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S. HRG. 117–967, PT. 7

DEPARTMENT OF DEFENSE AUTHORIZATION REQUEST FOR APPROPRIATIONS FOR FISCAL YEAR 2023 AND THE FUTURE YEARS DEFENSE PROGRAM

HEARINGS

BEFORE THE

COMMITTEE ON ARMED SERVICES
UNITED STATES SENATE

ONE HUNDRED SEVENTEENTH CONGRESS

SECOND SESSION

ON

S. 4543

TO AUTHORIZE APPROPRIATIONS FOR FISCAL YEAR 2023 FOR MILITARY ACTIVITIES OF THE DEPARTMENT OF DEFENSE, FOR MILITARY CONSTRUCTION, AND FOR DEFENSE ACTIVITIES OF THE DEPARTMENT OF ENERGY, TO PRESCRIBE MILITARY PERSONNEL STRENGTHS FOR SUCH FISCAL YEAR, AND FOR OTHER PURPOSES

PART 7
STRATEGIC FORCES

APRIL 27; MAY 11, 18, 2022

Printed for the use of the Committee on Armed Services

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CONTENTS

APRIL 27, 2022

Page

DEPARTMENT OF ENERGY'S ATOMIC ENERGY DEFENSE ACTIVITIES AND DEPARTMENT OF DEFENSE NUCLEAR WEAPONS PROGRAMS 1

MEMBER STATEMENTS

Statement of Senator Angus King 1
Statement of Senator Deb Fischer 3

WITNESS STATEMENTS

Hruby, The Honorable Jill M., Administrator, National Nuclear Security Administration 2
Caldwell, Admiral James F., Jr., USN, Deputy Administrator for Naval Reactors, National Nuclear Security Administration 4
White, William, Acting Assistant Secretary of Energy for Environmental Management 10
Adams, The Honorable Marvin L., Deputy Administrator for Defense Programs, National Nuclear Security Administration 22
Wolfe, Vice Admiral Johnny R., Jr., USN, Director, Navy Strategic Systems Programs 35
Cotton, General Anthony J., USAF, Commander, Air Force Global Strike Command 42

Appendix
Special Report
Meeting Medical and Research Needs for Isotopes Derived from Uranium-233 59
Audit Report
The Disposition of Uranium-233 at Oak Ridge National Laboratory 84
Chinese Academy of Sciences and U.S. Department of Energy Cooperation in Nuclear Energy Sciences and Technologies
First Executive Committee Meeting 101

MAY 11, 2022

UNITED STATES SPACE FORCE PROGRAMS 215

MEMBER STATEMENTS

Statement of Senator Angus King 215
Statement of Senator Deb Fischer 216

WITNESS STATEMENTS

Calvelli, Frank, Assistant Secretary of the Air Force for Space Acquisition and Integration 216
Plumb, The Honorable John F., Assistant Secretary of Defense for Space Policy 217
Thompson, General David D., USSF, Vice Chief of Space Operations 223

Questions for the Record 246

MAY 18, 2022

MISSILE DEFENSE STRATEGY, POLICIES, AND PROGRAMS 251

MEMBER STATEMENTS

Statement of Senator Angus King 251
Statement of Senator Deb Fischer 252

WITNESS STATEMENTS

Honey, The Honorable David, Deputy Under Secretary of Defense for Research and Engineering 252
Plumb, The Honorable John, Assistant Secretary of Defense for Space Policy .. 254
VanHerck, General Glen, USAF, Commander, United States Northern Command and North American Aerospace Defense Command 259
Karbler, Lieutenant General Daniel, USA, Commanding General, United States Army Space and Missile Defense Command 269
Hill, Vice Admiral Jon, USN, Director, Missile Defense Agency 280

Questions for the Record 300

DEPARTMENT OF DEFENSE AUTHORIZATION REQUEST FOR APPROPRIATIONS FOR FISCAL YEAR 2023 AND THE FUTURE YEARS DEFENSE PROGRAM

WEDNESDAY, APRIL 27, 2022

UNITED STATES SENATE,
SUBCOMMITTEE ON STRATEGIC FORCES,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

DEPARTMENT OF ENERGY'S ATOMIC ENERGY DEFENSE ACTIVITIES AND DEPARTMENT OF DEFENSE NUCLEAR WEAPONS PROGRAMS

The Committee met, pursuant to notice, at 4:30 p.m. in room SD–G50, Dirksen Senate Office Building, Senator Angus King (Chairman of the Subcommittee) presiding.

Committee Members present: King, Warren, Rosen, Kelly, Fischer, and Tuberville.

OPENING STATEMENT OF SENATOR ANGUS KING

Senator KING. This is a hearing on the Department of Energy's (DOE's) atomic energy defense activity and Department of Defense (DOD) nuclear weapons programs in review of the Defense Authorization Request for fiscal year 2023. This is a meeting of the Strategic Forces Subcommittee of the Committee on Armed Services of the United States Senate.

Senator Fischer is on her way over from the floor and will be here shortly, but I am going to begin the hearing and we will have a brief statement from her when she arrives.

First I want to thank all the witnesses for joining us today. The purpose of our hearing is to examine the fiscal year 2023 budget request for the defense portion of the Department of Energy's budget. This portion of the DOE's budget involves primarily the National Nuclear Security Administration, or NNSA, and the environmental cleanup of the DOE's former defense sites.

Our NNSA witnesses will be Administrator Jill Hruby; the Deputy Administrator for Defense Programs, Dr. Marvin Adams; and the Deputy Administrator for Office of Naval Reactors, Admiral Frank Caldwell. For the DOE Office of Environmental Management our witness will be Mr. Ike White, the office's senior advisor.

The NNSA's fiscal year 2023 budget request is $21.4 billion, a 3.7 percent, or $754 million increase from the fiscal year 2022's enacted level of $20.6 billion. The DOE Office of Environmental Man-

agement's fiscal year 2023 request of $6.9 billion is up 3 percent, or about $205 million from the fiscal year 2022 enacted level of $6.7 billion.

This hearing will also examine the fiscal year 2023 budget request for the Air Force and Navy as it relates to atomic defense activities. For the Air Force, our witness is General Cotton, the Commander of the Air Force Global Strike Command, and for the Navy is Vice Admiral Johnny Wolfe, Director of the Strategic Systems Program Office.

In order to meet DOD requirements, the NNSA is the busiest it has been since the 1980s—congratulations, Ms. Hruby—with five major warhead programs and a number of large construction projects. I am hopeful we can understand the challenges that the NNSA faces in dealing with DOD needs. Likewise, I am hopeful we can understand from our DOD witnesses what they see as the key hurdles facing NNSA as well as unique DOD requirements as they relate to the NNSA's modernization programs.

Today's hearing will involve two panels. The first will have Administrator Hruby, Admiral Caldwell, and Senior Advisor White. The second panel will have Deputy Administrator Adams, General Cotton, and Vice Admiral Wolfe. After short opening statements we will proceed with questions from each Member at 5 minutes each, and as I say, when Senator Fischer arrives we will give her a moment to make a brief opening statement.

But in the meantime, Administrator Hruby, why don't you begin. I apologize for this awkward arrangement, but everybody is having meetings this afternoon, and this is room we drew, and this is the setup, understanding the circumstances.

Administrator, please proceed.

Ms. HRUBY. Okay. I am waiting for a light. Yeah, it is on. All right.

STATEMENT OF THE HONORABLE JILL M. HRUBY, ADMINISTRATOR, NATIONAL NUCLEAR SECURITY ADMINISTRATION

Ms. HRUBY. Chairman King and Ranking Member Fischer to be, and Members of the Subcommittee, I am honored to present the President's fiscal year 2023 budget request for the National Nuclear Security Administration. Thank you for your enduring bipartisan support.

Chairman King, I have provided a written statement and respectfully request that it be submitted for the record.

Senator KING. Without objection.

Ms. HRUBY. The President's fiscal year 2023 budget request for NNSA is $21.4 billion. Informed by the 2022 Nuclear Posture Review, this request underscores both our expanded mission and the increasing pace required to meet program needs.

The weapons activity request is $16.5 billion, and includes nearly equal funding for stockpile management, about $4.9 billion, and production modernization, about $4.6 billion. This is an indication of NNSA's biggest challenge, to succeed in parallel weapons modernization and infrastructure revitalization.

This approach carries risk. However, it is our only feasible path to meet requirements, and we are making steady progress. The W88 Alt 370 for the sea leg of the triad and the B61–12 for the

air leg have achieved first production and are on track to meet DOD schedules. The W80–4 for the long-range standoff missile, the W87–1 for the Sentinel intercontinental ballistic missile, and the W93 for the sea-launched ballistic missile are in various phases of design.

On the infrastructure side, the uranium processing facility is enclosed and projected to be complete in 2026, and the 90 percent designs are underway for our two pit production facilities.

We continue stockpile sustainment, other production projects, and science, including establishing a program to strengthen stockpile digital resilience. Together these programs will fulfill the Administration's commitment to a safe, secure, reliable, and effective nuclear deterrent into the future.

The Defense Nuclear Nonproliferation budget request is $2.3 billion, and it aims to reduce global nuclear threats, and is essential in today's geopolitical landscape. Lowering nuclear risk with robust safeguards and stepping up cooperation with governments, international organizations, and the private sector help support the global expansion of peaceful nuclear use while managing proliferation. We continue to strengthen our ability to respond to nuclear and radiological incidents, and these capabilities have proved pivotal to inform the ground truths about nuclear threats in Ukraine. Admiral Caldwell is here to provide detail on the naval nuclear reactor budget request.

The key to success is a high-quality workforce, and we are placing a high priority on attraction and retention throughout the enterprise.

In summary, NNSA faces difficult mission requirements in a difficult world. This budget request strikes the balance for NNSA to be responsive and responsible.

Thank you. I look forward to your questions.

Senator KING. Senator Fischer, I reserved time for you to make a brief opening statement if you would like.

STATEMENT OF SENATOR DEB FISCHER

Senator FISCHER. Thank you very much, Mr. Chairman, and my apologies for being a few minutes late.

Overall I was very pleased to see that the budgets strongly support nuclear modernization that has been presented and embraced the renewal of our nuclear triad and nuclear infrastructure conceived during President Obama's tenure over a decade ago. However, I still have a number of concerns about the Administration's budget request.

In particular, I am concerned about the shortfall in funding for NNSA's budget and the impact this could have on plutonium pit production. While additional resources alone will not be sufficient to ensure pit production requirements are met, I believe we must do all we can to minimize the delay in delivering this critical capability.

Additionally, the Air Force's unfunded priorities list included several items related to our nuclear forces and nuclear command, control, and communications architecture, including $63 million in unfunded requirements for the Minuteman-III sustainment.

While we often focus heavily on modernization programs, we cannot forget that our current nuclear forces must be sustained and remain effective over the next decade until the replacements are fully operational.

I look forward to hearing more from our witnesses. I thank you all for being here. I thank you for the work that you do, and thank you, Mr. Chairman, for the hearing.

Senator KING. Admiral Caldwell, please.

STATEMENT OF ADMIRAL JAMES F. CALDWELL, JR., USN, DEPUTY ADMINISTRATOR FOR NAVAL REACTORS, NATIONAL NUCLEAR SECURITY ADMINISTRATION

Admiral CALDWELL. Chairman King, Ranking Member Fischer, Distinguished Members of the Subcommittee, thank you for the opportunity to testify here today.

Your consistent support for naval reactors allows my team to provide the Navy with the unmatched power and capability of nuclear propulsion. This gives our Navy the reliability, agility, and firepower to carry our national security missions around the world. Our investments in research and development over many decades have enabled the advanced technology in today's fleet. These investments have given the Nation a competitive edge in the maritime environment.

Today we cannot do more of the same and expect that same advantage in the future. Our adversaries are pursuing military modernization programs across the spectrums of warfare aimed at eroding our maritime preeminence. Focusing on the future is a necessity, but that future needs to be built on the foundation of our people, our technology, and our facilities.

My budget request for fiscal year 2023 is for $2.08 billion and invests in three key areas of that foundation and three priority projects.

First, the budget request supports our most important resource, our people. The talented and dedicated people at our D.C. headquarters and our field offices around the country are absolutely essential to our strong, centralized management and oversight of the important work we perform for the Nation.

Second, the budget request reflects the continuation of increased investment in research and development. Technology investment must be reinvigorated today to be ready for future ships with the goals of lowering costs, reducing construction timelines, and adding capability to our fleet.

My request also focuses on investments to modernize our critical laboratory infrastructure and reduce our legacy environmental liabilities. Without this we will be unable to support fleet operations and vital research and development.

This year's request also supports the continued execution of three national priority projects. The first is the development of the reactor plant for the *Columbia*-class ballistic missile submarine, directly supporting the Navy's number one acquisition priority. Manufacturing the lead, life-of-ship reactor core is well underway. This year's request will allow my team to continue the work required for reactor plant testing and reactor plant delivery.

The second project is the refueling overhaul of our land-based prototype reactor in New York. Once complete, this reactor will provide 20 more years of student training and vital research and development.

The third project is the continued construction of the Naval Spent Fuel Handling Facility in Idaho, which will enable long-term, reliable processing and packaging of spent fuel from the Navy's nuclear fleet.

In closing, your strong support enables me to carry out Naval Reactors' mission. I respectfully urge your endorsement of our fiscal year 2023 budget request. Thank you very much.

[The prepared statement of Admiral Caldwell follows:]

PREPARED STATEMENT BY ADMIRAL JAMES F. CALDWELL

Chairman King, Ranking Member Fischer, and Distinguished Members of the Subcommittee, thank you for the opportunity to appear before you today and present the President's Fiscal Year 2023 Budget for Naval Reactors. Your strong support for the work we do ensures our nuclear Navy can carry out vital missions around the world with agility, endurance, and firepower. As underscored by the unprecedented events currently playing out on the world stage, great power competition is here to stay, therefore it is vital for the United States that we maintain a robust naval advantage over our adversaries. Congress' support of our past efforts has allowed the Navy to maintain these advantages, and your partnership with the Navy is needed now, more than ever, as we work on the current and future endeavors in naval nuclear propulsion that are needed to protect the national security of the United States.

I have had the pleasure of serving as the Director of Naval Reactors for almost 7 years out of an 8-year tenure. Before that, I had the privilege of serving in many operational and staff roles throughout the course of my Navy career. As I reflect on these decades of service and our Navy's global standing, I am increasingly concerned that our competitive advantages over our near-peer rivals are diminishing. It is vitally important for us to focus on technology investment now; failure to do so could have catastrophic implications for our future Navy in a future fight. Rivals are pursuing military modernization programs aimed at achieving regional hegemony in the near-term and eroding United States preeminence in the long-term. All domains of the maritime environment are becoming increasingly contested, and to preserve freedom of the seas, deter conflict, defend allies, and protect our national interests, we must sustain and grow our naval warfighting capabilities at an accelerated pace.

As amplified in our latest National Defense Strategy, we cannot simply do more of what we've done in the past. New advancements and refinements in nuclear propulsion are needed as the Navy innovates to increase and expand our competitive advantage. Naval Reactors' historical investment in advanced technologies has given the Nation an enviable position in the maritime environment; further investments, however, are necessary to maintain our technological edge well into the future. Our ships need to retain their advantage against future threats across multiple domains and must be affordable. We also need to be able to design and build our propulsion plants faster to ensure the Navy stays ahead of increasing demands, and we must do this more cost effectively. As the CNO has conveyed in his Navigation Plan, "there is no time to waste—our actions in this decade will set the maritime balance of power for the rest of the century." Our Nation took a new step this past year when the President announced the AUKUS enhanced tri-lateral security partnership, directing a period of consultation with the objective of identifying the optimal pathway for delivering a conventionally-armed, nuclear-powered submarine capability to Australia by the earliest achievable date. This partnership creates an opportunity to amplify our naval power, strengthen a key ally and our own shipbuilding capability, and build the additional industrial and vendor base capacity our Nation needs. Through the consultation period, Naval Reactors is also focused on strengthening our partnership with the United Kingdom, and ensuring Australia understands and establishes the strong foundation of capabilities necessary to properly steward nuclear submarine technology. Given the global threats we face, it is imperative that we ensure our closest allies remain relevant in the undersea domain.

