu/nuclear

Prepare For The Unthinkable

THREAT: Too often, laboratory and other highly technical personnel do not receive the access to analytical exercises that decision and response groups do. As a result, these technical personnel often are unaware of the many highly qualified technical resources available nearby.

SOLUTION: Analytical exercises allow participants to develop technical relationships among groups that have never explored opportunities to work together. In March 2020, the California WMD-Civil Support Team did not wait to be called upon to respond to the COVID-19 pandemic. Science Officer Cpt. Brian Quigley, who had participated in a 2018 NSRI exercise with local partners, called the Orange County Public Health Laboratory directly and offered to help. They were directed to a nearby county in great need. The NSRI team also immediately integrated several resources and offered to help the county perform diagnostic assays based on polymerase chain reaction.

► nsri.nebraska.edu/fot

Support The Warfighter

THREAT: Traumatic lung injury often leads to death, particularly on the battlefield, since the body relies on the lungs to provide oxygen.

SOLUTION: Researchers from the University of Nebraska Medical Center (UNMC), the University of Nebraska–Lincoln (UNL) and the University of Colorado–Boulder developed and validated a patented, life-saving solution using oxygenated microbubbles to bypass damaged lung tissue and release oxygen into the abdomen. Microbubbles technology can increase the survival rate of victims of mass casualty events, as well as injured, forward-deployed warfighters in low-resource environments.

► nsri.nebraska.edu/medical

EMPOWERING OUR PEOPLE

The ever-changing strategic defense environment demands ongoing parallel changes in expertise to meet dynamic research needs supporting defense leaders and warfighters. Within the last two years, NSRI has brought on leading talent to ensure accurate and efficient delivery to the Department of Defense.

NSRI LEADERSHIP

In total, NSRI's leadership team possesses more than 275 years of experience working in or supporting the work of the Department of Defense.

See biographies, published articles and recent news from these NSRI leaders at nsri.nebraska.edu/experts.



► Robert Hinson
USAF, Lt. Gen. (Ret.)
NSRI Executive Director



► Richard Evans
USAF, Maj. Gen. (Ret.)*
Deputy Executive Director



► Neal Woollen, DVM, Ph.D., MSS*
Senior Research Strategy
Officer

**TOP ROW FROM LEFT:**

- ▶ Christopher Yeaw, Ph.D.*
Research Director
Nuclear Programs
- ▶ Joshua Santarpia, Ph.D.*
Research Director
CWMD Programs
- ▶ Wes Carter
Director, Field Operations
and Training

MIDDLE ROW FROM LEFT:

- ▶ Dillon Cunningham
Director, Special Projects
- ▶ Katelyn Ideus, MA*
Director, Communications
- ▶ Thomas Mueller, Ph.D.*
Director, Chemical Defense
Programs

BOTTOM ROW FROM LEFT:

- ▶ Anna Ravnholdt, MPA
Director, Compliance
- ▶ James Taylor, Ph.D.
Director, Strategic Mission
Systems
- ▶ John Tencer, MBA
Director, Business
Operations

**Leader brought on to NSRI since 1 July 2018.*

JULY 2018–JUNE 2020

NSRI PRINCIPAL INVESTIGATORS

KEN BAYLES, PH.D.
UNMC

AIMEE KETNER
NSRI

LANA OBRADOVIC, PH.D.
UNO

DAVID BERKOWITZ, PH.D.
UNL

SEAN KINAHAN
NSRI

STEPHEN OBARO, M.D., PH.D.
UNMC

JOHN SWEGLE, PH.D.
NSRI

EMMANUEL KUMFA
NSRI

DAVID ROBERTS
NSRI

MICHELLE BLACK, PH.D.
UNO

SY-HWANG LIOU, PH.D.
UNL

JOSHUA SANTARPIA, PH.D.
NSRI, UNMC

PAUL BRANTMIER
NSRI

JOHN LOWE, PH.D.
UNMC

JAMES TALMADGE, PH.D.
UNMC

KEELY BUESING, M.D.
UNMC

RUPAL MEHTA, PH.D.
UNL

JAMES TAYLOR, PH.D.
NSRI

WES CARTER
NSRI

THOMAS MUELLER, PH.D.
NSRI

DONALD UMSTADTER, PH.D.
UNL

DILLON CUNNINGHAM
NSRI

JODY NEATHERY-CASTRO, PH.D.
UNO

MICHAEL WILEY, PH.D.
UNMC

CARRICK DETWEILER, PH.D.
UNL

LAURA NOLAN
NSRI

CHRISTOPHER YEAW, PH.D.
NSRI, UNL



“Teaming up with the team at USSTRATCOM was an amazing experience that helped me understand the constraints under which their work takes place, and the ways in which automation of some of those processes makes it possible to enable improved performance of a support for military units across the DOD.”

DUSTIN WHITE, PH.D.

NSRI PRINCIPAL INVESTIGATOR, UNO ASSISTANT PROFESSOR

STUDENTS OF NSRI

► DYLAN CHRISTIANSEN

COMPUTER SCIENCE
UNIVERSITY OF NEBRASKA AT OMAHA
MAY 2020 GRADUATE

Dylan teamed up with three other University of Nebraska students in summer 2019 to research and develop an innovative method to increase communications reliability that could support the nation's future Nuclear Command, Control and Communication (NC3) architecture at U.S. Strategic Command. Specifically, Dylan and a fellow student developed a simulation to show the applicability of their overall findings, which focused on adapting Airborne Mesh Communication networks.

► ALICIA BEVINS

MECHANICAL ENGINEERING
MAY 2020 GRADUATE
COMPUTER SCIENCE, GRADUATE STUDENT
UNIVERSITY OF NEBRASKA-LINCOLN

Throughout 2018 and 2019, Alicia served as an undergraduate research assistant on a project funded through NSRI. Her role was to develop mechanical additions for a drone.

"Working on this team with computer science researchers and students showed me what was possible when you bring these disciplines together. This project is the reason why I've gone on to graduate school."

See more about undergraduate and graduate opportunities for University of Nebraska students at nsri.nebraska.edu/workforce.



NSRI BOARD OF DIRECTORS

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USN, VICE ADMIRAL (RET.)

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OMAHA PUBLIC POWER DISTRICT

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USAF MAJ. GEN. (RET.)

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COUNSEL TO THE BOARD
DEPUTY GENERAL COUNSEL
UNIVERSITY OF NEBRASKA

► **HONORABLE BENJAMIN
“BEN” NELSON**

SENATOR FOR NEBRASKA
2001-2013



“Our researchers develop novel, cutting-edge research and solutions critical to supporting those leading our national security. We recruit exceptional faculty and students and, as needed, expand our facilities. I am proud of what we deliver to our customers and remain committed to expanding NSRI’s portfolio and the resources needed to address its core mission.”

JENNIFER LARSEN, M.D.

VICE CHANCELLOR FOR RESEARCH
UNIVERSITY OF NEBRASKA MEDICAL CENTER

UNIVERSITY OF NEBRASKA LEADERSHIP

► **TED CARTER**

PRESIDENT
UNIVERSITY OF NEBRASKA

► **SUSAN FRITZ, PH.D.**

PROVOST
UNIVERSITY OF NEBRASKA

► **JEFF GOLD, M.D.**

CHANCELLOR
UNIVERSITY OF NEBRASKA
MEDICAL CENTER
UNIVERSITY OF NEBRASKA
AT OMAHA

► **RONNIE GREEN, PH.D.**

CHANCELLOR
UNIVERSITY OF NEBRASKA-
LINCOLN

► **DOUG KRISTENSEN, JD**

CHANCELLOR
UNIVERSITY OF NEBRASKA
AT KEARNEY



"Nebraska's tremendous research growth is expanding our capacity to deliver results for our partners across the Department of Defense. Our continued momentum and NSRI's unique focus are critical to discovering solutions for the 21st-century challenges our military faces to keep this country safe."

RONNIE GREEN, PH.D.

CHANCELLOR
UNIVERSITY OF NEBRASKA-LINCOLN

CATALYST FOR OUR PARTNERS

The University of Nebraska (NU) continues to demonstrate its prowess in national security research and solutions. With NSRI as a DOD-designated University Affiliated Research Center (UARC), NU is a trusted-agent of the Department of Defense and a tremendous asset to the federal government.

Researchers, students, colleagues and sponsors who work with NSRI discover opportunities beyond their initial inclinations, and NSRI is proud to be a catalyst for leading national efforts coming out of the University of Nebraska.

In particular, in spring 2020 under the leadership of NSRI PI Gina Ligon, Ph.D., Jack and Stephanie Koraleski Professor of Collaboration Science and professor of management, the University of Nebraska at Omaha (UNO) became the home of the National Counterterrorism Innovation, Technology and Education Center, a U.S. Department of Homeland Security (DHS) Center of Excellence. The center is spearheading a consortium of academic, industry, government and laboratory partners throughout the country in support of DHS' mission to keep the country safe.



"NSRI played a significant role in winning the largest federal grant in the University of Nebraska at Omaha's history. The opportunities NSRI has provided NU faculty across all four campuses has allowed us to build our capabilities in ways that are unmatched for national security research at other institutions."

GINA LIGON, PH.D.

