DNN *Sentinel*

> DEFENSE BY OTHER MEANS

SPECIAL EDITION:

Achieving Our Mission During COVID-19

Join Our Mailing List!

Email us at **DNNOutreach@nnsa.doe.gov** to request to be added to the mailing list.

Visit us!

From the Deputy Administrator

I am immensely proud of the perseverance, adaptiveness, and innovation demonstrated by Office of Defense Nuclear Nonproliferation (DNN) staff amid unprecedented circumstances. Nearly six months into our current maximum telework posture, the entire DNN family has continued to step up, support one another, work diligently and safely to fulfill our critical mission, and maintain important relationships with international partners through an array of virtual engagements.

This publication highlights some of DNN's key accomplishments in this unique work environment. Faced with challenges due to the COVID-19 pandemic, the Office of Nonproliferation and Arms Control's International Nuclear Export Control Program conducted a multi-day, virtual meeting with Vietnamese counterparts to discuss the launch of Vietnam's national Weapons of Mass Destruction Commodity Identification Training course. The Office of Material Management and Minimization worked with partners in Kazakhstan to complete the downblending of the last tranche of unirradiated highly enriched uranium in that country and to sign a Joint Statement committing to conversion of the IVG.1M reactor to low enriched uranium fuel in 2021. The Office of Global Material Security's International Nuclear Security program hosted virtual technical exchanges with the Belgian Federal Agency for Nuclear Control on countering unmanned autonomous or remotely piloted aircraft systems against nuclear facilities. The Office of Defense Nuclear Nonproliferation Research and Development advanced new protocols and approaches for virtual meetings that allowed them to complete their program reviews online.

These are just a few examples of DNN's diverse and concerted efforts to continue its vital work. DNN continues to exhibit remarkable creativity, flexibility, and dedication to its mission. I am grateful for DNN's commitment and contributions to our national security, and honored to serve alongside such a resilient team. I hope you find the articles in this publication to be not only informative, but a testament to the true dedication of some of the best and brightest in government.

Remote Engagement with Foreign Partners: INECP's Successful Transition in the Midst of COVID-19

By Samra Wolde-Tensae

COVID-19's sweeping impact compelled many around the world to make drastic changes. For DNN's Office of Nonproliferation and Arms Control's (NPAC) International Nuclear Export Control Program (INECP), this task was particularly challenging. Prior to March, INECP held all engagements with foreign partners in person. The program needed to institute swift and creative restructuring to ensure the continuity of its mission. Despite the unexpected constraints of COVID-19, INECP successfully maintained its engagement with foreign partners and achieved significant milestones along the way.

In July, INECP and the Department of State's (DOS) Export Control and Border Security Program (EXBS) conducted a day and a half meeting with their Vietnamese counterparts to discuss plans for launching Vietnam's national Weapons of Mass Destruction (WMD) Commodity Identification Training (CIT) course. CIT teaches customs inspectors to recognize WMD-related goods. The meeting included participants spread across four time zones—with simultaneous translation—and still achieved its goal of formulating a path for the launch and sustainment of Vietnam's national WMD CIT course. Rich Goorevich, Assistant Deputy Administrator for NPAC, added, "despite major obstacles, this event resulted in a major success story for INECP. This engagement is just one example of how INECP has creatively maintained its mission throughout this pandemic."

INECP also regularly holds virtual meetings with its partners from Brazil to discuss best practices and strategies for export licensing and targeting of strategic goods. These meetings involve in-depth discussion of specific dual-use commodities, case studies, and catch-all controls.

Participants in Vietnam view their INECP and EXBS counterparts on the screen during their July 2020 discussion to formulate a path for the launch and sustainment of Vietnam's national WMD CIT course.

Remote Trainings in Tajikistan Present Unforeseen Benefits

Kevin Roshdieh, NNSA NA-213; Scott Maple, PNNL

DNN's Office of Global Material Security's (GMS) Nuclear Smuggling Detection and Deterrence (NSDD) program, in partnership with the Tajikistan Nuclear and Radiation Safety Agency (NRSA), led three virtual training events with support from NSDD trainers from May 25 to June 10.

This training gave Tajik Customs and Border Guard agencies the tools and techniques to maintain their mobile detection devices, perform administrative functions on their detection systems, and successfully operate handheld detection devices, all of which contribute to ensuring nuclear safety and security in the region.