Our success in the future will rest on the foundation of what we build today. Therefore, I want to highlight some of the many contributions of our nuclear fleet. Our ballistic missile submarines provide the most survivable leg of our nuclear triad and are essential to our ability to deter major warfare, and provide assurance to our allies. Our fast attack submarines operate with confidence, undetected, safeguarding vital commercial sea-lanes, and stand ready to protect American interests where needed. Our aircraft carriers provide our Nation a credible, sustained ability to project combat power, deter conflict, and protect our interests around the world.

Lead ship construction for *Columbia*-class is underway, which will allow the Navy to continue the seamless execution of the sea-based strategic deterrent mission that began over six decades ago. The USS *Ohio* (SSBN 726), lead ship of today's ballistic missile submarine fleet was commissioned over 40 years ago. This class will start to be replaced by the *Columbia*-class in 2031 with lead boat delivery in fiscal year 2028. I remain focused on ensuring the transition between these two classes is uninterrupted—the sea based strategic deterrence mission is too important to fail. The *Columbia*-class will be a bedrock of our national security posture for decades to come and will be the first submarine to operate for over 40 years on a single reactor core, an incredible testimonial to the technology investment that has occurred over the past decades.

In attack submarine shipbuilding, the Navy continues to work toward a steady cadence of *Virginia*-class submarine delivery. I recently took part in sea trials on Pre-Commissioning Units (PCU) *Montana* and *Oregon.* This submarine class now makes up over one third of our operational attack submarines. The Navy is also assessing improvements to capability and lethality for future *Virginia*-class submarines; these improvements will not only add capability to today's fleet but allow the Navy to prove candidate technologies that will influence our next-generation attack submarine. Naval Reactors is closely aligned with the Navy on all of these efforts. Along with the technologies being inserted for *Virginia*-class submarines, Naval Reactors has renewed our focus and investment in advanced technologies which will pave the way for improvements in speed, energy density, and stealth for the follow on SSN(X) program. We are also focused on refueling up to seven *Los Angeles*-class submarines, helping to maintain our submarine force structure with boats that have the warfighting capability to contribute effectively to undersea missions.

In aircraft carrier shipbuilding, USS *Gerald R. Ford* (CVN 78) continues to make great progress and will soon be employed and operating alongside U.S. and allied forces. This phenomenal ship is ready to provide over a half century of naval presence around the globe. This past year marked a significant event in the employment of the *Ford*-class—Full Ship Shock Trials. The positive result of this testing is a tribute to the precision, rigor, and execution that go into the design, production, and delivery of the world's most capable aircraft carrier. The second ship of the *Ford*-class, the *John F. Kennedy* (CVN 79) continues propulsion plant testing and is on track for delivery to the Navy in 2024. Progress also continues on construction of *Enterprise* (CVN 80) and *Doris Miller* (CVN 81), carriers in a two-ship buy that allows the Navy to realize important cost savings, while maintaining a steady, predictable workload within our vital industrial base.

NAVAL REACTORS OVERVIEW

This Committee's support has enabled the safe operation of the nuclear fleet, substantial progress on our key projects, and our continued oversight and regulation of all areas across the Naval Nuclear Propulsion Program. Naval Reactors' budget request for fiscal year 2023 is $2.1 billion. Your past support has allowed significant progress on our three major Department of Energy funded projects—*Columbia*-class propulsion plant development and production, the refueling overhaul of our research and training reactor in New York, and the construction of the Naval Spent Fuel Handling Facility in Idaho. When I first arrived at Naval Reactors in 2015, these three projects had not yet hit their peak funding. Over the course of the past several years, these projects have been a major focus for the Naval Nuclear Propulsion Program. We have managed and lead the way through many challenges, and today, I can confidently say that the development and production of the first *Columbia*-class propulsion plant is proceeding in support of lead boat construction; and the refueling of our research and training reactor will complete within fiscal year 2023. With your support, the Program also continues to make significant progress on construction of an incredibly important Naval Spent Fuel Handling Facility. While we are staying focused on completing these efforts, we are also preparing for the future with renewed emphasis on advanced and innovative technologies.

MAJOR PROJECTS

Columbia-class Propulsion Plant

The *Columbia*-class ballistic missile submarine remains the Navy's number one acquisition priority. Naval Reactors is supporting lead ship construction and is delivering the life-of-ship reactor core and the electric drive propulsion system for the *Columbia*-class program. The fiscal year 2023 budget includes $53.9 million that will allow continued support for lead ship propulsion plant design and safety analysis work required for lead ship reactor testing and delivery.

S8G Prototype Refueling Overhaul

The fiscal year 2023 budget request includes $20 million toward final execution of the refueling and overhaul of the New York land-based prototype, which will enable an additional 20 years of Naval Reactors' commitment to research, development, and initial operator training. Over the course of the past three years, the project has worked through performance and testing equipment challenges, and in April of last year met a key milestone—installation of the new reactor core. This reactor core, called the Technology Demonstration Core, includes *Columbia*-class type fuel modules as part of testing and demonstrating the manufacturability necessary for production and delivery of the *Columbia*-class reactor core. We continue to provide strong oversight to improve cost and schedule performance, and the project will complete in fiscal year 2023. I look forward to providing the final update on this multi-year project in next year's appearance before the Committee.

Spent Fuel Handling Recapitalization Project

Naval Reactors is constructing the Naval Spent Fuel Handling Facility (SFHP), located at the Naval Reactors Facility in Idaho. The facility is critical to our mission to manage naval spent nuclear fuel and support aircraft carrier and submarine fleet requirements. The fiscal year 2023 budget request includes $398 million for continuation of this project through several key milestones. Economic conditions influenced by the COVID–19 pandemic and the discovery of unexpected bedrock conditions beneath the facility's foundations have presented significant challenges for us. To address these challenges, we evaluated actions necessary to ensure the overall Project milestones remain achievable, including additional resources (e.g., extended/added shifts, parallel and fast-tracking of work efforts) and additional funding to mitigate impacts to current and future construction subcontracts. Consistent with these actions, I approved a revision to the SFHP Performance Baseline in fiscal year 2021. Funding in fiscal year 2023 will be critical to implementing our construction sequence. I remain committed to keeping the Committee informed of our progress, and actions to mitigate construction challenges, as we aggressively manage and oversee this complex and large-scale infrastructure project.

TECHNICAL BASE FUNDING

In addition to our three priority projects, Naval Reactors maintains a high-performing technical base. The technical base is the set of fundamental skills and capabilities necessary to safely and effectively support the nuclear Navy. It includes a foundation of specialists in nuclear materials, nuclear physics, thermal-hydraulic testing, acoustics, electrical design, software development, system development, refueling, and other specialized skills, along with the associated facilities and laboratories to conduct our work. The people and activities that make up our technical base are leveraged for our priority projects but also perform essential work to support the operating fleet and ensure our day-to-day technological advantage over our competitors. Specifically, the technical base: 1) addresses emergent needs and challenges of our nuclear fleet, 2) executes nuclear reactor technology research and development that supports improving today's fleet and future capabilities, and 3) modernizes critical infrastructure and reduces the Program's legacy environmental liabilities. This base also supports the lean yet highly effective federal workforce that provides the oversight necessary to carry out this important technical work safely and efficiently. These activities provide 24–7 support to the globally deployed nuclear-powered Navy. Attracting and retaining top talent is critical to our technical base's ability to fulfill and mature our mission amidst a wide array of challenges and new demands in this era of strategic competition. The engineers and scientists at our Naval Nuclear Laboratory and nuclear capable shipyards are national treasures, who are in high demand from other areas of our economy. We continue to work with the leadership of our labs and private shipyards to identify innovative means to stay competitive in this aggressive talent market.

Program Direction

Our small but highly skilled federal workforce is critical to execution of our responsibilities. With the fiscal year 2023 Program Direction request, I remain highly focused on attracting, developing, and retaining a talented and diverse workforce to oversee and manage a wide array of work across the Naval Nuclear Propulsion Program to ensure mission success. The talented and dedicated people at our Washington, DC headquarters and field offices are absolutely essential to our strong centralized management and oversight of the important work we perform for our Nation.

Building ships that have over forty years of expected life requires staffing continuity to ensure the Nation has a workforce with the deep technical knowledge needed to execute Naval Reactors' cradle-to-grave responsibilities of these robust systems. I must have sufficient Federal staffing to meet the demands of sustaining and improving today's fleet while simultaneously growing our future capabilities. The cumulative effect of personnel costs growing above inflationary rates and an increase in recent senior level retirements has impeded our ability to reach this goal and challenged our ability to maintain our staffing levels. The market for this talent is exceptionally competitive. Increasingly complex systems, new and innovative research efforts, and growing cyber and other vulnerabilities require additional expertise and new perspectives that can only be gained through reaching our full personnel requirements. I will continue to communicate with the Committee on our requirements and progress in reaching our related staffing goals. In concert with our renewed focus on research and development that I have highlighted over the last several years, we need to find new ways to bring the Nation's top talent into Naval Reactors and retain this talent to transition technical innovations into our submarines and aircraft carriers. I respectfully request Congress' support, which will allow me to recruit, select, develop, and retain the talented workforce that was started by Admiral Hyman Rickover many decades ago and that has proved to be crucial to the success of the Program.

Research and Development

Our research and development strategy represents a renewed investment in cutting-edge technologies aimed at reversing an eroding capability gap with strategic adversaries like China and Russia. Technology investment must be reinvigorated today to have new technologies ready for future classes of ships and to lower costs and reduce construction timelines. It should be noted that these investments also enhance and improve the performance of today's fleet; this is especially important given the increasing competition in the global maritime environment. Our critical research and development is conducted by the dedicated and talented teams of people at our Naval Nuclear Laboratory sites—the Bettis Atomic Power Laboratory in Pittsburgh, the Knolls Atomic Power Laboratory and Kesselring Site in greater Albany, and the Naval Reactors Facility in Idaho.

Our first priority is always support of today's fleet. Our labs perform approximately 4,000 technical evaluations annually that enable Naval Reactors to thoroughly assess and respond to emergent issues, thereby keeping our ships mission-ready while ensuring nuclear safety. These efforts are essential to keep our ships at-sea operating abroad for longer periods of time, our carrier strike groups globally engaged, and ballistic missile and attack submarines ready to respond at any time.

Beginning with last year's fiscal year 2022 budget, Naval Reactors has embarked on a path to identify and develop new technologies for inclusion in the next generation of nuclear powered ships while simultaneously delivering the enhanced capabilities to the existing fleet mentioned earlier. We are pursuing advanced reactor core and fuel systems, advanced manufacturing and inspection techniques, next-generation instrumentation and control architectures and sensors, and asymmetrical applications of emerging technologies (e.g., advanced power conversion, artificial intelligence, data analytics, additive manufacturing, and advanced robotics). These advancements have the potential to deliver both greater capability and lower acquisition and lifecycle costs, while ensuring the Navy is constantly improving our advantage and innovating. I commit to further engagement with the Committee on these advanced technology maturation efforts to enhance understanding and support for the actions described above. I take great pride in highlighting our innovative and new technologies and how we can transition them into meeting requirements for the Fleet of tomorrow.

I want to assure the Committee that our investments are supported by a comprehensive and rigorous planning effort we undertake with our partners at the Naval Nuclear Laboratory. Our annual work execution plans are derived from this comprehensive alignment, and I personally review and approve each plan to ensure we are making the right investments and tradeoffs in all areas of our business.

Facilities and Infrastructure

Our Naval Nuclear Laboratory facilities and infrastructure are essential in carrying out Naval Reactors' mission. This year's budget request supports continuing our recapitalization of Naval Nuclear Laboratory facilities and infrastructure systems, many of which have supported the Program since its inception over 70 years ago. Specifically, this budget includes a consolidation and recapitalization of our thermal hydraulic testing capabilities that will advance cutting-edge technologies and improve testing efficiency. Without these recapitalization efforts, we will be unable to effectively support nuclear fleet operations and advanced research and development efforts at the level required by this complex technology. We are ramping up our efforts in decontaminating and decommissioning (D&D) older facilities that have been in existence since the start of the Program in the early 1950s. We have approximately $8 billion in environmental liabilities requiring D&D efforts. Over one-third of this estimate is associated with the cost to remediate and demolish inactive facilities and infrastructure at the Naval Nuclear Laboratory sites. We continue to retire these liabilities in an environmentally responsible and cost-effective manner to support best use of our funding. I look forward to future engagement with the Committee to discuss our specific actions and tangible examples of Naval Reactors' long-term plan to reach our goals. Through our established partnership with the Department of Energy Office of Environmental Management (DOE–EM), we are leveraging their experience in efficient, safe, and cost-effective remediation of environmental liabilities across the complex. I am pleased with the collaboration on this effort with my partners in DOE–EM.

AUKUS

In September of last year, President Biden announced an enhanced trilateral security partnership between Australia, the United Kingdom, and the United States (AUKUS). The three governments are engaging in an 18-month consultation period to seek an optimal pathway for delivering a conventionally-armed, nuclear-powered submarine capability to Australia at the earliest achievable date. Naval Reactors is playing a key leadership role in developing this plan to ensure that our nation's preeminent expertise is applied to the nuclear-powered submarine initiative. We are now more than six months into this consultation period and are focused on ensuring Australia understands the full scope of capabilities necessary to design, build, operate, and maintain a nuclear navy, as well as properly dispose a nuclear powered ship at the end of service. This includes an in-depth analysis of the trilateral partners' existing regulatory frameworks, as well as the existing educational, industrial, and technical capabilities, and capacities needed to identify the optimal path forward. This effort involves emphasizing to Australia the key leadership roles, labor talent, and infrastructure investments they will need to contribute to bring this to reality. In February, I along with a team of subject matter experts from Naval Reactors and the United Kingdom traveled to Australia to assess their current capability. During this trip, I met with senior Australian Government officials. As part of our discussions, we emphasized that obtaining a nuclear powered submarine capability is a long road which requires steadfast commitment to the highest levels of stewardship. While my number one priority is supporting our current and future nuclear fleet, the AUKUS efforts are being supported by a small cadre of experts who are responsible for ensuring the critical facets of this consultation are completed effectively. The foundation on which this effort is built is made up of our people, our technology, and the facilities that support our own Naval Nuclear Propulsion Program. While Australia is funding this consultation period, Congress' support of Naval Reactors' fiscal year 2023 budget request is vital to support our primary mission and allow the Naval Reactors leadership team the ability to support key activities during the consultation period.

CONCLUSION

The Navy's ability to maintain mastery of the undersea domain and sustain a formidable forward presence and its resultant value cannot be simply assumed. Naval nuclear propulsion is an incredible but unforgiving technology, and must be treated appropriately, with a constant focus on safe operation. Naval Reactor's cradle-to-grave responsibility to manage this technology is paramount, and I assure this Committee that I will balance investments in today's fleet with the requirements of a future fleet, carefully steer future cooperation efforts, and preserve the focus on providing effective naval nuclear propulsion for the United States Navy. I appreciate the strong support this program receives from Congress and respectfully urge your support for our fiscal year 2023 budget request.

Senator KING. Thank you, Admiral. Mr. White, please.

STATEMENT OF WILLIAM WHITE, ACTING ASSISTANT SECRETARY OF ENERGY FOR ENVIRONMENTAL MANAGEMENT

Mr. WHITE. Chairman King, Ranking Member Fischer, and Members of the Subcommittee, it is an honor to appear before you today to represent the Department of Energy's Office of Environmental Management (EM).