**DIRECTOR, NATIONAL COUNTERTERRORISM
INNOVATION TECHNOLOGY AND EDUCATION CENTER**

PREPARING FOR OUR FUTURE

In some ways, national defense is an inexact science. We have no choice but to grapple with unpredictable shifting, changing circumstances of world conflict and aggression from year to year and from decade to decade.

However, science and diplomacy can be used to deftly mitigate the uncertainty and respond intelligently and confidently to threats that could tear apart our way of life. Throughout

the past two years, NSRI and the University of Nebraska have continued fighting behind the scenes to support our brave leaders and warfighters on the front lines of conflict. In the pages of this report, you'll read the highlights of our efforts — and we'll help you peer into the potential of coming years. We invite you to join the fight in your own way: through supportive contributions, participation, collaboration, communication and legislation.

NSRI'S MISSION

**ENABLE DETERRENCE OF, PREPAREDNESS
FOR AND RESPONSE TO STRATEGIC NATIONAL
SECURITY THREATS ACROSS MULTIPLE DOMAINS
THROUGH LEADING RESEARCH AND SUPPORT**

CONTRACTING & BUSINESS PROCESS

As a University Affiliated Research Center (UARC), NSRI accesses an indefinite delivery/indefinite quantity (IDIQ) contract vehicle through its sponsor U.S. Strategic Command. This shortens the timeline from identification of need to contract award and creates trusted, collaborative relationships.

BENEFITS OF WORKING WITH NSRI

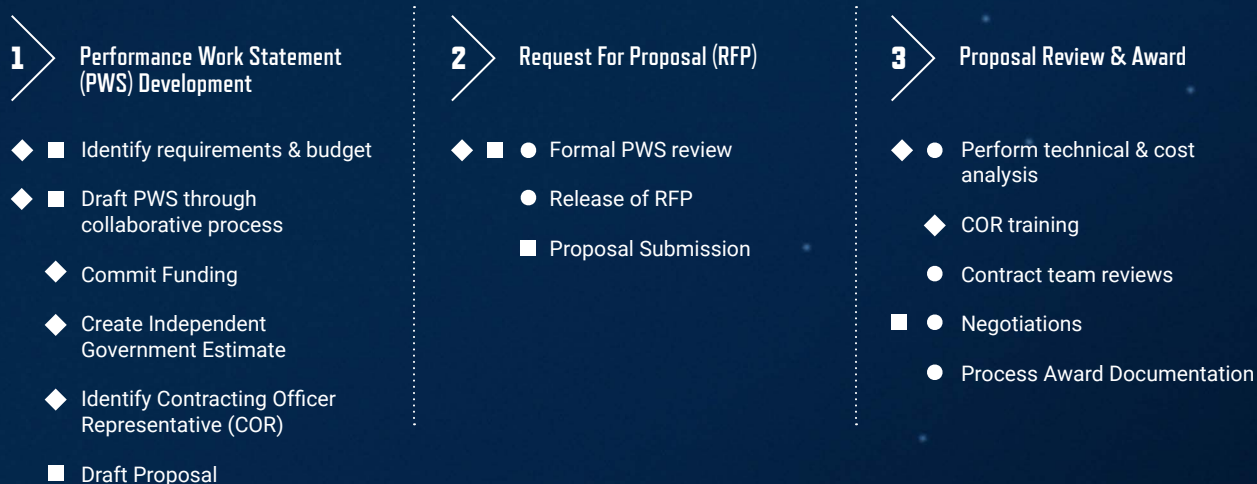
- ▶ Comprehensive knowledge of sponsors' requirements and problems
- ▶ Broad access to information, including proprietary data
- ▶ Broad corporate knowledge
- ▶ Independence and objectivity
- ▶ Quick response capability
- ▶ Current operational experience
- ▶ Freedom from real and/or perceived conflicts of interest

3-STEP IDIQ CONTRACTING PROCESS

Our Integrated Team Process significantly reduces the contracting timeline and increases responsiveness to requirements.

Teams: ◆ Requesting Sponsor ■ NSRI ● 55th Contracting Squadron

USSTRATCOM facilitates and assists throughout the process.



NSRI also accepts funding from direct contracting vehicles, other transaction agreements, cooperative agreements and grants. Extended details available at nsri.nebraska.edu/business.

MEETING OUR CUSTOMERS

NSRI and the University of Nebraska continue to invest in opportunities to provide customers across the DOD and federal government with convenient access to leading facilities and subject matter experts. Several of the capabilities of the university campuses are discussed on pages 22–45 of this report. Within the last two years, NSRI has upgraded its headquarters in Omaha, Neb., to a secure facility, Scott Technology Center, adjacent to the University of Nebraska at Omaha and within a short distance to the University of Nebraska Medical Center.

NSRI also opened a field office in Melbourne, Fla. The 4,100-square-foot building, adjacent to Patrick Air Force Base and less than 25 minutes from Cape Canaveral Air Force Station and NASA's Kennedy Space Center, is well-positioned geographically to host, execute and expand scientific and engineering projects efficiently for federal sponsors.

NSRI LOCATIONS

Headquarters¹

Scott Technology Center
Omaha, NE

National Capital Region (NCR) Laboratory & Conference Center

Annapolis Junction, MD

Space Coast Field Office²

Melbourne, FL

Fredericksburg Field Office & Laboratory

Fredericksburg, VA

Office at U.S. Strategic Command

Offutt Air Force Base
Nebraska

Office at University of Nebraska–Lincoln

Behlen Hall



1



2

REFLECTING ON OUR ACCOMPLISHMENTS

The National Strategic Research Institute (NSRI) at the University of Nebraska (NU) is one of an elite group of 14 university-associated research centers that provides critical defense solutions for the nation's decision makers. As a University Affiliated Research Center (UARC), NSRI is engaged in a long-term, strategic partnership with its Department of Defense (DOD) sponsor, United States Strategic Command (USSTRATCOM).

NSRI, a 501(c)3 organization, accesses the intellectual capacity of leading NU researchers to support the country's deterrence and defense objectives, providing mission-essential research and development capabilities for USSTRATCOM as well as other DOD components and federal agencies focused on national security.

"University Affiliated Research Centers (UARCs) are not-for-profit entities sponsored and primarily funded by the U.S. government to address technical needs that cannot be met as effectively by existing government or contractor resources. These organizations typically assist government agencies with scientific research and development, studies and analyses, and systems engineering and integration by bringing together the expertise of government, industry, and academia to solve complex technical problems in the public interest."

**DEPARTMENT OF DEFENSE UARC
ENGAGEMENT GUIDE**

NSRI BY THE NUMBERS

SEPTEMBER 2012-JUNE 2020



110

CONTRACTS AWARDED



40+

CUSTOMERS



\$162 MILLION

TOTAL AWARD VALUE FOR
RESEARCH CONTRACTS



350+

TASK ORDER PARTICIPANTS FROM
THE UNIVERSITY OF NEBRASKA

FROM 2018-2020, NU PRINCIPAL INVESTIGATORS
REPORTED THE FOLLOWING INSIGHTS.



34

UNDERGRADUATE STUDENTS
INVOLVED IN PROJECTS



44

GRADUATE STUDENTS
INVOLVED IN PROJECTS



10

PAID GRADUATE
ASSISTANTSHIPS

MISSION MILESTONES

The University of Nebraska (NU) competes in a national open call for and is selected as a University Affiliated Research Center (UARC) designated by the United States Office of the Secretary of Defense. NU establishes NSRI as an affiliated but independent 501(c)3 organization to carry the UARC designation.

U.S Strategic Command awards NU/NSRI its first indefinite delivery/indefinite quantity (IDIQ) contract vehicle representing future projects worth \$84 million. NSRI begins convening NU researchers with federal agency customers to accomplish deliverables.

NSRI serves its 10th customer. Projects demonstrate the breadth of NU's capabilities and capacity. Through a key project, "Low-Dose Radiographic System," University of Nebraska–Lincoln physicists eventually will demonstrate that laser-produced X-rays can penetrate steel much thicker than cargo container walls and detect an even smaller amount of uranium than the minimum required by inspection standards.

Total contract awards since 2012 surpass \$42 million, with \$18.3 million awarded in 2016 alone — the highest one-year total to date. NSRI and NU have provided deliverables on 60 task orders, contracts and grants. NSRI scientists with extensive DOD experience are brought on board and begin work on a \$9.3 million, 3-year contract involving biological field and laboratory support.

With \$600,000 NU startup funding, NSRI lands contracts for 22 task orders. The task orders total \$9 million — a significant accomplishment for a UARC's inaugural year. This validates the demand for national defense support and confirms the value of NU's and NSRI's research capabilities across chemical, biological, radiological, nuclear and explosive domains.

NSRI and NU complete their 25th research project for Department of Defense (DOD) and federal agency customers, while conducting 20 additional projects. In total, 24 NU researchers have participated as principal investigators on projects through NSRI since 2012. Projects include immunomics unit research support (\$5.3 million), traffic-calming elements for entry-control facilities to delay and contain threats (\$1 million) and a next-generation sequence training module (\$1 million).

2012

2013

2014

2015

2016

NSRI begins expanding its physical footprint beyond Nebraska to better support defense customers. The NSRI National Capital Region Laboratory and Conference Center opens in Annapolis Junction, Md., and the NSRI Fredericksburg Field Office & Laboratory opens in Fredericksburg, Va.