In-person trainings with the Tajik Customs and Border Guard agencies scheduled for March were postponed due to COVID-19 travel restrictions. NSDD and NRSA were able to turn the trainings into virtual events, in which NRSA trainers led instruction and NSDD staff provided virtual support. "During the training process, the Tajik trainers were proactive and demonstrated a high level of ownership," said NSDD Training Subject Matter Expert, Aaron Kriss. "They presented modules that adhered to instructor guides, managed multiple group activities and practical exercises, and evaluated themselves to

Handheld Equipment Operator Training
Dushanbe, Tajikistan | 08 -10 June 2020

identify areas of improvement for future training."

In all three sessions, NSDD and NRSA remained engaged throughout the entire process. NSDD's Training Team at Pacific Northwest National Laboratory (PNNL) did extensive planning to ensure backup options and contingencies for possible technical issues were available.

During the training, NRSA displayed their presentations via virtual conference tools in the classroom and to the U.S.-based team. An NSDD-provided VTC system at the NRSA Training Center enabled the U.S.-based team to view the participants and equipment demonstrations in the classroom. In addition, the U.S.-based team viewed and participated in practical exercises outside the classroom through
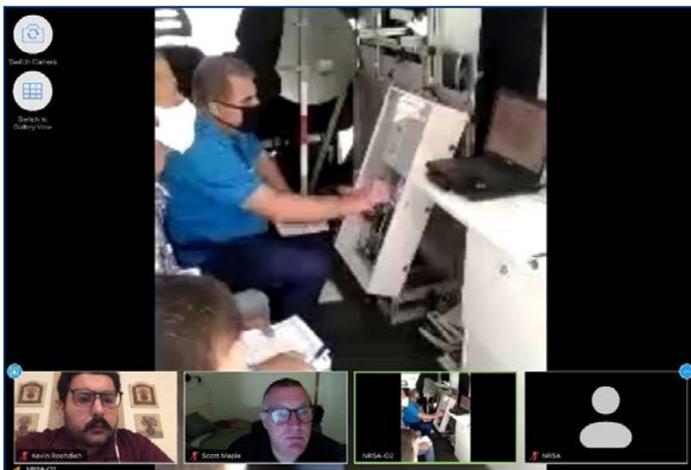
Remote Engagement– *Continued*

Additionally, INECP works collaboratively with DOS, the Department of Homeland Security, and Brazil to develop risk profiles for strategic goods that can be incorporated into Brazil's national targeting center.

More INECP virtual events are still to come. Starting in mid-September, INECP and the European Commission's Joint Research Centre-Ispra (EC-JCR) will host a series of two-hour virtual informational and training sessions for European Union Member State export licensing officials to replace an in-person seminar that INECP and EC-JRC have organized together for more than a decade. Six sessions are planned and more will be scheduled as new topics arise.

Finally, in partnership with DOS, the State University of New York – Albany, and the International Science and Technology Center, INECP initiated regular virtual meetings with representatives from Kenya in mid-July. The goal of these meetings is to aid Kenya's approval of the draft Strategic Trade Management Act and support it in the development of a curriculum for its strategic trade control academy.

Throughout the pandemic, INECP has maintained a steadfast commitment

U.S. Ambassador Kyle McCarter delivers a strategic trade control commodity identification training kit for Kenya, May 15, 2020.

to strengthening domestic and global efforts to detect and prevent the transfer of nuclear and dual-use materials, equipment, and technology intended for non-peaceful purposes. INECP will continue to improve and expand its virtual engagement strategy with foreign partners.

Samra Wolde-Tensae is the National Nuclear Security Administration Graduate Fellow in DNN's International Nuclear Export Controls Program within the Office of Nonproliferation and Arms Control. The NNSA Graduate Fellow Program is administered by Pacific Northwest National Laboratory.

Remote Trainings– *Continued*

the NRSA staff's smartphones. This virtual tool allowed for simultaneous viewing of multiple breakout groups within the session as participants went through rotational practical exercises.

"Although it is often difficult to replace the value of in-person engagements, NSDD and its Tajik counterparts gained valuable experience from the training," said NSDD Sustainability Program Director, Dick Pappas. NSDD's lack of physical presence encouraged NRSA to strengthen its problem-solving capabilities and demonstrate effective planning and execution of event logistics. Holding these trainings virtually due to travel restrictions during the COVID-19 pandemic pushed NSDD's counterparts out of their comfort zone to truly take a leadership role in the process. The success of these events is a testament to the trusting,

respectful relationships NSDD, NRSA, and Tajik counterparts have built over years of direct cooperation and face-to-face meetings.

Kevin Roshdieh is a Federal Country Manager in the Office of Nuclear Smuggling Detection and Deterrence (NSDD) overseeing radiation detection implementation and sustainability projects in various countries across Central Asia, Eastern Europe, and Africa. Kevin has supported NSDD in various capacities since 2013 and holds an MBA specialized in International Business Diplomacy from Georgetown University.