EM is focused on its commitment to clean up the environmental legacy of the national defense programs that helped end World War II and the Cold War. This work helps address the government's responsibility to the communities that played such an important role in U.S. history, and more importantly helps position them to continue to grow and thrive in the future.

Today EM has completed cleanup activities at 92 of 107 sites, most recently competing legacy work at the Brookhaven National Laboratory in New York.

Even as EM has grappled with a global pandemic over the past 2 years, we have achieved a set of impactful accomplishments in the cleanup program. At Y–12 in Oak Ridge, EM demolished the biology complex so that this area can be used by NNSA for their modernization program.

Senator KING. Could you get a little closer to the mic, please?

Mr. WHITE. Of course, sir. At Y–12 in Oakridge, EM demolished the biology complex so that this area can be used by the NNSA. More than 200 transuranic waste shipments were received last year at the Waste Isolation Pilot Plan, bringing the total to more than 13,000 shipments safely transported. That includes shipments from Los Alamos, where the team certified and completed 30 shipments to WIPP last year.

At the Hanford Site in Washington State, EM has begun large-scale treatment of radioactive tank waste in the Tank Side Cesium Removal system, another project completed ahead of schedule and under budget. We have treated around 200,000 gallons of waste since the system came online just a few months ago.

At Savannah River in South Carolina, EM is processing record amounts of tank waste, helping to address one of the largest environmental and financial liabilities there.

The EM team in Idaho recently completed its buried waste remediation project 18 months ahead of schedule. This high-priority cleanup project helps protect the Snake River Plain Aquifer and meets the commitment we made to the State of Idaho.

The fiscal year 2023 budget request will enable EM to further advance its mission, maintain national security priorities, and support those most impacted by the environmental legacy of the past. We will treat 1 million gallons of radioactive tank waste at the Hanford site and advance work to begin vitrifying this tank waste by the end of 2023. After decades of support from Congress, this transformational accomplishment is well within sight.

As EM prepares to operate these facilities, it is also ramping up work on Hanford's high-level waste facility so that we are ultimately able to treat that portion of the tank waste too.

In South Carolina, EM will accelerate waste processing and tank closure activities, and at the Idaho National Laboratory we are ad-

vancing towards liquid waste treatment with the Integrated Waste Treatment Unit. The request will also allow us to address high-risk excess contaminated facilities and contaminated groundwater across the complex.

In addition to reducing environmental risks, the budget request supports broader national security and scientific research missions. The Waste Isolation Pilot Plant will be modernized and ensure that the facility is equipped to meet the needs of legacy cleanup activities and ongoing national security programs. As the mission is carried out, we are committed to continuous improvement. GAO's [Government Accountability Office] latest high-risk report acknowledged the steps EM has taken to demonstrate this commitment, and we aim to go even further as we plan for the future.

The cleanup program depends on the talented men and women on the ground at our sites. That is why I am pleased the budget request boosts support for workforce development and for building a pipeline of talent that promotes diversity, equity, and inclusion.

As EM makes steady cleanup progress and prepares for future mission needs, we remain committed to those most impacted by the environmental legacy of the past. Our sites are fortunate to be surrounded by diverse communities and tribal nations who are strong partners in advancing cleanup and planning for the future.

I appreciate the Subcommittee's support for the EM mission. I thank you for your time, and I look forward to your questions.

[The prepared statement of Mr. White follows:]

PREPARED STATEMENT BY WILLIAM "IKE" WHITE

Chairman King, Ranking Member Fischer, and Members of the Subcommittee, it is an honor to appear before you today to represent the Department of Energy's (DOE) Office of Environmental Management (EM).

EM's mission represents the government's strong commitment to cleaning up the environmental legacy of the national defense programs that helped end World War II and the Cold War. EM's vital mission does not just address past legacy, though, it also helps to support and enable DOE's ongoing national security and scientific research missions.

The fiscal year 2023 budget request of $7,643,202,000 for EM reflects the Biden Administration's strong commitment to advancing the cleanup mission and preparing for sustained success, maintaining national security priorities, and supporting communities most impacted by the environmental legacy of the past.

RECORD OF RESULTS FOR THE ENVIRONMENT

Over the last 30 years, EM has made significant progress, completing cleanup the environment at 92 out of a total of 107 sites. EM's significant accomplishments to date have included completing demolition of the Plutonium Finishing Plant, a facility that produced two-thirds of the nation's Cold War-era plutonium at the Hanford Site in Washington state; completing the removal of the former uranium enrichment complex at Oak Ridge in Tennessee; opening the world's only deep geological repository for transuranic waste generated from atomic energy defense activities at the Waste Isolation Pilot Plant in New Mexico; and completing construction on the entire tank waste treatment system at the Savannah River Site in South Carolina, enabling significant progress in how the Department tackles one of its largest environmental and financial liabilities at that site.

NEW ERA OF CLEANUP SUCCESS

These accomplishments are enabled by the significant investments Congress has made in the EM program and have ushered in tangible results for communities and the environment in a safe, effective, and responsible manner. Even as EM continues to grapple with a global pandemic, the program achieved a set of impactful accomplishments at sites across the country.

At the Y–12 National Security Complex in Oak Ridge, Tennessee EM demolished the Biology Complex. EM also advanced deactivation and demolition work at the Oak Ridge National Laboratory (ORNL) with demolition of the Radiological Lab's West Cell Bank and the Tritium Target Preparation Facility now complete. ORNL and Y–12 house hundreds of excess contaminated facilities that comprise the largest inventory of high-risk buildings in the DOE complex. Collectively these efforts are reducing risks, stabilizing facilities, and paving the way for advancing cleanup and providing land for research and national security missions. At the Hanford site in Washington state, EM is treating radioactive and chemical waste from large underground tanks for the first time ever on a large scale, and we are progressing towards initiation of the Direct Feed Low Activity Waste (DFLAW) project that will convert into glass or vitrify this waste for disposal. At the Savannah River Site in Aiken, South Carolina we are now processing record amounts of tank waste and recently broke ground on the important Advanced Manufacturing Collaborative facility that will provide essential space for mission work and facilitate academic, industry, and community collaboration in state-of-the-art laboratory space. The Advanced Manufacturing Collaborative will bring cutting edge innovations to help meet the needs of the EM cleanup mission and create an environment to develop a diverse and talented next generation workforce.

The EM team in Idaho recently completed buried waste remediation helping to protect the Snake River Aquifer. More than 200 transuranic waste shipments were received last year at the Waste Isolation Pilot Plan (WIPP) in New Mexico. This includes shipments from Los Alamos National Laboratory, where the EM team certified and completed 30 shipments to WIPP last year.

Cleanup activities at the Brookhaven National Laboratory in New York are complete with demolition of the 320-foot-tall red-and-white High Flux Beam Reactor exhaust stack, restoring the areas skyline. Lastly EM completed environmental remediation work at the Tonopah Test Range in Nevada, enabling transfer of portions of that site to the Office of Legacy Management for long-term stewardship.

STEADY PROGRESS PLANNED FOR FISCAL YEAR 2023

The fiscal year 2023 budget request builds on these significant achievements by positioning EM for steady and sustained progress in how we tackle radioactive tank waste. Key investments are proposed to continue to drive risk reduction and significant changes across EM's portfolio of sites, as well as to continue to aid the Department's vital science and defense missions.

Protecting the environment by addressing radioactive waste stored in underground tanks at Hanford, Savanah River and the Idaho National Laboratory is a top priority for EM. The budget request enables treatment of one million gallons of tank waste through the Tank Side Cesium Removal system and supports the commencement of vitrifying this waste by the end of 2023 via the Direct Feed Low Activity Waste system. After decades of support from the local community, Congress and the workforce this transformational accomplishment is within sight.

As we prepare to begin operating Hanford's low-activity tank waste vitrification capabilities, the budget request also invests $316.2 million to ramp up work on the Waste Treatment Plant's High Level Waste facility to be able to tackle that portion of Hanford's tank waste inventory. In parallel, EM continues to identify safe, effective, and viable options for the treatment of all Hanford's tank waste, including supplemental low activity waste. One such approach is the proposed Test Bed Initiative (TBI) Demonstration. The proposed TBI Demonstration would address independent recommendations and comments from the Government Accountability Office, the National Academy of Sciences, national laboratories, and others to further study the potential cost, safety and environmental performance of potential treatment and disposal alternatives. Implementation of this TBI Demonstration technology on an industrial scale could have the potential to safely pretreat low-activity waste from Hanford tanks, solidify the waste in grout, and dispose of it off-site in a manner that is protective of the workers, the public and the environment.

In addition to helping solve the challenges of Hanford tank waste, the request will enable EM to continue meaningful cleanup progress to place another former production reactor into interim safe storage, transfer radioactive capsules to safer dry storage, and treat another 2 billion gallons of contaminated groundwater.

In South Carolina, the fiscal year 2023 budget request supports full utilization of capabilities to process tank waste. The Salt Waste Processing Facility will further accelerate the tank waste mission by increasing the processing of to 6 million gallons in fiscal year 2023 up from an expected 3 million gallons in fiscal year 2022. As a result, the Savannah River Site could complete the bulk of its tank waste treatment mission in a decade.

EM actively works with other DOE organizations to assess infrastructure needs across the Department and will continue to pursue modernizing efforts throughout the complex, including at the Savannah River Site to facilitate project completion.

At the same time, risk reduction work will continue at the Savannah River Site, including work towards disposition of remaining transuranic waste and remediating contaminated soil and groundwater.

At the Idaho National Laboratory, the request supports operations of the Integrated Waste Treatment Unit which will ultimately treat about 900,000 gallons of liquid waste by turning it into a granular solid. EM also will meet another key commitment to the state of Idaho by completing the transfer of EM-owned spent nuclear fuel to on-site dry storage.

SUPPORT FOR NATIONAL SECURITY MISSIONS

In addition to reducing environmental risks at these and other sites across the complex, the EM mission benefits the Department's broader national security and scientific research missions. Nowhere is this more evident than at Oak Ridge where the successful demolition of the former uranium enrichment complex at the East Tennessee Technology Park has enabled EM to begin major cleanup operations at the Oak Ridge National Laboratory and Y–12 National Security Complex. Demolition of the Biology Complex at the Y–12 National Security Complex involved tearing down the six-story, 255,000 square-foot Building 9207 and the three-story, 65,000 square-foot Building 9210. With this project complete, EM will transfer the 18-acre area to the National Nuclear Security Administration (NNSA) later this year. The area is the planned location for the future Lithium Processing Facility.

Today, EM is in the midst of a significant infrastructure and modernization campaign at WIPP. Last year EM began mining the West Access Drifts and completed construction of the Salt Reduction Building. The Salt Reduction Building is a key component of the Safety Significant Containment Ventilation System (SSCVS) to improve air quality in the underground portion of the site. Along with providing for continued WIPP operations, as well as waste characterization and transportation programs, the budget request supports the continued infrastructure recapitalization projects, as well as mine modernization activities and safety upgrades in fiscal year 2023. Shipments of legacy transuranic waste to WIPP will progress from sites across the DOE complex, including the Los Alamos National Laboratory in New Mexico, where deactivation and decommissioning of NNSA's Ion Beam Facility will be initiated in fiscal year 2023.

At the Lawrence Livermore National Laboratory, the removal of the Livermore Pool Type Reactor was completed. This marks a significant cleanup milestone and demonstrates EM's strong cooperation with its NNSA and U.S. Army Corps of Engineers partners while setting the stage to begin demolition of Building 280 later this year.

In addition, EM is pursuing a world-class technology development program to accelerate the overall cleanup mission, increase efficiency, and protect human health and environment. EM is leveraging the expertise of the Savannah River National Laboratory and the Network of National Laboratories for Environmental Management and Stewardship to develop innovative solutions in the fields of environmental cleanup, national security and science and energy security that will benefit EM, the NNSA and other DOE missions.

DIVERSE AND TALENTED WORKFORCE

The talented and dedicated men and women across EM are the program's greatest assets. While significant progress continues across the DOE complex, the EM mission will span several decades at some sites. With that in mind, EM is taking steps to ensure a successful and sustainable program that will enable mission completion. EM is investing to support workforce development and build a workforce that promotes diversity, equity, inclusion, and accessibility. These principles are fundamental to EM because they enable every aspect of the cleanup mission.

The budget request provides resources to build a diverse pipeline of talent and support high-quality jobs in environmental cleanup. For example, the $56 million request in fiscal year 2023 supports EM's Minority Serving Institutions Partnership Program, which is designed to help build and maintain a well-trained, technically skilled, and diverse workforce. By partnering with Minority Serving Institutions and Historically Black Colleges and Universities, this program promotes the education and development of EM's next generation workforce in STEM-related disciplines.

SUPPORT FOR IMPACTED COMMUNITIES

As EM makes steady cleanup progress and prepares for future mission needs, EM remains committed to addressing the responsibilities the Department has to the communities most directly impacted by the environmental legacy of the past. The fiscal year 2023 request represents a significant investment in helping the communities that played such an important role in U.S. history continue to grow and thrive in the future. The EM mission itself is aligned with broader environmental justice goals that lead to a vibrant future in all communities. This year, the EM Los Alamos Field Office was selected as one of five DOE pilot programs for the cross-cutting Justice40 Initiative. At its core, the Justice40 Initiative is a whole-of-government effort to lift communities by delivering at least 40 percent of the overall benefits from certain federal investments, including the remediation and reduction of legacy pollution, to disadvantaged communities.

The budget request further boosts support for the Tribal Nations, Alaska Native communities, and communities around EM sites ensuring they are safe, providing opportunities for local input into cleanup priorities and helping build a vibrant future. The request includes Payment in Lieu of Taxes funding for communities near Hanford and Savannah River to support schools, roads and other local priorities. In addition, $40 million is provided to establish a new Community Capacity Building initiative. This grant program will provide assistance to those communities around EM sites and will be developed in consultation with community stakeholders to address their needs.

CONCLUSION

The fiscal year 2023 budget request is the latest sign of this Administration's strong support for EM's vital mission. As the mission is carried out, EM is committed to continuous improvement and making further advancements to ensure that cleanup activities are conducted in a safe, efficient, and cost-effective manner.

EM will continue to work in a collaborative manner with workers, unions, Tribal Nations, states, local communities, and Congress on opportunities to achieve shared goals of protecting the environment and preparing for future cleanup success.

Senator KING. Thank you. We will have 5-minute rounds, and we will ask a few questions. We will probably have more than one round. We have a second panel.

Ms. Hruby, the budget request is about a 3 percent increase, but as I mentioned in my opening statement you are as busy as the agency has been in 40 years. Is 3 percent enough to meet the demands of the recapitalization, the Savannah River cleanup? I mean, we have got a whole host of problems. Is this amount sufficient?

Ms. HRUBY. Yes, Senator King, thanks for that question. We think this is a budget that we can execute and that will keep us on track for requirements, on our requirements. It is true that it would be nice to complete our construction projects and have them ready to go for the rest of our war head modernization programs, but we simply cannot go any faster than we are currently going on those construction projects and have acceptable risk and get the products that we want.

So we think this is the right budget. It was fully informed by the Nuclear Posture Review, and it does, in fact, underscore the expanded mission and the accelerated pace. It comes on top of budget increases over the last several years that have been significant.

However, as I said in my opening statement, the parallel approach we are taking for modernization and infrastructure revitalization carries some persistent risks and includes things like single points of failure in our production complex, supply chain issues in construction projects, and workforce recruitment and retention across the complex. So we feel like this is a practical, accelerated

budget, but it will carry risk because we are moving as fast as we can.

Senator KING. Let me change the subject a minute to nonproliferation. One of the things that is not discussed much with regard to the Ukraine war is that Ukraine gave up its nuclear weapons in exchange for a guarantee of territorial integrity, which was signed by Russia. What has what has happened in Ukraine done to the whole theory and practice of nonproliferation? If you were Kim in North Korea, would you give up your nuclear weapons, having seen what has happened in Ukraine?