A cross-campus partnership of UNMC and UNL launches the Nebraska Drug Discovery Pipeline through a \$7.3 million DOD contract. The pipeline will go on to assist in development of drugs to mitigate and/or counteract effects of Acute Radiation Syndrome.

NSRI and NU experience the most significant year-over-year contract growth to date — a 51% increase over 2018. Since 2012, NSRI has facilitated \$155 million in contracts, with an estimated NU ROI of \$3.30 for every \$1 invested. By 2019, NSRI has served more than 40 defense customers. NSRI's employee numbers surpass 50, and the institute expands its leadership team.

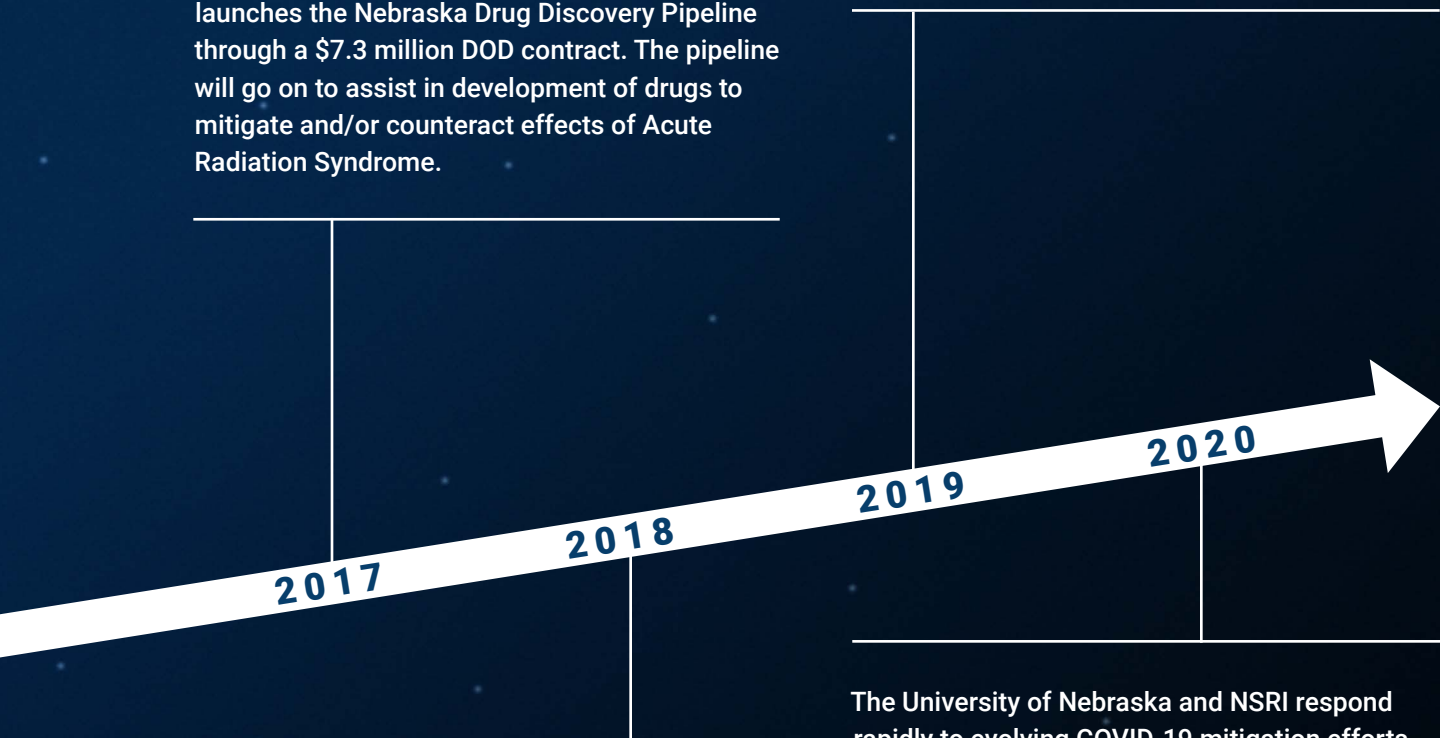
NSRI has facilitated 83 contract awards from 24 sponsors, totaling \$61 million. More than 240 NU researchers and students have participated in projects. In this year alone, five contract awards total more than \$8 million each.

Several projects enter a second phase, including, "En Route Care Acute Respiratory Distress System (ARDS) Mitigation Using Oxygenated Microbubbles" and "Medical Countermeasure Drug Discovery and Development."

To keep pace with demand, USSTRATCOM awards the second IDIQ to the University of Nebraska through NSRI. This one for \$92 million.

The University of Nebraska and NSRI respond rapidly to evolving COVID-19 mitigation efforts, quickly adapting existing defense data, skills, tools and personnel to support the nation's most immediate need.

NSRI is awarded its third IDIQ contract from USSTRATCOM, another \$92 million for application to ongoing defense initiatives, and the institute opens the new Space Coast Field Office in Melbourne, FL.



INNOVATIVE CAPABILITIES ACROSS MULTIPLE DOMAINS

With the University of Nebraska, NSRI delivers technology, product and strategy development as well as training, exercises and subject matter expert advice to Department of Defense sponsors across the spectrum of national security threats and across multiple domains.

While the institute's priorities shift based upon the needs of the Department of Defense, its focus within the core competencies defined by its designation as a University Affiliated Research Center endure. Institute and university leadership continually build upon the accomplishments of researchers and students to bring the foresight of its experts to bear on not only the current needs of those charged with protecting our country, but the needs of the future as well. The following pages drill down into the abilities and deliverables within the key focus areas of the institute over the last two-year period.

UARC CORE COMPETENCIES

- ▶ Active & Passive Defense Against Weapons of Mass Destruction
- ▶ Nuclear Detection & Forensics
- ▶ Consequence Management
- ▶ Detection of Chemical & Biological Weapons
- ▶ Mission-Related Research



"From developing life-saving technologies to training some of the nation's top civilian security specialists, the University of Nebraska with NSRI is proud to directly support those with the mission to defend our country and deter future threats. The impact of our research is far-reaching. It can save the lives of our service members and help to protect our nation."

JEFFREY GOLD, M.D.

CHANCELLOR, UNIVERSITY OF NEBRASKA MEDICAL CENTER,
UNIVERSITY OF NEBRASKA AT OMAHA

NSRI FOCUS AREAS

Nuclear Weapons Enterprise Support

- ▶ Weapons policy analysis: foreign threats, arms control, conceptual weapon design, strategic materials production
- ▶ Strategic conflict deterrence and escalation dynamics: tabletop exercises, wargames, model development, decision support tools
- ▶ Consequence management: nuclear detection and forensics, hazard modeling, disaster mitigation research
- ▶ Support technologies: future NC3 technology exploration, advanced concepts and architecture, materials research, advanced manufacturing, nuclear certification

Threat-Based Training & Exercise Support

- ▶ Academic, hands-on, just-in-time and scenario-driven programs across the CBRN-E spectrum, conducted on site or at NSRI's secure location
- ▶ Full-scale exercise coordination challenging all levels of technical and tactical WMD response teams
- ▶ Sponsor-tailored scenarios that promote multi-jurisdiction participation of mission partners during a WMD-related incident
- ▶ Facilitation of advanced development acquisition support and DOD T&E activities
- ▶ Subject matter expert support to customer-run exercises

Medical Countermeasures & Response

- ▶ Disaster medicine and global health security
- ▶ High-consequence, pathogen-infected patient management and training
- ▶ Vaccine, therapeutic, diagnostic capability discovery and development

Technologies for Detecting & Countering Biological, Chemical & Radiological Weapons

- ▶ Development of detection, collection, identification, exploitation strategies
- ▶ Technical collection, field exploitation, forensic capabilities
- ▶ Hazard detection, decontamination, mitigation, remediation
- ▶ Aerosol science: Environmental characterization, dissemination
- ▶ Materials biology: Substrate effects, binding kinetics, surface integration
- ▶ Threat and effects: Intelligence analysis, modeling, simulation studies
- ▶ Chemical defense: Development and independent testing of field detection and mitigation technologies

NUCLEAR WEAPONS ENTERPRISE SUPPORT

PASSING THE BATON: NEXT-GEN NUCLEAR DETERRENCE, DEFENSE & DIPLOMACY

Early in the morning, a young Connecticut boy slings a bag of newspapers across his body and hops on his bike to deliver the news to his neighbors. As he pulls out each rubber-banded roll, words catch his eye: “Cold War,” “bomb,” “fusion.” He often unrolls the papers to learn more, and by middle school knows he wants a doctorate in particle physics or nuclear fusion. It’s the science that intrigues him. He chooses nuclear fusion in college, and while U.S. President Ronald Reagan talks of “star wars” on television, he studies.

Today, that young man has become a preeminent nuclear weapons and defense diplomacy expert, often called upon by national leaders to research, analyze and present new ideas to help them manage the demands of 21st century defense. He is Dr. Christopher Yeaw, NSRI’s new research director for nuclear programs, a position he has held since 2018 in addition to other prestigious roles he fulfills throughout the U.S. nuclear enterprise. Dr. Yeaw was hired to lead NSRI’s contingent of nuclear researchers through the evolving missions of its sponsor U.S. Strategic Command (USSTRATCOM) and other defense stakeholders.