Scott Maple is a senior Project Manager at PNNL, focused on building multidisciplinary and multi-organizational teams to execute complex technology deployments. Scott has led numerous international stakeholder engagements to deploy radiation detection equipment to foreign partners and advise them on best practices to detect and interdict smuggling of nuclear and radioactive materials.

Material Management and Minimization Work Continues During COVID-19

By Jessica Halse

Office of Material Disposition

M3's Office of Material Disposition continues to make progress toward dispositioning weapon-usable materials that are surplus or excess to national security requirements. Despite facing challenges resulting from COVID-19, Savannah River Nuclear Solutions employees at the Savannah River Site's (SRS) K-Area resumed plutonium downblending after an outage for extensive upgrades to the K-Area Interim Surveillance (KIS) glovebox. Plutonium downblending is the process of mixing plutonium oxide with a multicomponent adulterant to enable the Department of Energy (DOE) to meet requirements for shipping it to an out-of-state repository for disposition.

Employees at the SRS's K-Area resumed plutonium downblending after an outage for extensive upgrades on the KIS glovebox.

The KIS upgrades, which include improved shielding and new material entry and removal devices, are designed to reduce the absorbed radiation dosage among workers and improve process flow. The improvements make the process more efficient while still maintaining safety.

These upgrades will support DOE's nonproliferation mission to disposition plutonium, and the domestic commitment to accelerate plutonium removal from South Carolina.

Office of Nuclear Material Removal

During the COVID-19 pandemic, M3's Office of Nuclear Material Removal continued to carry out its mission to eliminate excess inventories of weapon-usable nuclear material. Notably, the Remove Office worked with Kazakhstan to complete the downblending of all unirradiated highly enriched uranium (HEU) graphite fuel from the IGR reactor, which eliminated the last batch of unirradiated HEU in Kazakhstan and fulfilled a promise made between the two nations at last year's International Atomic Energy Agency (IAEA) General Conference. Additionally, the Remove Office continued campaigns to remove HEU in North America and advanced planning and preparation for future removals from countries in Asia and Europe. The team also made significant great progress on the development of the Mobile Melt Consolidate system to address fuels with no disposition pathway

and on the effort to reconcile U.S.-origin plutonium exports, all while continuing to enhance the Office's HEU minimization capabilities.

To facilitate these activities, the Remove Office transitioned from in-person meetings to video teleconferences, including participation in virtual technical meetings in cooperation with the IAEA to discuss preparations for a spent fuel removal from Kazakhstan to Russia. Although future face-to-face meetings will be necessary to advance some removal activities, the Office has worked as closely as possible with international counterparts to advance its threat reduction mission and prepare for removal campaigns in fiscal year 2021.

Office of Conversion

M3's Office of Conversion manages the Molybdenum-99 (Mo-99) Program, a nonproliferation effort aimed at transitioning global Mo-99 production from the use of HEU to low enriched uranium (LEU) and accelerating the establishment of domestic Mo-99 produced without the use of HEU. While the U.S. demand for Mo-99 is approximately 50 percent of the world market, the United States currently imports over 90 percent of this radioisotope from overseas suppliers to conduct approximately 40,000 nuclear medical diagnostic procedures each day.

To date, all but one major international producer of Mo-99 has converted from the use of HEU to LEU. The final producer began initial LEU production and has committed to fully transition to LEU in 2022. Additionally, in 2018, NorthStar Medical Radioisotopes, an NNSA Cooperative Agreement partner, began producing Mo-99 without the use of HEU. This is the first domestic production of Mo-99 for U.S. patient use in nearly 30 years.

During the COVID-19 pandemic, global Mo-99 supplies dwindled as transportation challenges emerged and international flights were restricted or canceled, borders to countries that supply Mo-99 were closed, and operations at international facilities producing Mo-99 were curtailed.

To avert a shortage of this critical radioisotope in the U.S. medical community, the Office of Conversion joined a virtual multi-agency working group with the Departments of State, Health and Human Services, Transportation, and Homeland Security, and successfully worked with international and domestic airlines and European governments to ensure flight schedules from Europe were available on a regular basis to ship sufficient supplies of Mo-99 to meet U.S. medical needs. Without NNSA's involvement in this virtual interagency effort, tens of thousands of U.S. patients may not have received the medical care they needed during the pandemic.