Ms. HRUBY. Senator King, this is an important question. The Ukraine guarantees, you know, people will look at around the world. I am confident of that. At the same time, we will do everything we can in NNSA to uphold the nonproliferation regime that we have today. We will reach out, and we are reaching out to our allies and partners as particularly the allies that we have a guarantee with, to make sure they understand how strong our commitment to that guarantee is. We will continue to support activities in the nonproliferation area. But we must step it up in our ability to convince people around the world that nuclear weapons are not the best approach and hopefully not take the wrong lessons from Ukraine.

Senator KING. Well, I hope you are right, but I think it is of significant concern.

Pit production. Are we facing a pit gap? In other words, is it likely that we are going to be able to meet the needs or are we going to be, in 5 years, talking about some emergency program to fill in the gap to meet the needs for the newly deployed weapons?

Ms. HRUBY. We think—look, we are not going to be able to make 80 pits per year by 2030.

Senator KING. Is 80 a magic number? Is 80 the number that we project we will need?

Ms. HRUBY. That is a good question. We are working really closely right now with the Department of Defense, NNSA and the Department of Defense, to look at the outyear requirements and to see how we can satisfy the program of record in ways that we are all comfortable with, that mean a safe, secure, reliable, and effective weapon program, nuclear weapons in the United States. We believe there will be a path through that, but we are still working closely together to define the details of that.

Senator KING. I would rather you say we know there is a path, rather than say "we believe."

Ms. HRUBY. I would rather say that as well, but, you know, I am being honest with you, that we are still in the process of sorting that all out in the Nuclear Weapons Council.

Senator KING. Well, to the extent you refine the estimates and realize there is a problem, let us know sooner rather than later so we can attend to this problem now rather than 5 years from now.

Ms. HRUBY. Let me just say another word about this. We are establishing pit production as a hedge against plutonium aging and pit aging. Our pits are not, today, at any kind of an aging cliff. We can reuse pits. We just do not like that plan because we may have to take them out before the end of the life of the weapon system. But right now we are not at the cliff of aging program. We just

would like to put new pits in because we want the weapons to stay in the stockpile for 30 years, and we do not have the 30-year confidence we would like to have.

Senator KING. Thank you. That is helpful.

Senator FISCHER. Thank you, Mr. Chairman.

Ms. Hruby, this year's budget talks about minimizing the delay in pit production and repeatedly emphasizes achieving the necessary rate of 80 pits per year, quote, "as close to 2030 as possible." Yet your letter to this Committee on your unfunded priorities states that additional resources would allow NNSA to begin additional activities at the Savannah River plutonium processing facility. Would the additional resources referred to in your letter help minimize the delay in pit production?

Ms. HRUBY. Senator Fischer, thank you for that question. The answer is yes. We would like to bring money forward from out years on the Savannah River pit production facility to do some early buys—glove boxes, nuclear-quality piping, other shortages that we are seeing in the supply chain. We would also like to build a training facility at Savannah River to get the workers ready to get to rate production once construction is complete. So we would like to try to accelerate how fast we can go with construction, once our design is complete, and how fast we can get to rate production after the construction is complete. That is what the unfunded request letter is about, is the money that we would like to pull forward into the 2023 budget request from our future years request.

Senator FISCHER. In our discussion this morning you said we are looking at a 2032 to 2035 time frame for achieving the 80 pits per year rate that I believe we need to have, and it also will likely be another 2 years before we have a good idea of how to get there. I think I need to be clear. The additional resources you are referring to make achieving full production by 2032 more likely. Is that correct?

Ms. HRUBY. Yes.

Senator FISCHER. So are in a position now, would you say, to be able to shape events so that we can reach that desired outcome of 2032, if we take the correct steps now?

Ms. HRUBY. That is what we think. I just want to foot-stomp that we did get the money that we need to complete the 90 percent design, so a significant amount of money, $700 million. This additional request would allow us to position ourselves to make sure once we are done with the design we can go as fast as possible.

Senator FISCHER. Okay. Earlier today we also discussed the goal of having nuclear infrastructure that is truly responsive to the changing security landscape that we are facing. When we talk about a responsive nuclear enterprise we usually think of facilities and production capabilities. But do you think that our processes are set up to allow us to move quickly? Do we need to take a fresh look at things, like the Phase X process, to see if we can go faster, where we can go faster?

Ms. HRUBY. Yes, thank you, Senator Fischer, for that question. Our processes are set up to ensure we get to the end state we want, and that is important. They are not set up to go fast. I do think we have to begin to look at how we can move faster without undermining the intent of staying, you know, on schedule and on

budget and get what we want and how we can manage the risk with changing those processes and moving faster.

Senator FISCHER. One thing we have seen on this Committee, when it comes to the Department of Defense, is that over the last several decades they have structured their processes I think to minimize risk. Now as we see our security environment changing, I believe we need to prioritize speed and also innovation, but that sometimes means that we develop new approaches instead of relying on legacy development processes that are already in place.

Do you think that the NNSA faces a similar challenge?

Ms. HRUBY. Absolutely, and for probably largely the same reasons. So we will look for ways to learn from what the DOD is finding. We will look for ways to make our processes more streamlined. We have had some success on smaller construction projects where we cut out pieces of the processes. We saved a lot of money. We have gone faster. So we are doing some experiments on lower-risk systems, but we have to carry that forward. I appreciate the question.

Senator FISCHER. Thank you. Thank you, Mr. Chairman.

Senator KING. Senator Rosen.

Senator ROSEN. Well, thank you, Chairman King, Ranking Member Fischer, for holding this hearing. It is very important. I would like to thank each of the witnesses for testifying today. Thank you for the service to our country.

I want to talk a little bit about the long-term funding strategy for the Nevada National Security Site, because since its inception, NNSS—I do not know which one is easier to say, Nevada National Security Site or NNSS. It is a tongue-twister. But it has relied on its large and remote area to conduct missions for the nation's nuclear weapons and nonproliferation programs as well as other elements of our national security community.

It is larger than all other NNSA sites combined, and it is an equivalent size to the state of Rhode Island. NNSS has a vast amount of infrastructure, a vast amount of infrastructure to maintain, and I am delighted that you and Secretary Granholm each visited the site recently. We welcome the excitement and the attention that your visits have brought to the important and really unique work that we are doing there.

However, over the past few decades NNSS has faced unstable and unpredictable program funding. It is leaving the site with degraded infrastructure, despite being a facility of national importance responsible for the certification of our nuclear stockpile.

I am pleased to hear the programmatic situation is now changing in a positive direction, but I remain concerned that we address this infrastructure funding issue so that NNSS can continue to be a center of excellence for the enterprise.

Administrator Hruby, are you considering innovative approaches to assure that NNSS infrastructure is supported, recapitalized, including base funding to guide future investment planning?

Ms. HRUBY. Yes, Senator Rosen, it is nice to see you and thanks for your continued interest and support of the Nevada National Security Site. I will say that the Secretary's visit and my visit were actually separate visits but a week apart. I think I influenced her by calling in every day saying, "Oh, it was a great visit to Nevada."

Senator ROSEN. It is a great site, is it not?

Ms. HRUBY. It is a great site, and I have been there many, many times, but I have not been there for a few years. I will tell you I was very impressed by the progress that has been made in Nevada, in the infrastructure and in the collaboration with the laboratories to do experiments there underground.

So to answer your question, I think we have a really great plan for the Nevada National Security Site, and the plan, from my perspective, looks like get our infrastructure to a state that is really bringing important contributions and is a good place for people to work, and then fund those new capabilities to do important experiments for us going forward. So we are spending a lot of time and money now on construction. That will lead to a new demand in Nevada that will bring that base funding that you are looking for.

Senator ROSEN. Well, thank you. I want to build on that because the Nevada National Security Site oversees our Stockpile Stewardship Program, principally at the U1a facility, the underground lab where the science is conducting subcritical experiments to verify the reliability and effectiveness of our nuclear stockpile. As you were just there, U1a is undergoing major construction.

Could you provide us—I know we are not in a classified setting, but as much as you can—provide us an update on the upgrades and how these advancements really are going to make a difference for those subcritical experiments that are really going to improve our stewardship program?

Ms. HRUBY. Sure. I would be happy to. There is this program, another acronym mouthful, called Enhanced Capability for Subcritical Experiments, ECSE, that includes upgrades to the U1a tunnel complex, which is the tunnels that we do science experiments in. It also includes new tools, especially the sort of centerpieces, a radiography tool that allows us to watch implosion, also critical, of course.

This ties back to Senator King's question in an interesting way. We need to understand how plutonium ages. This facility, with the radiography, will allow us to watch implosion in real materials, realistic geometries, which we have not been able to do before.

If we believe that we can get a good, excellent estimate of plutonium lifetime it allows us all kinds of—actually pit lifetimes—it allows us all kinds of options going forward, and we do not have to use head strategy of making sure we can make pits while we study aging.

Senator ROSEN. Well, thank you. My time is up. I am going to submit some questions for the record about the Remote Sensing Lab that is also part of the Nevada National Security Site and plays a critical role to our community as well.

Thank you so much.

Senator KING. Senator Tuberville.

Senator TUBERVILLE. Thank you, Mr. Chairman. Thank you, panel, for being here today and your time.

Mr. White, are you familiar with Uranium-233?

Mr. WHITE. Yes, sir.

Senator TUBERVILLE. Yeah, I figured you were. Your office was tasked with downblending Uranium-233 in 2001. As you may know, the U.S. pioneered thorium reactor technology in the 1960s.

These reactors cannot melt down and actually consumes nuclear waste and do not rely on high-assay low-enriched uranium, which all the Department of Energy's next-generation reactors rely on.

Mr. White, what is the chief problem with the HALEU? Do you know? It comes from Russia. Correct?

Mr. WHITE. Yes, sir.

Senator TUBERVILLE. Thank you very much.

Not only is 233 proven to create safe and clean power, its grandchildren isotopes are also valuable to fighting cancer. A May 2008 DOE report found that the destruction of Uranium-233 threatened the supply of these lifesaving treatments. The DOE's 2010 audit report said that destroying Uranium-233 would blunt scientific research and weaken National Security Administration's test readiness program.

Mr. White, how many kilograms of this Uranium-233 remain to be blended? Do you know?

Mr. WHITE. I do not know that exact number off the top of my head, but I will be happy to take that for the record and get it back to you.

Senator TUBERVILLE. I will give it to you real quick—450 that we have left, which is worth millions and millions of dollars. Do you know how much it costs us to downblend this U–233?

Mr. WHITE. Our budget request for this year is for $55 million.

Senator TUBERVILLE. Fifty-five million. Correct. Fifty-five million to destroy something that is worth hundreds of millions of dollars, that we also can use for other things.

Do you find it odd that your agency is tasked with destroying something while, at the same time, the DOE gave this technology to China? I mean, it is kind of odd. Does it not seem odd to you?

Mr. WHITE. The Environmental Management Program has a number of conversations with other programs across the Department as we look at whether facilities or material are excess and ready for disposition. Those conversations are often very difficult, and from an environmental management perspective what we really look at is once other programs have decided they no longer need the material, how we would prioritize the disposition of the material or the facilities within the scope of the larger cleanup program.

But the material that you are talking about at Oak Ridge, this is a high priority from a disposition perspective for the Environmental Management Program for a number of different reasons. The material, as it is currently stored at Oak Ridge National Laboratory, is one of the more significant safety and security risks that we have at Oak Ridge National Laboratory.

It is also material that is very expensive to safely store and secure. The laboratory spends over $50 million a year to safely store and secure this material, and it is being stored in some of the oldest operating facilities that we have in the Department of Energy, so the cost of continuing to store the material in these facilities is going to go up over time.

At the moment we also have a very unique opportunity, working with a public-private partnership, to make use of some of the benefits that you just described. We have a partnership that allows our contractor, Isotek, to extract the thorium from the material. That is provided to another company, TerraPower, which uses the tho-

rium to extract isotopes for lifesaving cancer research. In the process some of the cost of our disposition activity is covered by that agreement between Isotek and TerraPower.

Senator TUBERVILLE. Yeah. I would hope that we would really look at this to make sure that while we are destroying something that in the future we are not going to have to turn around and try to either buy it from China, buy it from Russia, or whatever, at the end of the day. I know it is probably dangerous, and we do store it in Tennessee. I am sure we could find a better place, that if they are not wanting it there, heck, we will take it in Alabama and put it in the Redstone Arsenal and protect it with our lives.

But I just hate that we are destroying something, that we are paying to have destroyed, that we might use in the future.

Mr. Chairman, I would like to submit these for the record. I have got a 2008 Department of Energy Audit Special Report, a 2010 Department of Energy Audit Report, and a 2012 Summary Meeting Report between the Chinese Academy of Sciences and the U.S. Department of Energy. I would like to submit these for the record.

Senator KING. Without objection.

[The information referred to follows:]

[The 2008 Department of Energy Audit Special Report, 2010 Department of Energy Audit Report, and 2012 Summary Meeting Report between the Chinese Academy of Sciences and the U.S. Department of Energy can be found in the Appendix.]

Senator TUBERVILLE. Thank you very much.

Senator KING. Senator Warren.

Senator WARREN. Thank you, Mr. Chairman, and thank you to our witnesses for appearing here today.

So we are modernizing our nuclear weapons program including constructing new plutonium pits which produce the radioactive raw material that we need for nuclear weapons. Resuming pit production is a huge undertaking for NNSA, and I have been a critic of some of NNSA's work because the agency has a pretty lousy record of waste and mismanagement that has cost taxpayers billions of dollars over the years.

Back in 2015, Congress set a requirement of producing 80 plutonium pits per year by 2030, and we are not off to a great start on that. The estimated budget for this work, at just one pit production site, doubled over the course of just a couple of months.

So, Ms. Hruby, what is the best current estimate for what 80 pits per year will cost?

Ms. HRUBY. Thank you, Senator Warren. I know this is a topic that you care a lot about. We are, I think as you know, in the process of completing the 90 percent design of the Savannah River production facility and the Los Alamos pit production project. Until those are done we will not have a cost estimate that we can stand behind. It is true there are always numbers floating around out there, but our processes are such that we are really trying to get a firm estimate and then come in on costs. So it would be premature for me to give you a number for that.

Senator WARREN. Premature? So NNSA budget estimates put the figure at $15 billion, I have seen press reports at $18 billion, and you cannot even tell me what neighborhood this is in?

Ms. HRUBY. I can tell you neighborhoods that it is in, and it is going to be—if I give a number then I am going to be held to it,

so with that caveat we do think it is going to be more than $10 billion.

Senator WARREN. Well, I just got to say, that is a lot of money.

Ms. HRUBY. I understand. It is a lot of money.

Senator WARREN. Whether it is $10 billion or $15 billion or $18 billion. But even this astonishing number is probably not enough to build these pits.

You know, when NNSA's Deputy Administrator was before the Committee a few weeks ago he said the 2030 goal is likely unachievable, and I am going to read you what he said. He said, "We can't get to 2030 by throwing more money at it," unquote.

So let's talk about why things are going so poorly. Last year the Department of Energy's cost estimating shop conducted an independent review of the Los Alamos facility's pit production plant. They found, quote, "There are significant risks in staffing, program management, production activities, supporting infrastructure, waste management, and other program requirements," unquote. You know, the biggest problem is there was not a single integrated plan in place to manage costs and schedule and performance.

Ms. Hruby, is there now a single integrated program management plan for pit production at Los Alamos?

Ms. HRUBY. Yes.