The Modernization of Nuclear Deterrence

U.S. defense efforts in many ways broadened after the fall of the Berlin Wall. The Cold War ended, and while foundational nuclear capabilities remained, the nation’s defenders turned their attention to terrorism and counterterrorism, with multiple expanding domains ranging from chemical and biological threats to electromagnetic security and evolving cyber and space threats.

Nuclear weapons again became a leading defense priority with the advancing nuclear capabilities not only of the U.S.’s traditional great power adversary, Russia, but of smaller competitors such as India, Pakistan and Iran, as well as an emerging third great power: China. In this multipolar threat environment, the U.S. government intensified its focus on nuclear deterrence and nuclear command, control and communication (NC3) at a level not seen in the decades since the last nuclear weapons were tested.

To support the government’s ability to lead the U.S. interagency and the worldwide diplomatic community in nuclear areas of national and global security, USSTRATCOM and the government called upon NSRI to expand and deepen its access to technical, analytic and policy expertise in this field. During the two years covered by this report, the institute’s service to American defense has been driven by this intensified focus and the ensuing needs of NSRI’s sponsor and the U.S. Department of Defense.

Anticipating and Responding to Evolving Threats

As a research arm of the University of Nebraska (NU) and in partnership with its University Affiliated Research Center (UARC) sponsor USSTRATCOM, NSRI since its inception in 2012 has mustered a critical mass of the nation's intellectual capital on nuclear deterrence, defense and diplomacy. In the evolving nuclear environment, these scientists, policy scholars and strategists – including a contingent of brilliant and talented students – are helping advance solutions to the challenges of nonproliferation, nuclear counterterrorism, detection of nuclear materials, consequence management and medical countermeasures, as well as diplomacy, treaty analysis and arms control to reduce nuclear risk.

Some of NSRI's notable developments during this reporting period are the hiring of Dr. Yeaw, commissioning of the Strategic Mission Systems Directorate and promotion of Lt. Col. (Ret.) Dr. James Taylor, to lead the new directorate. This dual emphasis represents a balance needed between diplomacy and technology to ensure the success of the nuclear enterprise.

Dr. Christopher Yeaw became the institute's research director for nuclear programs in September 2018. He brings a rich background of scholarship, innovation and collaboration with top researchers and senior officials at the highest levels of the U.S. government, including USSTRATCOM. This broad directorial role encompasses activities such as extremely time sensitive research on future arms control options, nuclear weapons research, intelligence and threat assessment, policy planning, decision-support, wargaming and red teaming plans.

“You can’t put a price on [Dr. Yeaw’s] ability to be concise and clear with very high-level officials. Though this might sound like an overstatement, it isn’t ... his work for us directly advances the peace and security of the United States, our Allies and the world.”

SENIOR GOVERNMENT OFFICIAL

Strategic Mission Systems Directorate was established in spring 2019 to unite efforts to support USSTRATCOM's mission. The new directorate is led by Dr. Taylor through research task order development and execution. Dr. Taylor previously served as a university research coordinator and 20-year USAF officer in developmental engineering. He worked on projects in air defense modeling, space nuclear power, airborne laser flight-testing, low observable technology development, information warfare research, aircraft survivability, wargaming and leadership development.

- Read more about Dr. Yeaw and Dr. Taylor at nsri.nebraska.edu/experts.

To further align NSRI resources and services in support of USSTRATCOM and 21st Century deterrence and defense needs, in this reporting period the institute convened an interdisciplinary research team that is harnessing the intellectual capacity of the University of Nebraska to benefit and support the future nuclear command, control and communications (NC3) capabilities of USSTRATCOM. The team's goal is to collect modeling and simulation capabilities and expertise within the NU system, then identify and fill gaps.

- Learn more about this initiative at nsri.nebraska.edu/NC3team.



As the shifting strategic deterrence needs of USSTRATCOM and other defense customers became clearer within this reporting period, the university and NSRI began strategizing formal ways to align deterrence-focused resources into a cohesive service center. The strategy group includes (from left front): Dr. Christopher Yeaw, NSRI research director for nuclear programs; Lt Gen. (Ret.) Robert Hinson, NSRI executive director; Dr. Michelle Black, UNO assistant professor; Dr. Lana Obradovic, UNO associate professor; Dr. Jody Neathery-Castro, UNO associate professor and department chair. (From left, back): Matt Hammons, NU assistant vice president for external relations; Maj. Gen. (Ret.) Richard Evans, NSRI deputy executive director; Dr. Tyler White, UNL assistant professor of practice; Dr. Peter Muhlberger, NU Public Policy Center research manager; Dr. James Taylor, NSRI director of strategic mission systems; Dr. Marc Warburton, UNL department of political science national security director.

Tangible Steps Toward 21st-Century Deterrence Solutions

TECHNICAL, ANALYTIC AND POLICY SUPPORT

Through a series of research efforts and strategic intelligence projects led by Dr. Yeaw, NSRI is bringing to bear expertise from NU, U.S. academia and the wider nonprofit and NGO community to provide the U.S. Department of State with extremely time-sensitive research on future arms control options: treaty architectures, core principles, national security implications, new technologies supporting treaty verification, and foreign nuclear threat and treaty compliance assessments. It is in this capacity that Dr. Yeaw served as special advisor to the head of delegation at the bilateral working group on warheads and doctrine in Vienna, Austria, during the summer of 2020. Dr. Yeaw and the NSRI team of experts continue to provide real-time, extensive support to these ongoing diplomatic negotiations.

NUCLEAR CERTIFICATION PROGRAM ENHANCEMENTS

NSRI recently convened an interdisciplinary team of nuclear enterprise and software engineering experts to examine complex issues surrounding the need to efficiently and effectively certify nuclear weapons and weapon systems and ensure their readiness. The project identified areas where streamlining could occur, including leveraging broad commercial software engineering practices where appropriate to enable innovation. The nuclear certification project team was led by Dr. Taylor and supported by Dr. Matthew Hale, assistant professor in the School of Interdisciplinary Informatics at UNO. The elite cohort of experts on this team examined DOD-level guidance and directives, hypothesized conditions that might keep systems from being delivered to the warfighter on time, then presented their findings and recommendations to senior DOD leadership.

► Learn more at nsri.nebraska.edu/nuccert.

TABLETOP WARGAMES FOR ESCALATION DYNAMICS

NSRI researchers, NU faculty and staff have become adept at turning ideas into plans and then testing those plans through wargames. This academic-focused exploration of

wargaming as a strategic tool and learning tool helps participants test creative theories about complex, real-world problems.

A new series of novel tabletop wargames originally developed for the Defense Threat Reduction Agency helps military leaders and personnel explore nuclear escalation dynamics in the context of limited nuclear conflict. Agency participants included Defense Threat Reduction Agency (DTRA) Director Val Oxford. The experience helps strengthen the capability of DTRA to support national leaders and warfighters as they deter adversaries.

Oxford referenced this work in his 11 February 2020 testimony to the Congressional Subcommittee on Intelligence and Emerging Threats and Capabilities: “We’ve used the [National Strategic Research Institute] in Omaha to attract future talent. We fund some of the research out there. We’ve also used some of the staff expertise within the [institute] to help us start to wargame some of the advanced threats. For example, we just ran a limited nuclear wargame within the agency to find out what challenges we may have confronting, for example, Russian use of nuclear weapons.”

► NSRI welcomes those interested in participating in this type of wargame to submit their request at nsri.nebraska.edu/escalationTTX.



“Some of the best research today exists along interdisciplinary boundaries. We can all learn from one another. NSRI brings together perspectives that make up valuable cross disciplinary teams.”

MATTHEW HALE, PH.D.

NSRI RESEARCH PARTNER, UNO ASSISTANT PROFESSOR



“NSRI’s support has been instrumental with this research grant, as it has allowed me to understand details from an allied perspective that I would have never been able to receive if I limited my conversations and research to just open source material.”

MICHELLE BLACK, PH.D.

UNO ASSISTANT PROFESSOR, NSRI PRINCIPAL INVESTIGATOR

INTERNATIONAL SECURITY IMPLICATIONS RESEARCH

Dr. Michelle Black, assistant professor of political science at the UNO College of Arts and Sciences, with NSRI’s assistance, was awarded NSRI’s first North Atlantic Treaty Organization (NATO) research contract. The deliverable is development of a methodology that could be adapted to future challenges within a complex international system to enable coherent deterrence within a multiple-actor deterrence framework.

The team has worked closely with NATO colleagues to begin testing the methodology and is developing further experimentation opportunities. In addition to providing a valuable methodology for future defense decision-making, the project provides an opportunity to involve students in real-world solution formulation. This approach allows students to gain valuable

skills for future careers and provides a fresh perspective to assist current decision makers.

Grooming the Next Generation of Nuclear Deterrence Decision Makers

As the years progress, the baton of nuclear deterrence planning, strategizing and leading nuclear forces will be passed to a new generation of scientists, scholars, diplomats and warfighters. The nurturing of this next generation of researchers and leaders is a priority within the NSRI portfolio of capabilities.