To continue NNSA's support of domestic industry, on July 30, M3 issued another Funding Opportunity Announcement (FOA) for the Mo-99 Program to invigorate domestic production of Mo-99. This FOA will be open for 60 days to solicit proposals from U.S. entities already undertaking projects to produce Mo-99 without HEU to bring their projects to commercial production and become long-term producers in the U.S. Mo-99 market. One or more Cooperative Agreements will be awarded, for a total of up to $35M, across the selected partners.

Jessica Halse is the Assistant Deputy Administrator for the Office of Material Management and Minimization (M3).

DNN R&D Takes Its Annual Program Reviews Virtual

By Angela Sheffield

I n March, as travel restrictions due to the COVID-19 pandemic were on the horizon, DNN's Office of Research and Development (DNN R&D) was making final preparations for its four annual program review meetings, which play a critical role in DNN R&D's coordination and collaboration with external mission partners and the performer community. In typical years, the first three reviews, which focus on projects at the National Laboratories, are attended by 150-200 participants from the Department of Energy (DOE), the U.S. National Laboratory complex, and partner agencies. Typically, principal investigators present 50 technical presentations and 25-50 posters at each review. The fourth review, the University Program Review, is attended by 250 participants, including students and faculty from DNN R&D's university consortia. Randy Bell, former DNN R&D Senior Science Advisor, explained, "Typically, these consortia engage hundreds of students and post-docs [postdoctoral students] – many of whom join the National Nuclear Security Administration nuclear security enterprise."
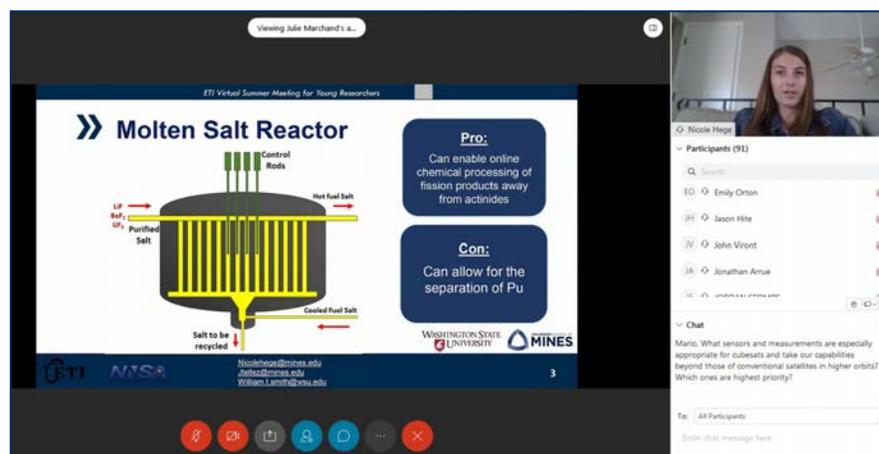
Nicole Hege, a graduate student at the Colorado School of Mines, presents her research enabling online monitoring of molten salt reactors during the Consortium for Enabling Technology and Innovation Virtual Summer Meeting.

Even before the United States reported rising cases of the novel coronavirus, DNN R&D began to prepare for potentially atypical conditions. Angela Sheffield and Tammie Borders, who lead DNN R&D's portfolio for data science, sought digital solutions to support the Office through lockdown. They quickly retooled a prototype, cloud-based collaboration platform to serve as an office resource for sharing materials across the complex and with external agencies. DNN R&D had been architecting the custom cloud platform for sharing and analysis of high volumes of Official Use Only (OUO) level research data by teams across the U.S. National Laboratory complex as part of a new, multi-lab research project. However, commercially available cloud-based services often fall short of meeting DNN's mission requirements, which demand multi-organization membership, tailorable high-performance computing and data analytics services, and OUO-level certification.

DNN R&D has been working with cloud service providers as well as information technology (IT), cybersecurity, and data management experts at the U.S. National

Department of Energy Support to International Atomic Energy Agency Safeguards Does Not Stop During the Pandemic

By Brian Ticknor, Arden Dougan

Even during the COVID-19 pandemic, the Department of Energy's National Nuclear Security Administration (DOE/NNSA) has contributed to key International Atomic Energy Agency (IAEA) safeguards operations. While COVID-19 impacted many IAEA efforts locally, essential activities like on-site inspections of nuclear facilities continued at sites where it was possible to do so safely.

After the completion of an on-site inspection, collected environmental and nuclear material samples must be characterized in a timely manner to ensure data reporting and subsequent evaluation can meet required timelines for drawing safeguards conclusions. The IAEA's Network of Analytical Laboratories (NWAL) in the Department of Energy (DOE) complex has maintained operations during the pandemic, continually accepting new field samples from the IAEA and reporting analytical results. Five U.S. National Laboratories provide these analytical services and are qualified members of the IAEA NWAL: Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, and Savannah River National Laboratory.