Senator WARREN. Yes. That is the good news, right? Yes, there is, and I appreciate that. This was the answer I wanted you to give. Yes, there is a plan in place. And I appreciate that NNSA is trying to address the problems with pit production. But there are no guarantees that this program will ever be successful, no matter how much money we spend. In fact, the pit production program has been drawing comparisons to a previous program called the Mixed Oxides Fuel Fabrication Facility, or MOX, which was designed to dispose of surplus weapons-grade plutonium. MOX was always technologically dubious and was finally cancelled after wasting $8 billion.

Here is my question, Ms. Hruby. Are you confident that we are not going to end up sinking billions of dollars, maybe tens of billions of dollars, into pit production before finally pulling the plug, like we did with MOX?

Ms. HRUBY. Yes, Senator, I am. Let me just say about this. This is a very important programmatic objective. We cannot fail.

Senator WARREN. Well, I have to say I do not share your confidence that this is going to work. As I told Dr. Adams last month, I remain very concerned about this program. I think we need to seriously assess whether our goals whether the timeline we are all working on is realistic. NNSA cannot keep wasting billions of dollars of taxpayer money. This just has to stop. So thank you.

Ms. HRUBY. Thank you.

Senator WARREN. Thank you, Mr. Chairman.

Senator KING. Thank you, Senator Warren.

Let's have our second panel join us please.

[Pause.]

Senator KING. Welcome to our second panel. Dr. Adams, will you begin?

STATEMENT OF THE HONORABLE MARVIN L. ADAMS, DEPUTY ADMINISTRATOR FOR DEFENSE PROGRAMS, NATIONAL NUCLEAR SECURITY ADMINISTRATION

Mr. ADAMS. Yes. Thank you. Chairman King, Ranking Member Fischer, and——

Senator KING. Please get a little closer to the mic.

Mr. ADAMS. Will do. Chairman King, Ranking Member Fischer, and Distinguished Members of the Subcommittee, thank you for the opportunity to discuss the President's fiscal year 2023 budget for NNSA. I thank the Committee and the Senate for your support during my recent confirmation process. I am honored to serve as Deputy Administrator for Defense Programs, and I am committed to working closely with you and others in Congress, along with our partners in DOD, to advance the nuclear security mission.

The fiscal year 2023 budget request for weapons activities is $16.5 billion, which is about 3.6 percent more than what was enacted in fiscal year 2022. This request, informed by the 2022 Nuclear Posture Review, will enable NNSA to keep our nuclear weapons stockpile safe, secure, and effective.

NNSA is simultaneously executing five warhead modernization programs. Two are in production and three are following closely behind. Drivers for these programs include technical issues with warheads, changes in DOD delivery platforms, and emerging capability gaps.

Warhead modernization requires reinstatement or replacement of lost manufacturing capabilities. With support from current and past administrations and Congresses, NNSA is modernizing and recapitalizing the production complex while simultaneous using both old and new infrastructure to manufacture modernized warheads.

Our highest infrastructure priority is reconstitution plutonium pit production capabilities. We are executing a two-site plan to produce plutonium pits at Los Alamos National Laboratory and the Savannah River site. We assess that this is the best way to reliably produce at least 80 war-reserved pits per year as soon as possible.

NNSA is also modernizing capabilities to process uranium and lithium to produce tritium, to manufacture and produce trusted rad-hard electronics, and to manufacture non-nuclear components.

As we focus on the time-urgent delivery of modernized warheads and an infrastructure that is modernized as well as we must also develop and nurture capabilities to meet future challenges. Continued investments maintain NNSA experimental and computational capabilities that address important stockpile questions, and importantly, that attract outstanding scientists and engineers, and let them develop into the experienced experts that the stockpile needs.

For example, ongoing investments support major experimental facilities at all three NNSA laboratories, it supports the enhanced capabilities for subcritical experiments projects at the Nevada National Security Site, supports exoscale computing that is coming, to be housed at Lawrence Livermore National Lab, and much more.

I am confident that with support of Congress and in partnership with DOD our dedicated workforce will meet these unprecedented challenges that we face to maintain, modernize, and sustain our nuclear deterrent into the future.

Thank you for this opportunity to testify. I look forward to your questions.

[The joint prepared statement of The Honorable Jill Hruby and The Honorable Marvin L. Adams follows:]

JOINT PREPARED STATEMENT BY THE HONORABLE JILL HRUBY AND THE HONORABLE MARVIN L. ADAMS

Chairman King, Ranking Member Fischer, and Members of the Subcommittee, thank you for the opportunity to present the President's Fiscal Year 2023 Budget for the Department of Energy's (DOE) National Nuclear Security Administration (NNSA). NNSA greatly appreciates the Committee's bipartisan support for our nuclear security mission and for the talented and dedicated workforce responsible for carrying it out every day.

The Department meets its enduring national security mission by maintaining and modernizing the nuclear weapons stockpile so that it is always safe, secure, reliable, and effective; by reducing global nuclear threats; and by providing the U.S. Navy's nuclear-powered submarines and aircraft carriers with militarily effective propulsion systems. NNSA remains uniquely qualified to fulfill these tasks on behalf of the American people and in support of our allies and partners.

The NNSA Fiscal Year 2023 budget request is informed by the 2022 Nuclear Posture Review and reflects today's increasingly complex geopolitical environment. Importantly, the budget request provides full support for the significant nuclear weapons design and production required to modernize all three legs of the nuclear triad. Once complete, this effort will provide the U.S. with a safer, more secure, and more reliable stockpile that, together with the Department of Defense modernization programs, will provide the U.S. with a modern nuclear deterrent capable of responding to a wider array of challenges. The fiscal year 2023 budget request also includes continued funding for the NNSA infrastructure revitalization program needed to produce the weapons and materials for the planned program of record and create an enterprise that is more resilient and flexible. Funding for research, technology, and engineering needed for stockpile certification and innovation activities is maintained in the request.

At the same time, the fiscal year 2023 budget request recognizes we must press ahead with our nuclear nonproliferation and nuclear counterterrorism and counterproliferation efforts as a complementary approach to respond to geopolitical realities. These programs continue efforts to implement and support robust security and safeguards for nuclear materials; shift commercial, research, and medical industries away from highly radioactive materials and technologies; and develop technologies for early detection of proliferent activity. This request recognizes the increased efforts required as nuclear power expands around the world in response to climate change, and as Russia, China, and North Korea continue to diversify and expand their nuclear arsenals.

The NNSA budget request provides the support needed for Naval Reactors to continue work designing, producing, operating, and maintaining the nuclear propulsion plants for U.S. nuclear submarines and aircraft carriers. The request also fully supports three critical initiatives: the *Columbia*-class ballistic missile submarine reactor systems development; construction of the Naval Spent Fuel Handling Facility; and the refueling and overhaul of the land-based reactor for continued training and technology testing.

In today's multipolar and more aggressive geopolitical environment, it is imperative that NNSA is both responsive to needs and acts responsibly to avoid escalation or arms racing while preparing for an uncertain future. Our budget request reflects this balance, and our work has never been more critical to global stability.

NNSA'S ACCOMPLISHMENTS IN 2021

Last year, NNSA achieved several key milestones across the nuclear security enterprise despite the unprecedented circumstances COVID–19 presented.

Life Extension and Weapons Modernization Programs: In 2021, NNSA completed first production units (FPU) for the W88 Alteration (Alt) 370 and the B61–12 Life Extension programs. Both refurbished weapons have increased safety and reliability.

Large Line-Item Construction: NNSA has three large line-item construction projects for nuclear materials underway: two projects associated with plutonium pit production—one at Los Alamos National Laboratory and one at the Savannah River

Site—and one project associated with uranium processing at the Y–12 National Security Complex.

The Los Alamos Plutonium Pit Production Project (LAP4) received Critical Decision (CD)-1 approval in April 2021. The Savannah River Plutonium Processing Facility (SRPPF) received CD–1 approval in June 2021. CD–1 approval marks completion of a project's definition phase and the conceptual design as part of DOE's Order 413.3B process for the acquisition of capital assets. Clearing the CD–1 process allows NNSA to establish 90 percent design and associated cost estimation during the subsequent CD–2 effort.

The Uranium Processing Facility (UPF) consisting of seven subprojects has completed three projects on schedule and under budget, and the final four are underway. During 2021, significant construction activity continued and led to the successful full enclosure of all buildings in April 2022, setting the stage for equipment installation.

National Ignition Facility (NIF): In August, the National Ignition Facility at Lawrence Livermore National Laboratory achieved a breakthrough with an experiment that yielded more than 1.3 megajoules of energy and resulted in a burning plasma state for the first time in any fusion research facility. Burning plasma research is needed for high fidelity modeling of nuclear weapons and is one of the milestones needed to achieve self-sustaining energy production.

Secure Transportation: The Office of Secure Transportation accomplished 100 percent of its assigned missions safely and securely with no mission degradation despite operational challenges present from COVID–19.

Infrastructure Innovation: NNSA purchased the LeMond Carbon Facility in Oak Ridge, TN to replace facilities at Y–12 built in the 1940s used for process development. Use of NNSA's purchase authority for acquisitions allows us to accelerate delivery of modern facilities without the need for new construction.

To support our climate goals, NNSA placed lease orders with the General Services Administration to replace gas-powered cars with approximately 50 zero-emissions vehicles, nearly doubling the size of electric-powered cars in NNSA's fleet.

Nuclear Material Disposal and Reduction: NNSA converted an additional 91 kilograms of plutonium to an oxide form, for a cumulative total of 1,187 kilograms, in preparation for final disposition, continued downblending excess plutonium, and completed construction of a characterization and storage pad for the first shipment of downblended plutonium from the Savannah River Site to the Waste Isolation Pilot Plant. Additionally, the Secretaries of Energy and Health and Humans Services jointly certified that global supplies of molybdenum-99 (Mo-99) produced without the use of highly enriched uranium (HEU) can meet the needs of patients in the U.S. This critical milestone in nonproliferation efforts also triggered a congressionally mandated ban on exports of HEU for foreign medical isotope production.

Global Material Security: NNSA conducted over 75 cyber engagements with international partners to enhance security of nuclear facilities and materials. Partnerships were also started with several domestic advanced reactor vendors for 'security-by-design' activities to enhance the security of the systems for both domestic and international use. NNSA replaced 50 devices (39 domestically and 11 internationally) that use high-activity radioactive sources with non-radioisotopic alternative technologies and secured 48 buildings (28 domestically and 20 internationally) with high priority radioactive sources. In addition, since the start of 2021, NNSA has signed new counter radioactive material smuggling arrangements with Estonia Ministry of Interior, Ukraine Ministry of Internal Affairs, Ukraine State Security Service, Mexico National Commission for Nuclear Security and Safeguards, Niger High Atomic Energy Authority, and Morocco Gendarmerie.

Counterterrorism: NNSA's Nuclear Emergency Support Team (NEST) conducted dozens of operations, including preventative radiological/nuclear detection support to the Presidential Inauguration, Presidential Address to a Joint Session of Congress, New Year's Eve celebrations in Las Vegas and New York City, Super Bowl LV, the Fourth of July celebration on the National Mall, and the 76th Session of the United Nations General Assembly. Additionally, NNSA conducted 50 virtual workshops with U.S. public information officers, law enforcement, first responders, and technical experts concerning radiological counterterrorism to build capacity and improve crisis and risk communication.

Workforce Development: NNSA achieved its highest federal workforce level since 2013 with a total of 1,825 federal employees onboard. To help develop the next-generation workforce, NNSA awarded 13 Minority Serving Institution Partnership Program grants for a total of 24 consortia grants to reach tens of thousands of students in STEM disciplines.

NNSA'S FISCAL YEAR 2023 BUDGET REQUEST

The President's Fiscal Year 2023 Budget Request for NNSA is $21.4 billion, an increase of $1.0 billion, or 5.1 percent, over the fiscal year 2022 enacted level.[1] This funding request reflects the expanded mission in NNSA and need for accelerated delivery of the modernization and infrastructure programs. The three NNSA missions—the nuclear deterrent, nuclear security and nonproliferation, and naval nuclear propulsion—have key deliverables in fiscal year 2023. In addition, the capabilities to position NNSA to be successful in the future must be nurtured. We are grateful for the sustained, bipartisan commitment by Congress and multiple administrations and ask for continued support.

WEAPONS ACTIVITIES APPROPRIATION

The fiscal year 2023 budget request for the Weapons Activities account is $16.5 billion, an increase of $566 million, or 3.7 percent over the fiscal year 2022 enacted levels. The request will be supplemented with prior year balances of $396 million. This budget request represents the Administration's continued strong commitment to a safe, secure, reliable, and effective nuclear deterrent backed by resilient, flexible infrastructure along with cutting edge science, cyber security, and physical protection.

NNSA is fully aware that delivering the deterrent and capabilities our Nation needs to respond to the current environment requires a faster pace and a more complete modernization of weapons than over the last several decades. That is why we are re-establishing production capabilities lost in the 1990s and overhauling both our physical infrastructure and human capital to retain technical advantages and build resilience into our enterprise. NNSA is looking forward to overcoming obstacles and building on the successes of the previous year.

The fiscal year 2023 request reflects the need to advance the weapons modernization programs and production capacity at an accelerated pace. The Weapons Activities account includes:

- Stockpile Management: Maintenance and modernization of nuclear weapons and production operations to sustain confidence in the safety, security, reliability, and military effectiveness of the stockpile without resuming nuclear explosive testing and associated activities.
- Production and Infrastructure Modernization: Investment in NNSA's infrastructure to rebuild capabilities lost in the 1990s and revitalize and expand the capacity of other elements to support stockpile modernization and science. These projects range from significant line-item construction for Plutonium and Uranium related activities to minor construction of offices and light labs to operational infrastructure such as electrical and networking utilities.
- Stockpile Research, Technology, and Engineering: Continued development of state-of-the-art scientific, engineering, and manufacturing capabilities to enable continuous improvement in design, certification, and production of the enduring nuclear weapons stockpile and to stay ahead of the threat.
- Transportation, Nuclear, and Cyber Security: Keeping pace with evolving threats and sustaining transportation, cyber and physical security across the nuclear security enterprise to improve resilience.

NNSA restructured the Weapons Activities budget in fiscal year 2021 to enable better alignment of portfolios with resources. This allowed improved prioritization within portfolios that have multiple programs and interdependencies. Further refinements are proposed in fiscal year 2023 to align programmatic construction with the portfolio each project supports. Comparisons throughout the Weapons Activities portfolio assume this alignment in the fiscal year 2022 enacted levels as well.

Stockpile Management

The fiscal year 2023 Stockpile Management budget request is $4.9 billion, an increase of $291 million, or 6.3 percent, over the fiscal year 2022 enacted level. This portfolio covers the maintenance of a safe, secure, reliable, and militarily effective nuclear weapons stockpile. Activities include life extension programs (LEP) and other weapons modernization activities; surveillance, minor alterations and limited life component exchanges; providing the safe dismantlement of nuclear weapons and components; and providing sustainment of needed manufacturing capabilities and capacities. The fiscal year 2023 request also includes funding for Nuclear Enterprise Assurance (NEA) to prevent, detect, and mitigate subversion risks to the nuclear weapons stockpile and associated design, production, and testing capabilities.

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[1] Funding does not reflect the mandated transfer of $92.75 million in fiscal year 2022 to the Office of Nuclear Energy for operation of the Advanced Test Reactor.

W88 Alteration (Alt) 370: NNSA expects the W88 Alt 370 program to enter Phase 6.6, Full-Scale Production, in July 2022. Production is currently on schedule to meet Department of Defense (DOD) deployment schedules.

B61–12 LEP: NNSA expects the B61–12 LEP to enter Phase 6.6, Full-Scale Production, in June 2022. The B61–12 LEP consolidates multiple variants of the B61 gravity bomb and improves the safety and security of the weapon. Production is currently on schedule to meet DOD deployment schedules.