In 2019, NSRI interns developed a concept for a novel airborne mesh communications network to increase connectivity in a crisis scenario. In 2020, NSRI interns partnered with ROTC cadets to refine a wargame that explores the impacts



“World War II was almost 80 years ago. A lot of people from my generation have lost awareness of ‘This is why nuclear weapons are important; this is how we use them every day.’ I was going to be a special prosecutor until I took a class on nuclear deterrence. I thought, ‘This is mind-blowing, and it’s still something we have to worry about today.’”

ASHLEE MCGILL

NSRI INTERN, NU STUDENT

NSRI interns and leadership from 2019 after the students' final presentation to USSTRATCOM leadership. From left: Chris Luther, NSRI senior operations analyst; Dylan Christiansen, student, UNO; Lt. Gen. (Ret.) Robert Hinson, NSRI executive director; Jasmine Cashin, student, UNL; Walker Pendleton, student, UNO; Dr. James Taylor, NSRI director of strategic mission systems.



of cyberattacks on NC3, including implications for deterrence and escalation control in nuclear crisis scenarios. Students presented the findings of these projects to senior leaders of USSTRATCOM, who have interest in creating a similar program for the command.

- Learn more about the students of NSRI at nsri.nebraska.edu/workforce.

R&D: The Bedrock of U.S. National Security through Nuclear Forces and NC3

In July 2020, USSTRATCOM Commander ADM Charles Richard said in an interview with the Mitchell Institute, “The United States and the Department of Defense have not had to consider the full implications of competition ... with a nuclear-capable peer adversary in close to 30 years. And when you think about that, the

implications of every single thing we do in the department are profound. And we have a good strategy to go address that situation, and we have fabulous leadership ... but it is important to recognize things have changed.”

NSRI provides a foundational piece of that emerging strategy: research and development. The institute is poised to provide the expert research personnel, data and other resources, including thought leadership, that our nation's leaders need to strengthen U.S. nuclear deterrence, modernize U.S. strategic weapons and counter the capabilities enabled by foreign nuclear and radiological weapons.

Somewhere in our nation's 50 states, there are young people, such as the young Christopher Yeaw and Ashlee McGill, who don't yet know how pivotal their work will be to the future protection of all Americans. When they are ready to meet their destiny, NSRI will be ready to meet them.

DETECTING AND COUNTERING BIOLOGICAL AND CHEMICAL WEAPONS

TRUSTED-AGENT OF THE FEDERAL GOVERNMENT WORKING TO MODERNIZE DEFENSE ASSETS

Shortly after news of the Anthrax letters became public, graduate student Joshua Santarpia, who was studying atmospheric aerosols at Texas A&M, began to wonder how he could apply his work to the problems of biological defense. He thought of technologies that could use light to discriminate biological threats from innocuous particles.

In 2005, Dr. Santarpia took his first job at the Edgewood Chemical and Biological Center and began testing biodetection devices for the Department of Homeland Security. At the time, the biodetection and identification systems might be the size of a refrigerator and no one understood their performance in an operational environment.

Today, Dr. Santarpia is a pathology and microbiology associate professor at the University of Nebraska Medical Center and NSRI's research director of CWMD programs. He is working with colleagues to develop a technology that will weigh less than five pounds, fit on a small unmanned aerial vehicle (UAV) and perform

the same functions as the refrigerator-sized systems of 15 years ago. He is also working on new technology, in collaboration with a colleague at Army Research Labs, that uses a novel light scattering technique to detect biological aerosols in the atmosphere.

Biological weapons are difficult to detect, but surveillance to identify attacks early is the best way to mitigate them.

Addressing Unseen WMD Threats with Real-World Solutions

In part due to advances in science and technology, such as UAV capabilities, throughout the past few decades there has been increased attention on chemical and biological terrorism and a growing concern that foreign states could use these WMD — or already are using them. The fast spread of the



"Our purpose is not just about giving answers. What we do is actually take the research and give our sponsors the capability, and that's what we do well."

JOSHUA SANTARPIA, PH.D.

NSRI RESEARCH DIRECTOR FOR CWMD PROGRAMS, UNMC
ASSOCIATE PROFESSOR OF PATHOLOGY AND MICROBIOLOGY



“I’m a scientist through and through. I’m not on the front lines, but this is my way to give back to support my country.”

THOMAS MUELLER, PH.D.

NSRI, DIRECTOR CHEMICAL DEFENSE PROGRAMS

COVID-19 coronavirus underscored the potential devastation that could result if someone did decide to use such a weapon.

However, the same technology that has advanced potential threats also increases defenders’ ability to fight them. For these and other reasons, interdicting, detecting and mitigating biological and chemical WMD is and has been a priority for NSRI and its defense customers.

Biological WMD solutions: NSRI has collaborated for many years with NU researchers and end-users to develop and implement new technology to support virtually every aspect of biological defense and biosurveillance, especially regarding organisms dispersed in aerosols. Individual efforts support a range of aerobiology and environmental microbiology research.

Chemical WMD solutions: NSRI researchers have been working to address chemical threats for defense agencies including supporting chemical detector programs and hosting tabletop exercises and technology reviews.

Anticipating and Responding to Evolving Threats

Built on a foundation of decades of University of Nebraska research capabilities, NSRI projects in the past two years have helped develop WMD countermeasures in multiple domains. Projects ranged from concept and development to testing and prototyping. Much of the work during these two years was focused heavily on detection using unmanned aircraft systems (UAS) like the one being developed by Dr. Santarpia’s team.

When the coronavirus appeared at the end of this period, NSRI and NU researchers were ready to step in with technology and skills already in play — and they expect to be working on virus-related challenges for some time.

In April 2020, NSRI formalized the process of developing chemical WMD solutions with a new chemical defense directorate. In the few months since opening, the new directorate has engaged in projects with NU research experts, top government stakeholders, other UARCs and private industry. The initial focus has been on direct support for operational use, including providing subject matter expertise, field testing, and training law enforcement.

The **NSRI Chemical Defense Directorate**, since its launch in April of 2020, has been led by **Dr. Thomas Mueller**. He offers a decade of senior-level experience in chemical research and development from Johns Hopkins University Applied Physics Laboratory (APL) and Battelle Memorial Institute. He has been with NSRI since 2018. Dr. Mueller will continue to grow NSRI’s capabilities across the chemical threat spectrum to become a go-to resource for government, military and private mission partners.

► Read more about Dr. Santarpia and Dr. Mueller at nsri.nebraska.edu/experts.



UNL graduate and undergraduate research assistants in the Terry Research Lab at Behlen Hall. From left: Grant Phillips, Dallas Drapal, Matthew Newman, Tony Wilson, Nathan Borczyk.

Much of NSRI's work in all of these domains is steeped in the science behind solutions, because the tasks are taken on by NU researchers who have devoted their lives to scientific study. However, lessons learned and skills obtained through science offer a secondary value as a support for operational and intelligence tasks within military and government defense-focused departments. In addition, NSRI researchers have worked with the institute's field operations and training team to prepare law enforcement departments, military missions and civil support teams to identify and successfully respond to incidents.

NSRI is committed to keeping the pipeline of scientific researchers filled to provide a future workforce in these areas. A great deal of the

institute's support goes to providing student opportunities. From building prototypes to manufacturing biomedical devices, mechanical engineering undergrad and graduate students directly supported projects for Department of Defense agencies during their experience in the University of Nebraska–Lincoln Terry Research Laboratory.

Evie Ehrhorn, senior molecular and biomedical biology major at the University of Nebraska at Omaha, was one of six undergraduate students working closely with Dr. Paul Davis, associate professor, on several projects through NSRI during this reporting period. She specifically focused on exploring the mechanistic actions of the immune system.



“Once beginning this research, I realized my love and passion for it. I have decided to pursue a doctorate degree in immunology and infectious diseases, and, in the future, I would like to continue my work of protecting our country by supporting the Department of Defense.”

EVIE EHRHORN

SENIOR, MOLECULAR AND BIOMEDICAL BIOLOGY, UNO

Tangible Steps Toward 21st-Century Solutions

COVID-19 PANDEMIC SUPPORT

NSRI's background and expertise in aerosolized bioweapons and measurement were immediately transferable to the institute's response to COVID-19, because transmission of the virus works in a similar way. NSRI teams were able to push solutions out to sponsors quickly.

Going forward, NSRI and NU researchers will work directly with the Department of Defense to help develop and field environmental monitoring capabilities and learn more about patient transport and general troop movements with the reality of the novel coronavirus. Scientists will develop capabilities for detecting the virus with new technologies, administer clinical samples of antibodies and very comprehensively help to address the problem in virtually every aspect.

UAS DETECTION

NSRI and the university have various people working on unmanned aircraft projects across this focus area. Projects include both fixed-wing chemical and biological detection devices, which expands the chemical and biological work of the last couple of years. The new systems are being developed at the request of government, military and commercial end-users who will use them to help protect military installations and other environments where biological WMD are suspected. Experience gained also is going to be used by a similar set of defense customers to evaluate detection technologies for COVID-19.



Dillion Cunningham, NSRI director of special projects, collects a surface sample for particle disposition, 6 April 2020, from inside a C-17 military transport aircraft located at the Nebraska National Guard air base in Lincoln, Nebraska. Photo credit: Senior Master Sgt. Shannon Nielsen



David Roberts, NSRI deputy director of technical collection, flies a UAV near the University of Nebraska-Lincoln Biological Process Development Facility (BPDF). Thanks to the BPDF and other leading facilities across the University of Nebraska, NSRI can respond efficiently to customer needs.