Debra Bostick, Senior R&D Chemist and NWAL lead for the ORNL analytical laboratory, performs chemical separations in a cleanroom laboratory while wearing full cleanroom attire.

> " *Once again, having DOE capability spread across the complex allows us to ensure U.S. support continues for IAEA analytical needs even when individual labs are impacted...* "
>
> - Robert Steiner, Senior Research and Development Scientist and NWAL Lead, Los Alamos National Laboratory

DOE's NWAL-affiliated laboratories benefit from being geographically spread across the United States so that reductions in on-site laboratory staff in states hit hard early in the pandemic, like Washington and California, did not impact the capacity of the entire network. Robert Steiner, Senior Research and Development Scientist and NWAL Lead at LANL, emphasizes this point, saying, "Once again, having DOE capability spread across the complex allows us to ensure U.S. support continues for IAEA analytical needs even when individual labs are impacted, just like when wildfires shutdown LANL's NWAL operations in 2000-2001 and 2011."

The analytical processes and ultra-low backgrounds required to characterize environmental samples also benefit the program in a time of social distancing. After receipt at the laboratory, samples are measured and counted for up to 24 hours largely unattended, requiring limited on-site staff. Typically, no more than two people may enter a clean laboratory while IAEA samples are being processed, making this activity consistent with social distancing policies. Standard cleanroom attire includes full body coverings, particularly disposable face masks and gloves, and these lab spaces feature heavily filtered air. Similarly, the high-precision mass spectrometry

DOE Support– *Continued*

A Multi-Collector Inductively Coupled Mass Spectrometer (MC-ICP-MS) with an autosampler at ORNL, used for high precision isotope ratio measurements of U and Pu contained in IAEA environmental samples, is located in a dedicated laboratory space with heavily filtered air.

instruments used to measure uranium and plutonium isotopes in environmental samples are in dedicated laboratories with filtered air and minimal staff traffic. The ability to operate instrumentation in an automated fashion further reduces the need for staff to be present in the laboratory during analysis.

From April through early July, the DOE NWAL program accepted every analytical request it received from the IAEA, totaling 11 separate requests with 43 environmental samples and 128 pre-inspection check (PIC) samples. Over the same period, U.S. National Laboratories have reported results for 31 environmental samples and 128 PICs to the IAEA. In these challenging circumstances, dedicated staff supporting the NWAL program across all National Laboratories have enabled DOE to continue its vital support to this area of IAEA safeguards.

Brian Ticknor is a Research and Development Staff Chemist at Oak Ridge National Laboratory and the Coordinator of the Department of Energy Network of Analytical Laboratories program. He has 10 years of experience in high-precision mass spectrometry for safeguards and nonproliferation.

Arden Dougan is the Federal Program Director for the Safeguards Technology Development Program in DNN's Office of International Nuclear Safeguards within the Office of Nonproliferation and Arms Control.

R&D Program Review– *Continued*

Laboratories to pilot custom approaches, protocols, and features that meet DNN's requirements. While DNN R&D cancelled the first program review, it also – for the first time – shared digital versions of the OUO-level program review materials with collaborators and stakeholders from DOE, the U.S. National Laboratory complex, and other agencies using a cloud-based collaboration capability.

As DOE and the laboratories, plants, and sites moved to a teleworking posture, DNN R&D transitioned to virtual program reviews. Patria Smith, the Office's lead for program review planning, led DNN R&D's efforts to redesign the reviews as virtual meetings, which involved far more than selecting which virtual collaboration tool to use. DNN R&D developed new protocols and approaches for virtual meetings, including procedures for managing large-scale OUO-level meetings, fostering audience participation, and designing redundancies and workarounds to smoothly manage potential technical issues. These approaches have become standard practices for all DNN R&D virtual meetings and have also been adopted by numerous stakeholder organizations planning their own virtual meetings. The program reviews were reformatted from three full-day sessions to 2-3-hour sessions spread across several weeks. Each session was attended by 100-150 participants. The virtual University Program Review also included informal sessions for students to discuss careers with researchers from around the complex.