W80–4 LEP: NNSA is continuing Phase 6.3 activities, Development Engineering, and plans to enter Phase 6.4, Production Engineering, in fiscal year 2023. The W80–4 FPU date is currently being re-evaluated due to COVID–19 impacts, slower than planned hiring and increased attrition, and component technical challenges. The updated FPU schedule will be developed by mid-2022. NNSA's revised schedule is expected to support the U.S. Air Force's (USAF) schedule for Long Range Standoff missile initial operating capability.

W87–1 Modification Program: The W87–1 will replace the aging W78 warhead using a modification of the existing W87–0 design. The W87–1 will deploy new technologies that improve safety and security, address obsolete designs and materials, and simplify warhead manufacturability. The fiscal year 2023 budget request supports NNSA's commitment for a planned FPU in fiscal year 2030 to meet DOD's scheduled deployment of the Sentinel missile. The request supports Phase 6.3, Development Engineering, activities including joint testing with USAF Sentinel missile and Mk21A reentry vehicle program and conducting the Conceptual Design Review. NNSA plans to enter Phase 6.3 in fiscal year 2022.

W93/Mk7: In February 2022, the NWC voted to authorize the W93's entry into Phase 2, Feasibility Study and Design Options. NNSA's fiscal year 2023 funding request will support the Phase 2 activities including further examination of design concepts from Phase 1, and down-selection to desired weapon design(s) to be subsequently developed in Phase 2A, Design Definition and Cost Study, planned for fiscal year 2026. All the W93's key nuclear components will be based on currently deployed and previously tested nuclear designs, as well as extensive stockpile component and materials experience. It will not require additional nuclear explosive testing to certify. The W93 is vital for continuing our longstanding cooperation with the UK, which is modernizing its nuclear forces. The U.S.'s W93 program is a separate but parallel program critical to the UK's replacement warhead (RW) for its submarine launched ballistic missile. As an allied but independent nuclear power that contributes to NATO's nuclear deterrent posture, the UK's nuclear deterrent is critical to U.S. national security.

Within Stockpile Management, the fiscal year 2023 budget request includes $1.3 billion for Stockpile Sustainment, an increase of $141 million, or 11.9 percent above the fiscal year 2022 enacted level. This program is responsible for producing and replacing limited-life components such as neutron generators and gas transfer systems; conducting maintenance, surveillance, and evaluations to assess weapon reliability and detect any potential concerns; and analyzing information compiled during the annual assessment process.

The request for Stockpile Management also includes $631 million for Production Operations, an increase of $62 million, or 10.9 percent, above the fiscal year 2022 enacted level. Included in this request is funding to support continued growth of base capabilities, both in staffing and equipment, required to support increased LEP workload as certain programs reach full-scale production rates.

Production Modernization

The fiscal year 2023 Production Modernization budget request is $4.64 billion, an increase of $484 million, or 11.6 percent, over the fiscal year 2022 enacted level. This funding focuses on production capabilities for nuclear weapons components including primaries, canned subassemblies, radiation cases and non-nuclear components needed to sustain the nuclear weapons stockpile near-to long-term.

Primary Capability Modernization: NNSA's most intensive recapitalization effort is reconstitution of plutonium pit production fabrication capabilities. NNSA is required to produce no fewer than 80 pits per year (ppy) during 2030. NNSA has outlined a two-site approach for producing 80 ppy utilizing Los Alamos National Laboratory (LANL) to produce 30 ppy and the Savannah River Site (SRS) to produce 50 ppy. The two-site approach will provide the required capacity while enhancing resiliency and flexibility. At this time, the production of 30 ppy at LANL during 2026 remains on schedule with some technical challenges remaining. However, the production of 50 ppy at SRS during 2030 is not achievable. The Secretary of Energy and the Nuclear Weapons Council have both notified Congress regarding the inability to produce 80 ppy in 2030. However, NNSA remains committed to achieving 80 ppy as close to 2030 as possible. The fiscal year 2023 budget request funds pit pro-

duction and associated efforts with a 26 percent increase compared to fiscal year 2022. NNSA continues to work with DOD to develop a plan to maintain the required stockpile until pit production capabilities are fully established.

The fiscal year 2023 request for LANL Plutonium Modernization will support equipment installation, continue decontamination and demolition work, and mature project design for the LAP4. This includes adding equipment in Plutonium Facility 4 (PF–4) to support 30 ppy in 2026, construction of a training facility to support workforce development, and construction of a higher capacity entrance control facility.

The fiscal year 2023 funds for SRPPF will be used to continue the CD–2 work to establish a 90 percent design. CD–2 is forecast for completion in early fiscal year 2024. Additionally, the request supports early site preparation including removal of unnecessary walls and building systems originally installed for the Mixed Oxide Fuel Fabrication Facility.

Secondary Capability Modernization: NNSA is also modernizing its uranium, lithium, and tritium processing efforts necessary to fabricate nuclear weapon secondaries. NNSA's uranium strategy aims to relocate enriched uranium processing capabilities into the UPF and other enduring facilities to reduce mission dependency on Building 9212, which is over 75 years old. This will be accomplished by completing construction of UPF to provide new floor space for high hazard operations; extending the operational lifetime of buildings 9215, 9204–2E, and 9995 into the 2040s; introducing new processes to increase safety and efficiency in the new facilities; and supplying the current stockpile with purified enriched uranium metal.

UPF will provide for the long-term viability, safety, and security of enriched uranium processing capability in the United States while significantly improving worker and public safety. The construction is well underway with a peak production workforce of 3,000 people in fiscal years 2022 and 2023. Ongoing supply chain issues and delays associated with the COVID–19 pandemic are projected to result in a delay of about 8 months beyond the scheduled completion date of December 2025. A comprehensive annual cost update is being conducted for the UPF project completion to better understand factors that could potentially affect total costs. Overall, UPF is 70 percent complete with the first three non-nuclear infrastructure subprojects completed under budget and on schedule.

Additionally, in fiscal year 2021, NNSA initiated the Depleted Uranium (DU) Modernization Program to meet growing mission requirements. This effort will reconstitute lapsed DU alloying and component manufacturing capabilities at Y–12; invest in key new technologies to improve efficiency and reduce lifecycle costs; and increase the reliability and capacity. The DU Modernization Program request for fiscal year 2023 is $170 million.

The U.S. no longer maintains a full lithium purification capability and relies on direct recycling as the main source of lithium for nuclear weapons systems. NNSA's Lithium Strategy will increase the supply of lithium by recycling components from dismantled systems, sustain and recapitalize existing infrastructure through a transition period, and design and construct a Lithium Processing Facility (LPF) to house processing capabilities by 2031. LPF will replace capabilities performed in Y–12's buildings 9204–2 and 9202 and will include recovery, purification, and component fabrication operations. While current capabilities can provide a sufficient lithium supply through 2035, operations take place in an aging facility with significant infrastructure challenges. LPF will alleviate those issues and reduce risk while providing capacity to meet material demands beyond 2035.

The fiscal year 2023 budget request for the Tritium and Domestic Uranium Enrichment is $580 million, an increase of $64 million, or 12.4 percent above the fiscal year 2022 enacted level. For Domestic Uranium Enrichment the fiscal year 2023 budget request supports HEU down-blending to extend the need date for LEU for tritium production to 2044, enrichment technology development, and acquisition activities to meet future enriched uranium needs. HEU downblending began in fiscal year 2019 and will continue through fiscal year 2025. NNSA is currently conducting an analysis of alternatives, which is expected to conclude in the mid-2020s that will inform a final down-select of an enrichment options. Other NNSA programs such as reactor fuel and naval propulsion fuel are also supported by this effort.

The Tritium Modernization Program's mission is to establish and operate a domestic source of tritium to meet national security requirements, which includes recycling tritium gas to maintain required inventories and sustaining reliable supply chain infrastructure and equipment. Since 2003, NNSA's tritium production has met all production, delivery, and schedule requirements. Because NNSA is currently ramping up production levels at the Tennessee Valley Authority to meet future delivery requirements, the requested budget has been increased. NNSA is also in the early phases of constructing the Tritium Finishing Facility (TFF), which will replace

a 1950s-era facility. TFF will house the finishing, packing, and shipping of gas reservoirs to meet mission requirements. This major infrastructure modernization initiative will fulfill a critical mission need and enable the program to meet contemporary safety standards. The facility will house functions to receive, inspect, finish, package, and ship reservoirs. Construction of the site preparation subproject is scheduled to start in fiscal year 2024.

Non-Nuclear Component Modernization: Non-nuclear components (NNCs) include a wide array of parts that weaponize the nuclear explosive package. Examples are gas transfer systems, neutron generators, microelectronics, and power sources. Non-nuclear components make up more than half the cost of weapon modernization due to the number, complexity, and their qualification in extreme environments over the warhead lifecycle. Therefore, delivering non-nuclear components requires an extensive foundation of capabilities for the design, development, qualification, production, and surveillance of these components. The fiscal year 2023 request includes funding to provide equipment for increased manufacturing capacity at the Kansas City National Security Campus; reconstitute thermal spray capability for weapon modernization; recapitalize radiation and major environmental test facilities at Sandia National Laboratories used to design and qualify NNCs; and tools and equipment at the Microsystems Engineering, Science and Applications (MESA) Complex at Sandia, which serves as the only approved source of trusted, strategically radiation hardened microelectronics.

Infrastructure and Operations

NNSA has been taking significant steps to modernize and recapitalize its infrastructure to meet expanding demands, reduce mission and safety risk, and draw down its deferred maintenance backlog. A well-organized, well-maintained, and modern infrastructure system is the bedrock of a flexible and resilient nuclear enterprise. Almost 60 percent of NNSA facilities were beyond their 40-year life expectancy at the end of fiscal year 2021 with some dating back to the Manhattan Project. Our modernization and recapitalization efforts will provide for the safety of our workforce, the communities around our facilities, and our environment. NNSA can address this challenge only with sustained, predictable, and timely funding.

The fiscal year 2023 budget request for Infrastructure and Operations is $2.63 billion, an increase of $144 million or 5.8 percent over the fiscal year 2022 enacted amount. This increase will enable NNSA to build on the Infrastructure Modernization Initiative, including adopting new practices that will streamline construction practices to save time and money on low-risk, non-nuclear, construction projects.

Deferred maintenance has been a key focus of both NNSA and Congress. At the end of fiscal year 2021, NNSA had $6.1 billion of deferred maintenance and an enterprise-wide replacement plant value of $121.5 billion. While this ratio may seem high, construction of new facilities and associated demolition of legacy facilities will have a substantial role in reducing NNSA infrastructure challenges. Approximately 90 percent of NNSA deferred maintenance is associated with facilities that are approaching or have surpassed their intended design life. NNSA is integrating its infrastructure modernization work with the Department's Office of Environmental Management supported effort to demolish high-risk excess facilities at the Y–12 National Security Complex, Lawrence Livermore National Lab and Los Alamos National Lab. NNSA is using this intentional approach to prioritize investments based on mission risk while underscoring the need for sustained commitment to move beyond legacy infrastructure. The fiscal year 2023 budget request includes increases in Mission Enabling Construction accounts so that NNSA can address mission needs, achieve operational efficiencies, and reduce risks to safety, security, the environment, and program.

For years, NNSA has used a prioritization methodology for recapitalization investments that factors in sustainability and resilience along with safety and mission risk. In fiscal year 2023, NNSA is increasing its emphasis on climate resiliency projects through the Energy Resilient Infrastructure and Climate Adaptation (ERICA) initiative. ERICA is part of NNSA's multifaceted approach to address climate adaptation and resilience using directand indirect-funded infrastructure programs and alternative financing. For example, the planned Building 848 Net Zero Energy Upgrade project at Sandia will move the facility to being 100 percent powered by on-site generated electricity while also improving its operations, indoor air quality, and thermal comfort.

NNSA uses data-driven, risk informed tools and initiatives to improve decision making, accelerate the delivery, and reduce the cost of commercial-like construction projects. For example, in fiscal year 2019 NNSA established the Enhanced Minor Construction & Commercial Standards (EMC2) pilot, which is challenging the paradigm for how NNSA executes low-risk, non-complex construction projects to accel-

erate delivery and reduce costs. There are 10 projects in the pilot, including the Lawrence Livermore National Laboratory's Emergency Operations Center (EOC) which is the first pilot project to be completed earlier this year. Using the EMC2 approach, the Livermore EOC was completed 13 months after receiving full construction funding in January 2021. In the first four pilot projects currently underway, estimated cost savings range from approximately 12 to 31 percent. An additional six EMC2 projects are projected to result in estimated cost savings of 17 to 38 percent.

Stockpile Research, Technology and Engineering

For Stockpile Research, Technology, and Engineering, the fiscal year 2023 budget request is $2.89 billion, a decrease of $83 million, or 2.8 percent below the fiscal year 2022 enacted level. The decrease results from the use of carryover balances to continue construction of the U1a Complex Enhancement Project at the Nevada National Security Site (NNSS). After adjusting for this reduction, the Stockpile Research, Technology, and Engineering request is stable from fiscal year 2022 enacted.

This portfolio provides the scientific foundation for science-based stockpile activities, including the capabilities, tools, and components needed to assess the active stockpile and to certify warhead modernization programs without the need for underground nuclear testing. NNSA's unparalleled science and technical capabilities, and commitment to their constant improvement, helps cultivate the knowledge and expertise to maintain confidence in the stockpile. The major activities in the Stockpile Research, Technology, and Engineering portfolio are:

Enhanced Capabilities for Subcritical Experiments (ECSE): ECSE will produce experimental data in underground tunnels at the NNSS that will enable high fidelity assessment of the current stockpile and certification of the future stockpile without the need to return to underground nuclear-explosive testing. ECSE experiments are designed to remain subcritical throughout the experiment to adhere to the U.S. policy of "zero yield."

Stockpile Responsiveness Program (SRP): SRP is responsible for exercising and enhancing capabilities across the entire nuclear weapons development and production process to improve the responsiveness of the United States to future threats, technology trends, and international developments not addressed by existing life extension programs. For example, SRP is investing in efforts to address issues in design for manufacturability, digital engineering, component, and system prototyping and testing.

Inertial Confinement Fusion (ICF) Program: The ICF Program supports the assessment and certification of the nuclear weapon stockpile by providing the facilities, scientific expertise, and experimental capability necessary to acquire data at the extreme conditions of nuclear weapon operation. The ICF program also supports research on thermonuclear fusion with the goal of reaching fusion ignition and eventually high fusion yield in the laboratory. The fiscal year 2023 request supports ICF research and facilities, enabling access to experimental data that underpin the safety, security, and effectiveness of the nuclear stockpile and continued progress toward the capabilities necessary to meet long-term stewardship needs.

NNSA Exascale Computing Initiative: The Exascale Computing Initiative (ECI) will provide NNSA with next-generation simulation capabilities to support weapons design, science-based stockpile stewardship, and stockpile certification activities. The fiscal year 2023 budget request will continue funding maturation of next-generation simulation and computing technologies and enables NNSA to meet its exascale system initial operation capability in fiscal year 2023, including transition of the next-generation, validated weapons codes to next-generation classified computing.

Academic Programs: The challenges of sustaining the nuclear deterrent long-term demand a strong and diverse base of national expertise and educational opportunities in specialized technical areas that uniquely contribute to stockpile stewardship. NNSA's Academic Programs are designed to cultivate, attract, and retain such a workforce. Funding in this area supports the Administration's Executive Order on Advancing Racial Equity and Support for Underserved Communities through the Federal Government, Academic Alliances and existing partnerships with Minority Serving Institutions, and an increase in student engagement and internship opportunities.