FIELD TEST OF MASS SPECTROMETER

With NU and commercial partners, NSRI researchers are integrating a high-pressure mass spectrometer (HPMS) into a fixed-wing unmanned aerial system (UAS). The HPMS provides trace-level chemical vapor selectivity to discriminate priority threats from interferents, as well as actionable intelligence, in seconds. NSRI is field-testing the integrated HPMS to provide real-time trace vapor detection capabilities with geolocation tags to support find-and-fix missions.

"We go into the field and put tech through its paces to make sure it works under operational conditions," Dr. Mueller said.

CONTRIBUTIONS TO DARPA ECHO

Exciting projects in the biological domain include exploration of the human epigenome in a new way to get a diagnostic and forensic picture that contains historic events locked into each individual's epigenome. The program goal is to harness the epigenome to determine if and when someone has been exposed to WMD precursors or agents. NSRI is coordinating the Defense Advanced Research Projects Agency ECHO effort focused on the large-scale production of synthetic opioids by providing subject matter expertise for opioid synthesis, operational training scenarios and sample collection for mission partners.

TRAINING COURSE FOR FENTANYL RESPONSE AND CHEMICAL SYNTHESIS

For the institute's training team, NSRI chemical WMD experts provided realistic scenarios focused on pharmaceutical-based agents, including fentanyl and analogs. The chemical defense directorate provides up-to-date information and current understanding of the hazards to course instructors.

"Because overdoses have been in the news a lot over the last couple of years, there has been a lot of misinformation about the hazards and how to respond," Dr. Mueller said. "Some of this stems from the media not understanding exactly what happens and how it works."

► Learn more about NSRI training opportunities on page 40.

Developing Defense-Ready Capabilities for Impending Threats

Until NSRI's next biennial report, much of the emphasis in this focus area will be on working in partnership with NU researchers to respond to evolving needs related to the COVID-19 pandemic.

However, the beauty of this and other work NSRI and NU researchers are undertaking right now is that the current advancements will help defense decision-makers anticipate the threats to the United States that may be coming next.

MEDICAL COUNTERMEASURES & RESPONSE

LEVERAGING MEDICAL AND SCIENCE PARTNERSHIPS FOR LIFE-SAVING TREATMENTS

Dr. Keely Buesing, a trauma surgeon with the University of Nebraska Medical Center (UNMC), stood in a pig stall at the animal science complex at the University of Nebraska–Lincoln. With help from her lab assistant and another tech, she prepared to deliver revolutionary, lung-augmenting technology in one of many tests on a trajectory to human trials. Dr. Buesing looked up for a moment and saw two Jersey cows over the barrier watching the procedure.

It was a humble but notable moment after two years of study and experimentation with her research partners Dr. Mark Borden of the University of Colorado and Dr. Ben Terry of the Terry Research Lab at the University of Nebraska–Lincoln. The brand-new technology the team is still working on is called *microbubbles*. The procedure is designed to temporarily deliver oxygen to the bloodstream when damaged lungs cannot do their job. It is a potential lifesaver not only to warfighters but to all sufferers of smoke inhalation and other lung-critical patients Dr. Buesing often sees in her emergency surgical practice.

“To see the microbubbles actually raise oxygen levels and keep them raised for 2-to-3 hours lit a fire under me to keep going,” Dr. Buesing said. “As a trauma surgeon, I’m very skeptical and doubtful that anything will work until I see it with my own eyes. I saw that this could actually help humans.”

Anticipating and Responding to Evolving Threats

To anticipate the Department of Defense’s needs for countermeasures against biological weapons of mass destruction and highly infectious disease, there must be a significant, consistent effort. NSRI helps match suitable experienced clinicians and researchers to achieve this. The work leads to critical medical countermeasures such as the development of microbubbles and vaccines to protect against biological toxins. This is research and development that literally can save the lives of those who sacrifice so much for our country’s safety.

UNMC, even before NSRI’s beginning, was known for groundbreaking achievements in medicine, including responses to infectious diseases. Since 2012, the institute and NU have forged a respected record of performance in design and development of medical countermeasures and responses. The list of achievements includes select agent vaccines; novel preventive and prophylactic treatments for neurotoxins; innovative approaches to vaccine and drug delivery; and research, development, testing and evaluation of equipment providing therapeutic treatment countermeasures for both military and civilian use.

Within the last two years, NU has made noteworthy advancements in capabilities through campus facilities.



The National Quarantine Unit at UNMC and Nebraska Medicine came online in January 2020 and was immediately put to use for some of the first U.S. patients infected with COVID-19. The 20-bed unit is the nation's only federal quarantine facility and the primary destination for people exposed to high-consequence infections.

An additional biosafety level-3 laboratory suite in Davis Research Center at UNMC is now available to work with pathogens that can cause serious and potentially lethal disease via inhalation. This laboratory suite has been designed specifically to provide needed protection against risk group 3 pathogens and other agents associated with certain safety and biosecurity concerns in research and diagnostic testing.

An animal biosafety level-3 facility was activated by UNL, allowing NU and NSRI scientists to safely work on highly transmissible agents.

For many years, NSRI has partnered closely with the UNMC Global Center for Health Security. Together, scientists from both entities lead numerous biopreparedness research efforts, ranging from basic science to safe air evacuations, including evaluation of the United States Air Mobility Command's Transport Isolation System. In the last two years, the team made significant advancements through several key projects related to patient transport and drug development.



"The University Affiliated Research Center designation that NSRI carries for the University of Nebraska is a huge advantage, especially since we are the only UARC with a major focus on biomedical research. We are able to offer our expertise and deliver products to our DOD and federal agency partners so much more efficiently because we are a trusted agent of the government, something we take incredibly seriously and are honored to do."

KEN BAYLES, PH.D.

UNMC ASSOCIATE VICE CHANCELLOR FOR BASIC SCIENCE RESEARCH AND PROFESSOR IN THE DEPARTMENT OF PATHOLOGY AND MICROBIOLOGY

Tangible Steps to 21st-Century Solutions

URGENT RESEARCH ON SARS-COV-2 TRANSMISSION

The infectious disease team at UNMC possesses invaluable experience transporting and treating patients who suffer from highly infectious diseases such as Ebola. The team put this experience to work in the search for safe ways to intake COVID-19 patients at the beginning of the mitigation efforts in February 2020.

Early this year, with access to the Nebraska Biocontainment Unit and National Quarantine Unit at UNMC, Dr. Josh Santarpia, NSRI research director for CWMD programs and associate professor of pathology and microbiology at UNMC, immediately went to work to identify the potential spread of SARS-CoV-2 in the air and on surfaces. His work provided some of the nation's initial insights into mitigating the virus. In July 2020, he published two professional articles, "The Infectious Nature of Patient-Generated SARS-CoV-2 Aerosol" and "Aerosol and surface contamination of SARS-CoV-2 observed in quarantine and isolation care."

RESEARCH AND DEVELOPMENT FOR ADVANCED CHEMICAL DETECTION AND DECONTAMINATION

With an award of more than \$9 million received in April 2020, NSRI and colleagues at NU and the DOD will screen novel active material that can be shown to target and disrupt growth of and/or kill harmful bacteria and viruses. This material could be used both for remediation of biological contamination and for detection of harmful bacteria and viruses.

In the theater of war, this research could be instrumental in mitigating agents of concern used

for biological warfare and terrorism and agents that present significant health risks to active military forces. The team will work to produce functional products from this novel active material to meet the needs of the sponsor. Just months into the project, the team already was screening existing samples, engaging in new environmental collection activities and performing the necessary laboratory studies.

OXYGENATED MICROBUBBLES TO SAVE INJURED SOLDIERS ON THE BATTLEFIELD

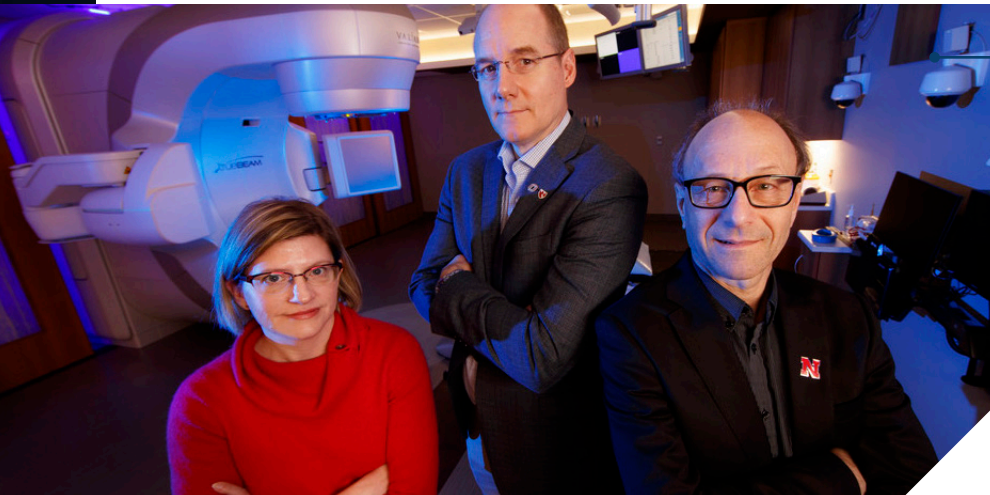
Traumatic lung injury often leads to death, particularly on the battlefield because it takes time to transfer injured soldiers to medical facilities where oxygen can be administered. Many soldiers die because injured lungs lead to damage of the brain and other vital organs. Since 2016, NSRI and NU scientists have worked on an innovative new treatment using oxygenated microbubbles.