According to Craig Sloan, Director of DNN R&D's Office of Proliferation Detection, "Cancelling the annual program reviews altogether would have put at risk the Office's mission effectiveness in fiscal year (FY) 2020 and readiness for FY 2021. The virtual program reviews worked – far more effectively than I had even hoped." Though not ideal, the virtual reviews ensured DNN R&D accomplished its mission despite the disruption of COVID-19. In addition, the approaches and digital solutions developed for the virtual reviews have enhanced DNN R&D's engagement with key stakeholders. For example, following the same virtual review format, DNN R&D recently hosted a large-scale seminar for DOE's Office of Intelligence and Counterintelligence (DOE-IN) on Data Science for proliferation detection, a key area of interest to DOE-IN.

While DNN R&D and the entire DNN community are eager to return to normal operations, DNN R&D will continue to use many of the best practices and enhanced approaches established to support the virtual program reviews even after COVID-19 restrictions are lifted.

Angela Sheffield (formerly Waterworth) leads DNN's Office of Research and Development (DNN R&D) data science portfolio to develop the next generation of artificial intelligence (AI) technologies to detect and characterize foreign nuclear programs. Prior to joining DNN, Angela was a senior scientist at Pacific Northwest National Laboratory, where she focused on developing methods to apply data science to nuclear nonproliferation missions, including nuclear materials measurements and signatures.

Making Progress in Nuclear Explosion Monitoring in a Pandemic

By Anthony Pollington

During the spring and summer of 2020, experts from the U.S. National Laboratories and facilities around the world focused their efforts on continuing the important work of monitoring the globe for undeclared nuclear explosions amidst the COVID-19 pandemic. The organizers of one such effort, the eighth Workshop on Signatures of Man-Made Isotope Production (WOSMIP), evolved the workshop into a virtual event.

Every 18 months, participants from the monitoring and medical isotope production communities meet at the WOSMIP workshop to exchange technical presentations and data and develop collaborations to support global nuclear explosion monitoring. The workshop focuses on issues regarding signatures released from nuclear reactors and power plants, medical isotope production activities, and nuclear explosions, as well as how to differentiate between explosive and non-explosive sources to enhance the monitoring mission.

Using radioisotopes to detect nuclear explosions in the presence of peaceful emissions is a challenge. "It's like a park ranger trying to differentiate an illegal campfire from legally permitted campfires," said Dr. Ted Bowyer, a Laboratory Fellow at Pacific Northwest National Laboratory (PNNL) and one of the WOSMIP co-organizers. "There's smoke all over the place and the park ranger has to determine if any of the fires are illegal, and, if so, which ones. Our goal is to stop the illegal fires by determining the cause of the smoke."

The eighth WOSMIP was originally scheduled to take place in Stockholm, Sweden, during the week of June 22, 2020, with participants from around the world. In light of travel restrictions imposed due to the COVID-19 pandemic, the in-person workshop was postponed until 2021. Rather than simply delaying the event, PNNL's organizing team had the innovative idea of moving the content online and developed a forum called "WOSMIP Remote."

WOSMIP Remote featured a bi-weekly video series with experts speaking on a range of topics, including the impact of civilian nuclear sources, improvements to atmospheric transport modeling, radioactive xenon gas abatement technologies, and more. Featured National Nuclear Security Administration (NNSA) projects included the Source Term Analysis of Xenon project, which installs stack monitors at medical isotope production facilities to better understand emissions from those facilities, and
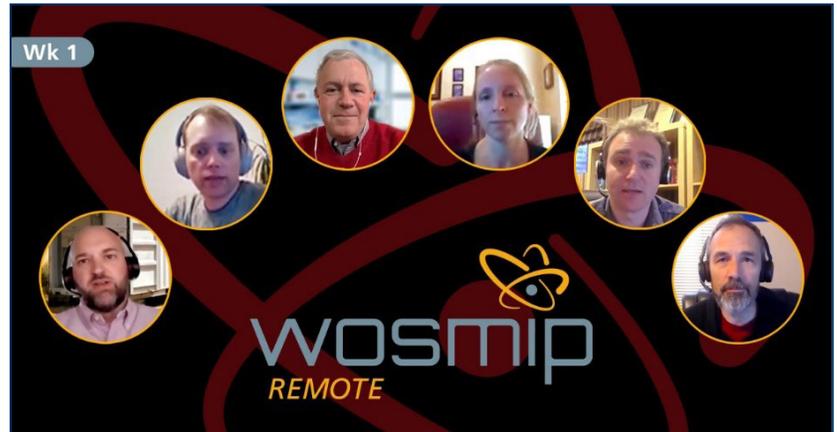
WOSMIP Remote logo and some of the presenters who helped make the meeting a success. *L to R: Ian Cameron, PNNL; Judah Friese, PNNL; Paul Saey, IAEA; Lori Metz, PNNL; Jonathan Burnett, PNNL; Ted Bowyer, PNNL.*

> " *I am proud of our work to keep momentum in this area through a virtual presence. This is a critical international effort.* "
>
> - Dr. Brent K. Park, NNSA Deputy Administrator for Defense Nuclear Nonproliferation

Xenon International, a next generation radioxenon collection and analysis system. Participants presented as if they were physically at the meeting, with follow-up question-and-answer sessions via video teleconference technology. All talks and presentations are currently available at www.wosmip.org/wosmip-remote.