Secure Transportation Asset

Secure Transportation Asset (STA) supports the safe, secure transport of the Nation's nuclear weapons, weapon components, and special nuclear material throughout the nuclear security enterprise to meet nuclear security requirements. Nuclear weapon life extension programs, limited-life component exchanges, surveillance, dis-

mantlement, nonproliferation activities, and experimental programs rely on STA to ensure safe, secure, and on-schedule transport. The fiscal year 2023 budget request for STA is $344 million, an increase of $13.7 million, or 4.1 percent, above the fiscal year 2022 enacted amount to increase the Federal Agent workforce to a level necessary to keep pace with the growing program deliverables.

The Office of Secure Transportation's (OST) priorities for fiscal year 2023 include modernization and sustainment of transportation assets. This includes the Safeguards Transporter (SGT) life extension program to secure its service until replacement by the Mobile Guardian Transporter (MGT), as well as the entry into service of procured 737–700 aircraft. The first MGT Production Unit is planned for completion in fiscal year 2026 and initial rate production is set to commence in fiscal year 2027. Currently, aircraft are undergoing heavy maintenance checks, painting to NNSA standards, and a major modification from a passenger jet to a FlexCombi that is configurable to carry various loads of personnel and cargo.

OST also remains focused on recruiting, stabilizing, training, and retaining the Federal Agent and staff workforce necessary to support mission requirements. OST has committed to a stable human resources strategy to achieve an optimal agent force. OST has increased staffing numbers by optimizing position qualifications and managing risk associated with the Human Reliability Program. Although COVID–19 impacted key milestones and deliverables, OST successfully accomplished every assigned mission for the previous year.

Defense Nuclear Security

Defense Nuclear Security's fiscal year 2023 budget request is $882.3 million, an increase of $38.2 million, or 4.5 percent over the fiscal year 2022 enacted level. The Office of Defense Nuclear Security's (DNS) primary mission is protecting the facilities, people, and assets critical to achieving NNSA's important national security missions. The need for increasing security due to growth across enterprise from projects such as LAP4 and UPF, along with additional resources required to sustain core security, has resulted in increased program requirements for DNS. Support for the request is vital for the protection of the enterprise, its people, and its sensitive material and information. DNS remains focused on improving physical security infrastructure with several new projects and the development and deployment of new systems. Progress is also being made in countering unmanned aircraft systems. The first such platform was deployed at LANL in December 2017. Deployment at other facilities is expected to be completed in late fiscal year 2022.

Cybersecurity and Emerging Issues

The fiscal year 2023 budget request for information technology and cybersecurity is $445.7 million, $39.1 million, or 9.6 percent, over the fiscal year 2022 enacted amount. This request funds ongoing operations and invests in improvements across NNSA to modernize both classified and unclassified systems, improves information management and data governance, implements critical aspects of a zero-trust architecture in our networks and systems, and allows for the execution of a robust cybersecurity program. As an example, NNSA recently recapitalized its deployed cyber sensor platform, significantly improving the ability to detect and respond to malicious activity.

Maintaining a strong cybersecurity program is a critical defense mechanism and a powerful deterrence tool. To strengthen oversight of the cyber program, the budget request includes a recategorization of certain Cybersecurity program investments into the Information Technology program. As a result, the request more clearly reflects investments in cybersecurity tools and services provided to the enterprise, maintains core cyber operations at the labs, plants, and sites, and improves management and transparency of these funds.

NNSA also recently completed an enterprise-wide cybersecurity assessment, in conjunction with the Institute for Defense Analyses, aimed at evaluating the overall cybersecurity posture and developing a set of recommendations to improve the program. That review calls for increased investment in information technology and cyber infrastructure to better meet current and emerging challenges, as well as outlines strategies related to workforce development issues. NNSA has already started acting on the findings and will continue to do so with the fiscal year 2023 requested budget.

DEFENSE NUCLEAR NONPROLIFERATION APPROPRIATION

The fiscal year 2023 budget request for the Defense Nuclear Nonproliferation account is $2.3 billion, an increase of $274 million, or 13.2 percent, over the fiscal year 2022 enacted level. When the use of prior year balances is considered, the proposed funding level for the account increases by $397 million, or 19.2 percent. The use of

prior year balances will allow DNN programs to supplement new budget authority across its programs.

This account funds all activities in the offices of Defense Nuclear Nonproliferation, Emergency Operations, and Counterterrorism and Counterproliferation. Within these offices, this appropriation funds six nonproliferation programs, a counterterrorism and counterproliferation program, and an incident response program as part of a whole-of-government approach. Together these efforts provide policy and technical leadership to prevent or limit the spread of weapons of mass destruction (WMD) and the related materials, technology, and expertise as well as to detect and respond to nuclear terrorism or proliferation events.

Nonproliferation Efforts

For decades, Defense Nuclear Nonproliferation (DNN) has developed and implemented policy and technical solutions to eliminate proliferation sensitive material and limit or prevent the spread of materials, technology, and expertise necessary for nuclear and radiological weapons. By working with governments, international organizations, and private sector partners around the world these efforts reduce the reliance on radioactive material in commercial and research industries; better secure nuclear and radioactive material; develop capabilities to interdict material outside of regulatory control; and maintain a robust response capability for nuclear and radiological incidents at home and abroad.

The fiscal year 2023 budget request will allow the Office of Defense Nuclear Nonproliferation to better confront current and anticipated proliferation challenges including the growing nuclear programs and strategic competition with Russia and China, the impacts of Russia's full-scale invasion of Ukraine, risks related to the North Korean and Iranian nuclear programs, and disruptive technologies that lower the barrier to proliferation. Through these efforts DNN aims to restore American leadership in nonproliferation solutions and cutting-edge technology required to address future threats.

The *Material Management and Minimization (M3)* program fiscal year 2023 budget request is $451 million, an increase of $108 million, or 31.5 percent, over the fiscal year 2022 enacted level. M3 programs reduce and, when possible, eliminate weapons-usable nuclear material around the world. The fiscal year 2023 budget request supports the conversion or shutdown of research reactors and isotope production facilities that use HEU, the use of non-HEU-based Mo-99 production, the removal and disposal of weapons-usable nuclear material, and the removal of plutonium from the state of South Carolina. Additionally, to date, nearly 7,270 kilograms of weapons-usable nuclear material from 48 countries and Taiwan have been removed or confirmed disposed, while 108 civilian research reactors and isotope production facilities have stopped using weapons-grade material in their work.

The *Global Material Security* program fiscal year 2023 budget request is $504 million, a decrease of $27.4 million, or 5.1 percent, below the fiscal year 2022 enacted level. The fiscal year 2023 request supports program efforts to prevent terrorists and other actors from obtaining nuclear and radioactive material for use in an improvised nuclear device by working with domestic and global partners. This includes improving the security of vulnerable materials and sites, promoting the adoption of alternative technologies that do not rely on radioactive sources, and increasing capacity to detect, disrupt and interdict illicit trafficking operations. Working through the RadSecure 100 Initiative, NNSA will accelerate and expand permanent risk reduction, security enhancements, and response integration with local law enforcement in the top 100 major metropolitan areas of the United States. To date, NNSA has replaced approximately 130 cesium-137 based blood irradiators with alternative technologies. The program remains on track to replace nearly all the estimated 400 such devices in the United States by 2027 as mandated in the fiscal year 2019 NDAA. In addition, NNSA is partnering with domestic advanced nuclear reactor vendors in 'security-by-design' activities to enhance the security of their systems for domestic and international use. Finally, NNSA continues to build additional partnerships with bilateral and multilateral partners focused on counter nuclear smuggling. To date, NNSA partners with 84 countries in this area and continues to expand cooperation with existing and new partners to expand global counter nuclear smuggling capabilities.

The *Nonproliferation and Arms Control (NPAC)* program fiscal year 2023 budget request is $208 million, an increase of $23 million, or 12.4 percent, above the fiscal year 2022 enacted level. The increased funding request supports two increasingly important activities: (1) policy and technology development activities for peaceful uses of nuclear energy along with support for the International Atomic Energy Agency (IAEA), and (2) policy and technology development for potential arms control

agreements that extend to new types of strategic weapons as well as tactical nuclear weapons.

By focusing on ensuring the peaceful use of nuclear energy, NPAC programs strengthen nonproliferation regimes through the development and implementation of effective technologies and policies. This is especially important as nuclear energy programs expand internationally in response to clean energy implementation to address climate change. New nuclear safeguards and monitoring and verification technologies are needed to secure materials and to detect proliferation activities early. NPAC works to mature technologies and transfer them to the International Atomic Energy Agency and partner countries to implement. The U.S. also supplies IAEA with U.S. subject matter experts, training, and equipment advice and procurement aid. In fiscal year 2022 and fiscal year 2023 NPAC is helping establish the nonproliferation enrichment testing and training platform. This platform will be turned over to the IAEA for commissioning and operation in fiscal year 2024. On the policy side, NPAC supports the development and implementation of Section 123 agreements and the careful regulation of nuclear technology exports utilizing Part 810 Authorizations.

Approximately $30 million funds increasing nuclear weapons verification activities. This will improve U.S. technical policy and readiness for future arms control agreements and associated verification technology. New investment in the Arms Control Advancement Initiative will strengthen NNSA's capacity to address future nuclear warhead monitoring and verification requirements through advanced technology development, robust modeling and measurements, and sustained expert engagement to maintain a pipeline of experts to helps advance arms control objectives over time.

The *Defense Nuclear Nonproliferation Research and Development (DNN R&D)* program fiscal year 2023 budget request is $720 million, a decrease of $9 million, or 1.2 percent, below the fiscal year 2022 enacted level. DNN R&D is the key component for the innovation of United States' technical capabilities to detect nuclear detonations; foreign nuclear weapons programs' activities; and the presence, movement, or diversion of special nuclear materials. The program also sustains and develops foundational nonproliferation technical competencies that ensure the technical agility needed to support a broad spectrum of U.S. nonproliferation missions and anticipate threats. Consistent with the growing nonproliferation challenges, this funding request for DNN R&D programs will expand activities that advance the development of next-generation nuclear arms control monitoring and verification technology and expertise symbiotic with the NPAC efforts.

The *Nonproliferation Construction* program fiscal year 2023 budget request is $72 million, a decrease of $84 million, or 54 percent, below the fiscal year 2022 enacted level. This decrease is due to the awarding of the long-lead procurement contracts for gloveboxes, emergency generators and HEPA filters under CD–3A Phase 2 in fiscal year 2022 and the expected fiscal year 2023 completion of design work for the Surplus Plutonium Disposition (SPD) project required for CD–2/3, Approval of Performance Baseline and Start of Construction. The fiscal year 2023 budget request supports the implementation of the dilute and dispose strategy, by continuing design for the SPD project. The SPD project will add additional glovebox capacity at the SRS to accelerate plutonium dilution and aid in the removal of plutonium from South Carolina.

NNSA is requesting the establishment of a *Bioassurance Program* in fiscal year 2023. The budget request is $20 million. As the COVID–19 pandemic has shown, the United States needs better capabilities to anticipate, respond to, and mitigate threats to the bioeconomy. NNSA proposes to establish a national security bioassurance program to perform activities to anticipate and detect threats and scale response solutions to support the security of the future bioeconomy and monitor and thwart malpractice in this area. This funding supports foundational work at DOE/NNSA laboratories including the anticipation of destabilizing threats through modeling, identifying threat signatures and developing detection technologies, and rapidly developing and validating safeguards and threat mitigation approaches. NNSA will integrate its high-security work with the Department's Office of Science supported "open" science work and other government agencies, providing the full spectrum of capabilities essential for a bioassurance program informed by national security expertise drawn from parallel and analogous work on nuclear threats, risks, export controls and licensing, nonproliferation, detection, and verification.

Nuclear Counterterrorism and Incident Response

The fiscal year 2023 request for the *Nuclear Counterterrorism and Incident Response (NCTIR)* program is $439 million, an increase of $68 million, or 18.4 percent, over the fiscal year 2022 enacted amount. The NCTIR program supports two subpro-

grams: Counterterrorism and Counterproliferation (CTCP) and Emergency Operations (EO).

CTCP is responsible for countering nuclear terrorism and nuclear proliferation, responding to nuclear incidents and accidents worldwide, advancing nuclear forensic capabilities, and building domestic and international partner capacity concerning emergency preparedness and response. CTCP's unique scientific and operational capabilities make it an integral part of the U.S. Government's layered defense against nuclear terrorism and nuclear proliferation.

CTCP manages the NEST, NNSA's multi-mission emergency response capability comprised of on-call technical specialists who are trained and equipped to respond to nuclear incidents and accidents worldwide. NEST's missions include both national security and public health and safety disciplines.

NNSA, in conjunction with the Federal Bureau of Investigation (FBI), supports regional counter-WMD teams in 14 major U.S. cities as part of the "Capability Forward" initiative. CTCP provides technology, equipment, and training in support of these teams to enhance regional capabilities to defeat nuclear and radiological devices, accelerating life-saving responses to a WMD event.

The fiscal year 2023 budget request addresses critical shortfalls in CTCP's capabilities to execute DOE's Primary Mission Essential Function (PMEF)-2, Respond to Nuclear Incidents. In coordination with interagency efforts to identify and address WMD response gaps, increased funding addresses staffing needs, ensures operational integration and full-spectrum training and exercises in accordance with interagency objectives, and supports technology development and infrastructure requirements.

Additional programmatic funding will also invest in new incident response expertise and technology; continue NEST equipment recapitalization efforts with planned procurement for replacement of diagnostic equipment and detection systems required for the public health and safety, counter-WMD, and nuclear weapon accident response mission areas; and bolster CTCP efforts to counter nuclear proliferation through applied analysis, concept development, predictive modeling, and testing.

CTCP also contributes to the interagency National Technical Nuclear Forensics mission, a central pillar of the U.S. strategy to deter hostile states from providing nuclear material to terrorists. CTCP's fiscal year 2023 budget request includes $43 million for this effort, including training and exercises for responders; procurement, maintenance, logistics, and technical integration of equipment; readiness to deploy pre- and post-detonation response and device assessment teams; and laboratory analysis of nuclear or radiological material.

EO provides both the structure and processes to ensure a comprehensive and integrated approach to all-hazards emergency management, thus improving readiness and effectiveness of the DOE Emergency Management System on a programmatic and performance level regardless of the nature of the emergency impacting the DOE/NNSA enterprise or its equities anywhere in the world. The fiscal year 2023 budget request supports Continuity of Operations, Continuity of Government, and Enduring Constitutional Government programs to advance the National Continuity Policy and ensure the continued performance and delivery of essential services under any circumstances. The fiscal year 2023 budget request also provides for 24/7/365 Consolidated Emergency Operations Center communications and coordination support to the DOE/NNSA Emergency Management Enterprise and Departmental Senior Leadership. The request also includes funding for investments in communications equipment and classified communications system improvements to support emergency operations and continuity infrastructure improvements.

NAVAL REACTORS APPROPRIATION

Advancing Naval Nuclear Propulsion

With over 40 percent of the Navy's major combatants being nuclear-powered, this technology remains critical to our national security posture. It provides the nation's submarines and aircraft carriers with unmatched mobility, flexibility, responsiveness, and endurance. The ability to maintain robust fleet capabilities on long-term missions is essential for the security of global trade and the security of our allies. The Office of Naval Reactors is the foundation of this national achievement in global security. Cutting edge advancements across all aspects of the Naval Nuclear Propulsion Program, from reactor plant development and design to the disposition of spent fuel, gives the U.S. Navy a decisive edge in naval warfare and enhances the security and reliability of the sea-leg of our nuclear triad.

The fiscal year 2023 budget request for Naval Reactors is $2.08 billion, an increase of $163 million, or 8.5 percent, above the fiscal year 2022 enacted level.[2] The budget request supports the continued safe and reliable operation of the nuclear-powered fleet, and it supports investment in technology development to deliver improvements in propulsion plant performance, manufacturability, and affordability—for current and future warships. Funding also supports requirements for the office's three major projects: *Columbia*-class ballistic missile submarine reactor systems development; construction of the Naval Spent Fuel Handling Facility in Idaho; and the refueling and overhaul of the S8G Prototype land-based reactor in New York for continued sailor training and technology testing.