The microbubbles bypass damaged lung tissue and release oxygen into the abdomen, essentially transforming the abdomen into a third lung, which helps maintain organ function while the soldier's lungs recover. As of the writing of this report, the microbubbles technology has passed small-animal and large-animal studies. Everything is in place to move to the next step, preclinical and first-in-man/clinical trials.

"To develop a technology that could directly speed patients to recovery or get them off of a ventilator is more than I can even get my brain around."

KEELY BUESING, M.D., FACS

ASSOCIATE PROFESSOR,
UNIVERSITY OF NEBRASKA
MEDICAL CENTER, NSRI PI



Researchers Dr. Becky Deegan (left) and Dr. Ken Bayles (middle) of UNMC and Dr. David Berkowitz (right) of UNL are jumpstarting the development of drug therapies to protect military service members from the effects of radiation exposure.

NEBRASKA DRUG DEVELOPMENT PIPELINE

The Nebraska Drug Development Pipeline was launched in 2017. Over the past two years covered by this report, the pipeline moved well beyond concept to achievements that are helping the Department of Defense fulfill its mission to shorten the U.S. military's wait for drugs that can prevent and counteract hazardous exposure. Led by Dr. Ken Bayles, UNMC associate vice chancellor for basic science research and professor in the department of pathology and microbiology, and Dr. David Berkowitz, chair of the department of chemistry at the University of Nebraska—Lincoln, the pipeline makes it possible to produce critically needed drugs that are

financially risky for the pharmaceutical industry to pursue. These efforts to build capacity over several years also have paved the way for NU's researchers to develop therapeutic antibodies to treat COVID-19 patients.

In 2019, NU received an additional award to bring the University of Nebraska, NSRI and pharmaceutical manufacturers together in unique partnerships to mitigate the lethal effects of radiation exposure, as in a nuclear accident or nuclear weapons incident. Many of NU's top scientists are working on medicinal chemistry, metabolomics and bioinformatics to move potential drug candidates toward clinical trials.

- Get the latest about the Nebraska Drug Development Pipeline at nsri.nebraska.edu/nddp.



"This project is an exciting collaboration among the federal government, our state university and two of its premier research campuses, and consultants from private pharma who are Nebraska alumni."

DAVID BERKOWITZ, PH.D.

PROFESSOR OF CHEMISTRY, UNL

Preparing the Next Generation of Knowledgeable Scientists

Many basic scientists do not receive formal training in methods used to understand dual global public health and national security applications of their work. However, it is critical that biodefense and health security students receive training grounded in principles used to conduct research aimed at protecting both civilian and military populations, as well as an appreciation for the unique research applications in this area.

In addition to numerous student pipeline initiatives across University of Nebraska campuses, UNMC has launched an interdisciplinary program in biodefense and health security. Students enrolled in this program engage in and learn processes and methodologies, fundamental elements and scientific principles needed to develop successfully as practitioners in emerging medical and scientific disciplines related to global security and defense against infectious disease.

Two tracks are available to students: one focused on biosurveillance and biodefense science related to national security and another focused on basic and clinical science related to global health. Either track consists of a mix of technical courses designed to develop a deep understanding of the student's focus area and practical or policy courses designed to guide the student to successful application.

► Learn more at unmc.edu/msia/programs/bdhs.

Catalysts, Conveners, Achievers: Taking Action to Deliver Results

As the SARS-CoV-2 pandemic unfolded throughout the world in early 2020, it became a humbling yet career-changing experience for many scientists who responded to and helped mitigate the infectious disease. Their decades of work were either thrust into the spotlight or halted to allow them to respond immediately to the pandemic. They will remember the many small victories and remarkable behind-the-scenes achievements they've been a part of during the course of this work for years to come. As these respected NU and NSRI scientists continue to learn and ask questions to protect our warfighters, they will remain highly aware of the broader needs of the country, so they can help keep all of us safe through medical countermeasures and responses they help develop — anticipating, advancing and delivering innovations in science and technology that take humanity to the next level of medical achievement.

THREAT-BASED TRAINING AND EXERCISE SUPPORT

SAVING LIVES THROUGH TOP-TIER INSTRUCTION AND EXPERIENCE

In the summer of 2019, the South Carolina 43rd Civil Support Team (CST) received a call from local law enforcement asking for help. Officers had encountered an unknown substance in the field while arresting a suspect for operating a makeshift pill pressing laboratory. They weren't sure how to identify the substance, but they knew enough to be worried. The highly addictive opioid, Fentanyl, at that time was emerging as a recurring threat — not only to civilians but to law enforcement officers who can become dosed or overdosed with the drug even when moving it into property and evidence.

Fortunately, just two weeks before, members of the 43rd CST had attended an NSRI course on pharmaceutical-based agents with their counterparts in Indianapolis with the 45th Indiana CST. The two-day event, held in Indianapolis, had been led by Daniel Polanski, NSRI's deputy director of field operations and training. The event included hands-on practical stations on pill manufacturing, decontamination, analysis of fentanyl analogs and improvised synthesis laboratories. NSRI's director of chemical programs, Dr. Thomas Mueller, led the group

through the manufacture, analysis and safe disposal of one of the precursors needed in the synthesis process.

The 43rd CST team used this new information they learned from NSRI to assist law enforcement officers with the identification of the white powders as Fentanyl, helping them avoid harm to themselves and civilians.

Readying Responders to Fight Evolving Threats

Weapons of mass destruction, terrorist threats, illicit drug manufacturing and infectious disease are constantly evolving. Civil Support Teams, law enforcement, HAZMAT teams, medical personnel and state and federal policymakers across the nation have a tremendous responsibility to keep citizens safe. To do that, they must learn new facts as quickly as possible about chemical, biological, radiological, nuclear and explosive threats (CBRNe).

NSRI constantly evolves with these threats and trains responders through up-to-date, technically



"We haven't found a need yet that NSRI and the University of Nebraska couldn't step up to, whether it has been coming up with new CBRNe response courses, infectious disease transport procedures or novel uses for UAVs."

WES CARTER

DIRECTOR, NSRI FIELD OPERATIONS AND TRAINING

accurate, immersive courses and exercises that can be customized to specific mission requirements. The team addresses aspects of all CBRNe hazards, as well as testing, protocols, policies and record-keeping tools that impact operations. NSRI's events also help build relationships, which can be critical to successful responses to dangerous scenarios.

The classes NSRI teaches are unique in that they combine hands-on practical exercises and lectures from some of the best subject matter experts in the field. The NSRI threat-based training team carries a full lab of equipment to trainings, and the students build labs themselves. This gives responders a deep knowledge of the scenarios they are likely to enter in the field – and a better chance of safely resolving incidents. This is especially important for those who haven't yet experienced a real event.

The ability to respond tactically to this type of threat begins with science. NSRI's training team works closely with the best available biological, chemical and radiological subject matter experts and University of Nebraska researchers to design the courses, serving as a bridge between academic knowledge and practical needs in the field. In addition to conveying this knowledge through its own offerings, the NSRI team conducts joint training programs with high-level national and international counterparts.

The NSRI field operations and training team is led by Wes Carter who served in the U.S. Department of Defense (DOD) for 21 years with a primary focus in WMD training and response. He held several U.S. Army positions related to infectious diseases, counterterrorism and emergency response. He has deployed to 23 different countries for disease investigation and outbreak response. Carter has recruited a team with similar depth of experience to ensure NSRI's courses continue to be known as leading-edge, top-tier, proven-effective trainings that lead to realistic response success.

"We do this because we believe in the mission," Polanski said. "We have been in the shoes of our students, so we know what their needs are."

Anticipating and Responding to Evolving Threats

The deep knowledge and significant experience of NSRI's field operations and training team was leveraged by several agencies and leaders within the COVID-19 response.

Jacob Ferry, former Army Special Forces Medic turned organizational psychology doctoral student and NSRI deputy director of field operations and training plans and programs, participated as a consultant to Nebraska Governor Pete Ricketts' COVID-19 response task force as well as the University of Nebraska Medical Center (UNMC) public health task force. Given his background, Ferry provided a high-level perspective across the scope of the state's response, including testing, public health outcomes and data analysis.

As the world continues to navigate COVID-19 mitigation, NSRI is also evolving its training, which has traditionally been delivered in classrooms, outdoor venues and practice laboratories with groups of students ranging from 20 to several hundred. The team's expansion before the virus was impressive. Requests for NSRI training courses increased 11 percent from 2018 to 2019 and revenue had more than quadrupled.

Given that this type of defense training can literally be a matter of life and death, the team continues to offer its leading in-person options whether on-site or at an NSRI facility. In addition, within just a few months of the pandemic, the team began leveraging hybrid in-person and virtual opportunities and is developing a deployable version of an in-house-designed virtual TTX simulation software.