Dr. Brent K. Park, NNSA Deputy Administrator for Defense Nuclear Nonproliferation, applauded the effort, commenting, "the Workshop on Signatures of Man-Made Isotope Production addresses key issues in nuclear explosion detection. Since the meeting could not be in person, I am proud of our work to keep momentum in this area through a virtual presence. This is a critical international effort."

Anthony Pollington is a Senior Technical Advisor in the Office of Nonproliferation and Arms Control's Warhead Verification Program. Anthony is most recently from Los Alamos National Laboratory where his work has focused on high-precision analyses for a range of topics including nuclear forensics, nonproliferation, and safeguards.

Earth Models Coming of Age for Nuclear Explosion Monitoring

By Ellen Syracuse (DNN R&D), LANL/NNSA

All nuclear tests since 1980 have been conducted underground, generating ground motions that are detected by networks of seismometers. Identifying source features, such as whether the cause of shaking was an underground nuclear explosion or slip on a geological fault, requires accurate predictions of the propagation of energy through the earth, from the source to the detectors. This energy propagation is tracked using models of Earth's seismic structure, which is typically mapped as compressional wave (akin to a sound wave) and shear wave velocities that vary in space throughout Earth due to geology. The more accurate the Earth model, the better the source features can be characterized.
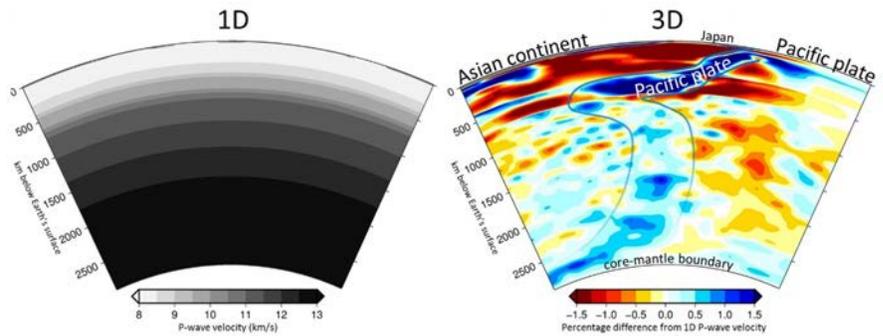
Progress in Earth tomography, shown as a comparison of (left) a 1D Earth velocity structure from 25 years ago to (right) a state-of-the-art 3D velocity model developed through DNN R&D efforts, highlighting the descent of the high-seismic-velocity Pacific Plate beneath Japan, through Earth's mantle, and pooling at its interface with the core.

With origins in the medical field as Computerized Axial Tomography (CAT) scans, tomography is now used to generate three-dimensional (3D) models of Earth's seismic structure. Due to computing capabilities in the 1960s through early 1980s, the seismic velocity structure of Earth was typically described by simple one-dimensional models that fit only specific aspects of a seismic signal. Through advances in computing in recent decades, 3D tomographic models at a range of scales and resolutions are now routine and may use hundreds of thousands of grid elements. The next frontier of modeling using the rich information contained in entire recorded waveform signals to constrain 3D Earth models is now becoming feasible.

DNN's Office of Research and Development (DNN R&D) researchers at Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories continue to advance state-of-the-art Earth tomography methods and model development (see Figure). Each new model holds unique strengths due to the dataset used to constrain the model or how the data are modeled. Examples include a high-resolution Earth model developed for a specific region by using a high-density network of seismic stations, or models that sample different regions of Earth by incorporating more exotic seismic wave phases. Such efforts have reduced the median uncertainty of global event locations to approximately 5 kilometers throughout the continents. Additionally, they have provided insight to the structure and evolution of Earth – for example through the imaging of a previously unknown tectonic plate being recycled deep beneath the Indian Ocean.

Current state-of-the-art and future efforts are moving toward Earth models that further improve resolution. For example, most present-day velocity models typically treat wave propagation as isotropic in all directions, while in reality, wave speed differs with direction due to rock fabric or stresses. Modeling this anisotropic propagation is computationally challenging but will result in better constraints on source parameters through improved modeling of surface waves. Other advanced inversion techniques improve resolution by leveraging the complementary information contained in multiple seismic wave types and other geophysical constraints, and leveraging the frequency-dependent timing, phase, and amplitude information contained in full seismic waveforms.

These advances in tomography and the Earth models they enable allow DNN R&D to continually advance the Nation's nuclear monitoring capabilities to effectively locate and characterize seismic events worldwide.

Ellen Syracuse is a Technical Advisor for DNN's Office of Research and Development (DNN R&D) from Los Alamos National Laboratory. She has over 17 years of experience doing seismological research in Earth modeling.

International Nuclear Security (INS) Counter Unmanned Aerial System (CUAS) Program Pivots to Remote Technical Exchanges

By David Avalos, Constance McAninch, and Pratap Sadasivan

DNN's Office of Global Material Security's (GMS) International Nuclear Security (INS) program established a pilot program to counter the use of unmanned autonomous aircraft systems (UAS) against nuclear facilities and identify how these technologies may be integrated into the protection strategies at nuclear installations. The INS Counter UAS (CUAS) team is implementing an approach for engagements with international partners, developing informational material on a wide range of UAS/CUAS topics, and actively cultivating domestic and international relationships.

Two recent international engagements demonstrate the value of this work to the international nuclear security community.

In December 2019, INS and the Belgian Federal Agency for Nuclear Control (FANC) agreed to co-host a technical exchange on countering UAS in the European Region and began planning an event scheduled for May. Due to COVID-19 related travel restrictions, the teams pivoted to scheduling a series of virtual exchanges. The first exchange in June was limited to representatives from INS and FANC, who shared overviews of their respective programs. The next exchange, held in July, included representatives from the broader Belgian interagency community. GMS participated in a third technical exchange with FANC on September 28 and included regulators and law enforcement from Finland, Sweden, and Switzerland. These exchanges explore areas of concern and interest on countering UAS and will lead up to the eventual implementation of a regional event.

Interest in countering UAS extends to other regions of the world as well. In June, INS and the Korean Institute of Nonproliferation and Control (KINAC) in the Republic of Korea (ROK) held a technical exchange under the umbrella of the bilateral Nuclear Security Working Group (NSWG) and Permanent Coordinating Group (PCG) agreements. During the exchange, representatives from both sides provided overviews of CUAS-related activities in their respective countries and shared information and lessons learned related to CUAS testing and evaluation efforts. INS and its ROK counterparts are planning a follow-on exchange. Additionally, a joint INS-Nuclear Regulatory Commission delegation traveled to Japan in December 2019 for a cyber security exercise, which included UAS components. INS and their Japanese colleagues are also planning a countering UAS technical exchange similar to previous meetings with the ROK and Belgium. Furthermore, INS is exploring opportunities for pursing a virtual technical exchange with counterparts from Israel after a planned activity in June was postponed because of COVID-19.

Idaho National Laboratory (INL) expressed appreciation to the CUAS team during a recent Lab Lead meeting: "A big thank you to the CUAS team for being flexible and willing to work remotely with our bi-lateral partners to continue moving forward with our engagements in this emerging area of nuclear security concern." Allison Johnston, INS Office Director, appreciates the large role INL has played in the development of INS's focus on CUAS capabilities.

The CUAS team continues to develop tools to support integration into other aspects of nuclear security. This includes incorporating countering UAS into sabotage and response force training materials, as well as exercises and video-based demonstrations of the latest UAS/CUAS technologies. The CUAS team is also cooperating with DNN's Office of Research and Development (DNN R&D) as they define requirements for a testing and evaluation bed to support R&D activities and international UAS/CUAS outreach. The team is looking forward to a formative and productive fiscal year 2021.

Testing Counter-Unmanned Aircraft Systems to Mitigate Drone Threats'

David Avalos is the INS Project Manager for the Republic of Korea and Japan. David comes to INS from a posting at the U.S. Embassy in Islamabad. In addition to his expertise in physical security, David is a trained culinary chef and shares his passion for cooking via virtual cooking lessons for his GMS colleagues.

Constance McAninch is the INS Project Manager for Belgium and has recently acquired the INS CUAS Program into her portfolio. Constance served for many years as a Lawrence Livermore National Laboratory Lab Lead in the Russian Material Protection, Control, & Accounting and INS Programs before becoming part of the Federal INS team in 2017.

Pratap Sadasivan is on an M&O assignment to INS as a senior advisor for the INS Innovation and Analytics program. Pratap stood up the current INS CUAS program and continues to provide insight and guidance.