Tangible Steps Toward 21st-Century Threat-Based Training Solutions

TRANSPORT OF HIGHLY INFECTIOUS PATIENTS¹

In 2018, the NSRI threat-based training team was asked by the University of Nebraska to assist with a government contract exploring ways to safely transport infectious patients. The team helped set standards and develop curriculum to teach first responders, military units and medical personnel. The program originally was designed as a response to Ebola, but the project is now relevant to COVID-19. The NSRI team will take a class to medical personnel across the nation and throughout the world.

NEW LABORATORY TRAINING²

At the beginning of the two-year period covered by this report, the NSRI training team created a new course to teach WMD responders field laboratory identification. While most local and regional CST teams have lab suites, they don't get to go downrange and do the decontamination and other things that happen on-site, essentially taking samples with little context.

NSRI's course puts lab personnel skills to the test. This is crucial. If personnel never get to the field with their equipment, they lose proficiency. The course was presented to public health departments and agencies throughout the DOD.



1



2



3



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RURAL NEBRASKA COORDINATED PREPAREDNESS TRAINING³

In August 2019, the threat-based training team facilitated the first disaster preparedness exercise in NSRI's home state with western Nebraska community hospitals. Participants in the full-scale disaster simulation included health care and public health staff, EMS professionals, local law enforcement, emergency management personnel and community residents. The event was organized through a \$3 million grant award to Nebraska Medicine from the Assistant Secretary for Preparedness and Response. The purpose was to identify gaps in coordinated patient care during disasters and learn how to use a new communications system called Knowledge Center. The ultimate goal, of course, was to save lives during real disasters.

SAMPLE COLLECTION⁴

It's important for NSRI training personnel to go into the field to stay relevant. In October 2017, the NSRI threat-based training team was asked by a Department of Defense sponsor to go to the Democratic Republic of the Congo and collect critical samples for an ongoing project. A genomics lab at the University of Nebraska had been unable to continue with a project because the government ran out of money for samples, which each cost \$17,000 to produce.

"NSRI was instrumental in facilitating the development of both discussion- and operations-based exercises. Their team provided a structured approach to the integration of a complex set of deliverables into a culminating event."

ANGELA VASA

NURSE MANAGER, NEBRASKA
MEDICINE

Coordinate, Analyze, Develop, Advise, Instruct: Mantra of the Nation's Top WMD Trainers

Sometimes it's easy to see tangible results of this NSRI directorate's trainings and consultations, such as when the South Carolina CST found itself using course lessons to manage a serious, real-life event. Other times, training is a latent power – unseen for now, crouching in place until one of NSRI's defense customers needs to spring into action, using learned skills and tools to respond to a threat.

Watch for news about important new projects and offerings at nsri.nebraska.edu/training.

FEATURED FACILITIES, CENTERS AND LABORATORIES

RESOURCES ON-TAP TO POWER DEFENSE MISSIONS

As a convener of people, science and systems that help power defense missions, NSRI's connecting reach extends to all points of a rich network of facilities and personnel. Thanks to the many programs, technologies and teams already in place at the University of Nebraska, NSRI can respond rapidly to defense customer requests and offer some of the best minds available in their disciplines. These pages introduce a sampling of the technical capabilities and intelligence Department of Defense and USSTRATCOM leaders had access to in the past two years — and will have access to going forward to fulfill missions and explore ways to anticipate and accelerate solutions for future defense concerns.



BIOLOGICAL PROCESS DEVELOPMENT FACILITY

The Biological Process Development Facility (BPDF) at the University of Nebraska–Lincoln (UNL) offers biopharmaceutical process development designed for successful technology transfer from the bench to large-scale GMP manufacturing. The facility also manufactures material suitable for nonclinical and Phase I–II clinical studies. Throughout its history, the BPDF has partnered with both public and private sectors to develop and produce biotherapeutics and vaccine candidates.



DAVIS GLOBAL CENTER

The Dr. Edwin G. & Dorothy Balbach Davis Global Center at the University of Nebraska Medical Center (UNMC) is a highly advanced clinical simulation facility designed to advance the practice of patient care in highly functioning and effective interprofessional teams. The Davis Global Center provides realistic replicated health care settings where teams can practice and experiment safely.

EXTREME LIGHT LABORATORY

The UNL Extreme Light Laboratory provides the DOD with nationally recognized high-power laser capabilities that have been used to successfully demonstrate new and unique methods for detecting chemical, radiological and nuclear weapons of mass destruction. Looking forward, the lab aims to extend a demonstrated method for detecting improvised explosive devices and shielded nuclear materials.

GLOBAL CENTER FOR HEALTH SECURITY

The Global Center for Health Security at UNMC is home to the National Training, Simulation and Quarantine Center, which features the nation's only federal quarantine unit and simulated biocontainment units for advanced experiential training. The Global Center also builds on UNMC's tradition of biopreparedness training, research and patient care through the internationally acclaimed Nebraska Biocontainment Unit team, which set the global gold standard for safely treating special pathogens during the 2014 Ebola outbreak.

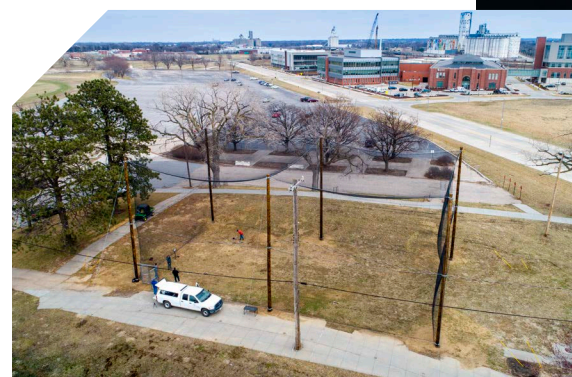
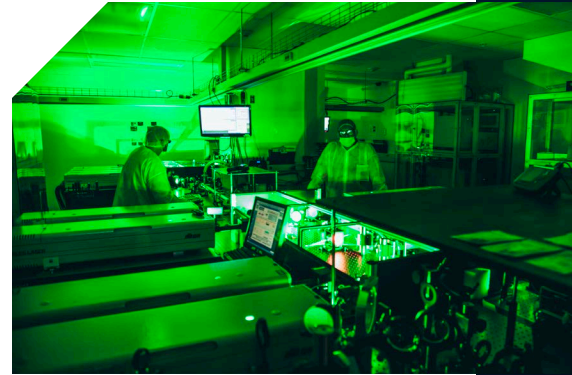
iEXCEL

Located on the UNMC campus, iEXCEL provides a transformative model for health care education, training and research. This program promotes experiential learning through a wide range of simulation and visualization technologies, with a vision of becoming a global leader in improving human performance and effectiveness in health care. Through iEXCEL, UNMC is reshaping the way health care education is delivered.

NEBRASKA INTELLIGENT MOBILE UNMANNED SYSTEMS (NIMBUS) LAB

The NIMBUS Lab at UNL is focused on research and technology used to develop more capable and dependable unmanned aerial vehicles. Recent lab projects include safe, precise and repeatable maneuvers; failure detection and recovery; extended flying autonomy; adaptive sensing; and teaming and coordination.

See an extensive list of NSRI and University of Nebraska facilities and centers at nsri.nebraska.edu/facilities.



DEVELOPING OUR FUTURE WORKFORCE

One of the greatest threats to our country's national security is the lack of workforce across the disciplines of science, technology, engineering and math. As a University Affiliated Research Center, one of NSRI's major responsibilities is to contribute to the development of our next generations of scientists and leaders. This is critical to staying ahead of evolving threats and international competition. NSRI takes action to empower and inspire postdoctoral scientists as well as graduate and undergraduate students.

POSTDOCTORAL SCHOLARS

NSRI postdoctoral scholars work directly with the Defense Threat Reduction Agency's basic research and development program managers to support the countering weapons of mass destruction mission. At one of the top Department of Defense research institutions in the nation, these scholars have the opportunity to contribute in the areas of nuclear technologies, CWMD technologies, chemical-biological sciences and test science.

Within the roles they fill scholars learn first-hand from operators in the field about technological gaps. They work to translate complex national security needs into basic research and development requirements while also providing technical programmatic oversight and actualizing innovative ideas and solutions in the CWMD mission space.

NSRI POSTDOCTORAL SCHOLARS DURING THIS REPORTING PERIOD INCLUDE:

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Richard Oates, Ph.D.

Adam Weltz, Ph.D.

Andrew Zeidell, Ph.D.

STUDENTS OF NSRI

University of Nebraska students have the opportunity to expand their perspectives and shape their futures through NSRI internships, training and research. Funded through sponsor contracts or NSRI initiatives, students gain invaluable, paid real-world experience and often earn course credit for their work. In all instances, their contributions lead to valuable deliverables for DOD and federal agency customers and/or NSRI.



“The amount of exposure to real projects is tremendous. Working for NSRI definitely sets you as an undergraduate ahead of others in skill, responsibility, dependability and experience.”

DALLAS DRAPAL

**MECHANICAL ENGINEERING, MAY 2020 GRADUATE
UNIVERSITY OF NEBRASKA–LINCOLN**

FEATURED STUDENTS THROUGHOUT THIS REPORT INCLUDE:

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▶ **Learn more about NSRI's workforce development opportunities at nsri.nebraska.edu/workforce.**

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