Consistent, sustained funding is vital for the support of these projects and will allow Naval Reactors to meet current and future force needs. Close coordination with the Navy led to the start of construction of the *Columbia*-class lead ship in fiscal year 2021. The S8G Refueling Overhaul is expected to reach completion in fiscal year 2023. The Spent Fuel Handling Recapitalization project at the Naval Reactors Facility in Idaho is making significant progress with an estimated completion in fiscal year 2026.

AUKUS

On September 15, 2021, Australia, the UK, and the U.S. announced the creation of an enhanced trilateral security partnership (AUKUS), focused on peace and security in the Indo-Pacific region. The three governments are currently six months into an 18-month consultation period to establish the most efficient path forward for the delivery of a nuclear-powered, conventional, submarine capability to Australia as expeditiously as possible. As part of the international working group developing nonproliferation and safeguards aspects of the AUKUS program, NNSA will provide technical advice to the interagency and our AUKUS partners on the full suite of requirements that underpin nuclear stewardship to implement strong safeguards measures and achieve the AUKUS objectives.

This cooperation is fully consistent with our obligations under the Nuclear Nonproliferation Treaty (NPT). The NPT does not prohibit naval nuclear propulsion. In our role in this trilateral partnership, we intend to implement the strongest possible nonproliferation standards to maintain the strength and integrity of the nuclear nonproliferation regime. Australia is not seeking, and the U.S. and UK are not and will not assist in any acquisition of nuclear weapons. Additionally, Australia has committed not to enrich uranium or reprocess spent fuel in the context of AUKUS.

FEDERAL SALARIES AND EXPENSES APPROPRIATION

The fiscal year 2023 budget request for Federal Salaries and Expenses (FSE) is $496 million, an increase of $32 million, or 7 percent, above the fiscal year 2022 enacted level. The increase in this account will support an additional 132 Federal Full-time Equivalents (FTE) above the fiscal year 2022 enacted level, bringing the total to 1,958. FSE increases will also support increased space and occupancy needs, travel costs, support service contractors, training, and other related expenses.

The NNSA Federal workforce is critical to the success of the Nation's nuclear security enterprise. NNSA's expanding mission requirements and pressing modernization and recapitalization needs require recruiting, training, and retaining a skilled Federal workforce with the appropriate capabilities to meet mission requirements and deliver on our objectives. This workforce represents some of the top minds on nuclear issues, consisting of a diverse team of scientists, engineers, project and program managers, foreign affairs specialists, and support staff that perform program and project management and conduct appropriate oversight of national security missions. NNSA's Federal workforce is distributed across the enterprise and can be found in eight states and Washington, DC.

NNSA currently faces two significant hurdles in achieving full staffing: retirement and private sector competition. As of fiscal year 2021 17.3 percent of NNSA FTE Federal staff are eligible to retire, a number that is expected to rise to 35.4 percent by fiscal year 2027. Additionally, in fiscal year 2021 the annual FSE attrition rate was 10.7 percent, higher than the average attrition rate of 8.9 percent over the past 13 years. NNSA also faces competition from the private sector for top talent in technical fields.

Combating these trends requires an aggressive, external hiring strategy. NNSA has utilized a renewed focus on virtual recruitment events that support hiring across the nuclear security enterprise in support of all program areas. In October

[2] Funding does not reflect the mandated transfer of $92.75 million in fiscal year 2022 to the Office of Nuclear Energy for operation of the Advanced Test Reactor

2021, NNSA initiated a pilot program for expedited hiring within 15 business days, from the time the program office selected a candidate to the time Human Resources provided an entry on duty date. NNSA is applying lessons learned from this pilot program to continue progress on a streamlined hiring effort. Finally, NNSA has expanded the effort to enlarge fellowship program candidate pools and employ available alternative hiring authorities to compress the hiring timeline for qualified candidates and increase the overall hiring rate.

NNSA's recruitment and hiring efforts will support mission and growth requirements and will continue to support the Administration's goals of promoting racial and economic equity as a way to foster scientific breakthroughs, research and development excellence, and enhanced national security.

CONCLUSION

NNSA's enduring responsibility is providing the United States with a nuclear weapons stockpile and naval nuclear propulsion systems that are the best in the world while simultaneously promoting nonproliferation and counterterrorism efforts to reduce overall nuclear risk. The President's fiscal year 2023 budget, informed by the 2022 Nuclear Posture Review, supports our efforts to keep the nuclear deterrent and naval nuclear propulsion systems safe, secure, reliable, and militarily effective. Recognizing the increasingly volatile geopolitical environment, NNSA must also stay resolute in sustaining and evolving our nuclear security, non-proliferation, and counterterrorism efforts to help offset and stay ahead of nuclear risks.

NNSA has a unique responsibility to provide an effective nuclear deterrent in a timely manner to protect our Nation and our allies. The fiscal year 2023 budget request funds the five life extension and modernization programs that support all three legs of the triad. In fiscal year 2023 the requested budget also supports significant investments in new production facilities for uranium processing and plutonium pit manufacturing at the fastest responsible pace. The budget request contains close to equal funding for stockpile management and production modernization, a true indication of the intent to accelerate activities by working on weapon design and production in parallel with infrastructure revitalization. The science and engineering support for the weapons program stays strong to allow for the continued development of capabilities to design and certify the stockpile without testing and to stay ahead of threats.

The Defense Nuclear Nonproliferation budget request sustains our efforts to reduce nuclear risk by eliminating, minimizing, and securing nuclear and radiological materials. In addition, the DNN portfolio request recognizes the changing world by increasing support for policy and technology development aimed at the increased proliferation risks associated with the increase in nuclear energy around the world, preparing for an increasingly complex arms control and global stability environment, and by initiating a bioassurance program. Similarly, the increased budget request for the counterterrorism and counterproliferation program is responsive to the changing threat environment.

The Naval Reactors budget request recognizes the excellent stewardship provided over the years and continues to support the high priority needs to replace aging tools, build a new spent fuel handling facility, and support the *Columbia*-class production schedule.

The challenges NNSA faces ahead are steep and we are mindful of the resources entrusted to it. For fiscal year 2023, NNSA scrubbed prior year balances and used available funds to offset some of the increased budget needs. NNSA, in partnership with Congress and our colleagues in the Departments of Energy and Defense, is steadfast in our commitment to fulfill vital national security mission and deliver our goals. We greatly appreciate your support.

Senator KING. Thank you, Dr. Adams.

Admiral Wolfe, please.

STATEMENT OF VICE ADMIRAL JOHNNY R. WOLFE, JR., USN, DIRECTOR, NAVY STRATEGIC SYSTEMS PROGRAMS

Admiral WOLFE. Chairman King, Ranking Member Fischer, Distinguished Members of the Subcommittee, thank you for the opportunity to testify on the Department of the Navy's fiscal year 2023 budget priorities for nuclear forces. I respectfully request that my written statement be accepted for the record.

Senator KING. Without objection.

Admiral WOLFE. For over 6 decades, the Navy has provided unwavering support to the sea-based leg of the nuclear triad. Since I briefed this Committee last year, I would like to share with you some of SSP's accomplishments that build on this remarkable history.

In an effort to deliver a reliable and credible strategic weapon system to the fleet we have successfully completed a demonstration and shakedown operation onboard the USS *Wyoming,* certifying this *Ohio*-class submarine to return to alert patrol after a midlife refueling overhaul, demonstrating to the world the continued performance and reliability of this platform and the Trident II D5LE strategic weapon system.

In coordination with our partners at NNSA, the W93/Mk7 program continues, and the W88/Mk5 ALT370 program has achieved initial operating capability, further demonstrating our commitment to responsible stewardship of our nuclear stockpile. Although not nuclear but of particular interest to this Committee, I am incredibly proud of the milestones our hypersonics team, responsible for the Conventional Prompt Strike Program has achieved. These milestones include successful experiments to demonstrate the maturity of the common hypersonic glide-body technology; three static fire tests of the Navy-developed 34½-inch missile booster; and a successful sounding rocket campaign, demonstrating that our advanced communications capability is sufficiently mature to field our navy platforms.

The Navy continues to manage the Nuclear Strategic Weapons System across three main mission priorities: sustaining the current weapon system through *Ohio* end of life, developing the strategic weapon systems of the future for sea-based strategic deterrence on *Columbia* through 2084, and safeguarding our special relationship with the United Kingdom embodied in the Polaris Sales Agreement.

First and foremost, we must maintain the current D5LE missile inventory and provide the necessary operational support to sustain *Ohio*-class submarines and today's strategic weapon system through its end of life in the early 2040s. This is being accomplished through an update to all of our sub systems. All of our life extension efforts remain on track, and our current program will support the deployment of all existing warheads. We must recapitalize all of our supporting Navy nuclear deterrence mission infrastructure to support and sustain nuclear weapons and SSBN operations.

Secondly, we must continue to ensure the transition between *Ohio*-class and *Columbia*-class submarine stays on schedule. For SSP, this requires a seamless transition of the current D5LE weapon system and missile inventory onto the new *Columbia*-class.

We have already started the work on the next variant of Trident and its corresponding weapon system, D5LE2. D5LE2 will yield multiple benefits in missile performance while providing flexibility in the system to meet future warfighter requirements. To achieve these requirements, we must design, develop, produce, and test this next-generation Trident over the coming decade, with the first flight test in 2033.

Finally, one of the greatest advantages the United States has is its alliances and partnerships. As the U.S. Project Officer for the Polaris Sales Agreement, we will continue to support the UK's sovereign deterrent for today's *Vanguard*-class submarines and their successor, the *Dreadnought*-class. For decades U.S. policy has recognized that the independent British nuclear deterrent adds to NATO, and indeed global, stability.

Nuclear modernization will take time to complete, so sustained resourcing and enterprise effort is absolutely essential. It is only through your continued support that the Department's top modernization program priorities can be achieved and the Navy can deliver reliable sea-based strategic deterrence to 2084.

As the 14th director, it is my highest honor to represent the men and women of SSP. My number one priority is to assure that these men and women are poised to execute this mission with the same level of success, passion, and rigor as they have since our program was founded.

Thank you for the opportunity to testify today on behalf of the team that makes deterrence of major power conflict their life's work, and I look forward to your questions.

[The prepared statement of Admiral Wolfe follows:]

PREPARED STATEMENT BY VICE ADMIRAL JOHNNY WOLFE

INTRODUCTION

Chairman King, Ranking Member Fischer, and Distinguished Members of the Subcommittee, thank you for this opportunity to discuss the sustainment and recapitalization of the sea-based leg of the nuclear triad. It is an honor to represent the Navy's Strategic Systems Programs (SSP) and the contributions the Navy provides to our national and global security through Sea Based Strategic Deterrence.

As Admiral Richard, Commander, US Strategic Command, testified before this Committee just last month, "Every operational plan in the DOD, and every other capability we have rests on the assumption that strategic deterrence, and in particular nuclear deterrence, will hold. If strategic or nuclear deterrence fails, integrated deterrence and no other plan or capability in the DOD will work as designed. The Nation's nuclear forces underpin integrated deterrence and enable the U.S., our Allies and partners to prevent, and if necessary, confront aggression around the globe using all instruments of national power." Nuclear weapons remain the most powerful and destructive weapons known to humanity. As long as nuclear weapons exist, we have a special charge to be responsible custodians of our nuclear capabilities and work with a sense of urgency to create a security environment that would allow for their elimination. SSP takes this charge very seriously.

SSP's core mission comprises two fundamental lines of effort: the safety and security of our Nation's strategic assets entrusted to the Navy; and the design, development, production, and sustainment of the Navy's Strategic Weapons System (SWS). We strive to maintain a culture of excellence, underpinned by rigorous self-assessment, to achieve the highest standards of performance and integrity for personnel supporting the strategic deterrent mission. We focus unremittingly on our tremendous responsibility for the custody and accountability of our Nation's nuclear assets. The men and women of SSP, our sailors, our marines, our navy masters at arms, our coast guardsmen, and our industry partners remain dedicated to supporting the strategic deterrence mission, to responding to the emerging needs of our warfighter, and to protecting and safeguarding our Nation's assets with which we are entrusted. We certainly could not do this without the support from this Committee.

The Nation's nuclear triad consists of intercontinental ballistic missiles, heavy bombers, and ballistic missile submarines (SSBNs) equipped with submarine-launched ballistic missiles (SLBM). These platforms and their associated weapons systems are essential to the very foundation of our Nation's security and survival. The Administration's recently concluded Nuclear Posture Review affirms the following roles for nuclear weapons: deter against strategic attacks, assure allies and partners, and achieve U.S. objectives if deterrence fails. While the U.S. nuclear arsenal remains safe, secure and effective, most U.S. nuclear deterrent systems—includ-

ing the SSBN fleet—are operating beyond their original design life, increasing concerns about mission effectiveness, reliability and availability. Replacement programs are ongoing, but there is little or no margin between the end of useful life of existing programs and the fielding of their replacements.

The U.S. Navy provides the most survivable leg of the nuclear triad with the interdependent *Ohio*-class SSBNs and the *Trident II* D5 SWS. The SSBN fleet is responsible for more than 70 percent of the Nation's operationally deployed nuclear warheads that are subject to the New START Treaty. As the Navy carefully manages the approach to end of life of *Ohio*-class SSBNs, addressing the viability of the SWS throughout the life of the *Columbia*-class SSBNs remains a top priority. *Columbia*-class SSBNs will ensure the effectiveness and availability of the nation's Sea Based Strategic Deterrent through the 2080s. The currently deployed *Trident II* D5LE missiles will support initial load-outs on *Columbia,* but modernization of the D5LE SWS, via D5LE2, is required to support later *Columbia*-class missile inventory and seamlessly sustain USSTRATCOM requirements. D5LE2 will ensure the SWS will be flexible and adaptable in order to maintain demonstrated performance and survivability despite the dynamic threat environment.

As the fourteenth Director, it is my highest honor to serve as the program manager, technical authority, safety and security lead, regulatory lead, and U.S. Project Officer under the Polaris Sales Agreement (PSA) for the Naval Nuclear Weapons Program. Most importantly, I am honored to represent the men and women of SSP, comprising approximately 1,500 sailors, 1,000 marines, 300 coast guardsmen, 1,400 civilians, and thousands of contractor personnel. It is my most critical goal to ensure they are poised to execute the mission with the same level of success, passion, and rigor both today and tomorrow as they have since our program's inception in 1955.

SWS SUSTAINMENT ON *OHIO*-CLASS SSBN AND PROCUREMENT FOR *COLUMBIA*-CLASS SSBN

The fragile relationship between sustainment of our legacy systems and the development and production of their replacements is an ever-present factor in the calculus of effectively deterring adversaries. The Navy's highest priority acquisition program is the *Columbia*-class submarine. The *Ohio*-class SSBNs will begin decommissioning in the late 2020s, and the *Columbia*-class must be ready to begin patrols no later than early fiscal year 2031. Recapitalizing our SSBNs is a significant investment that only happens every other generation, making it critically important that we do it right and on time. Delays to the Navy's SSBN modernization plan are not an option. The continued assurance of our sea-based strategic deterrent requires not only a next class of ballistic missile submarines, but equally critical, a credible SWS—to include not just the weapon system itself, but the infrastructure and the people as well. The Navy is taking the necessary steps to ensure that the next generation deterrent is designed, built, delivered, and tested on time and provides flexibility and adaptability in a dynamic threat environment.

To lower development costs and leverage the proven reliability of the Trident II D5 SWS, the *Columbia*-class SSBN will enter service with the same functionality and performance of the currently deployed Trident II D5 SWS, including the life extended Trident II D5 missile, which resides on today's *Ohio*-class submarines. Maintaining a common SWS during the transition between existing and successor submarine platforms allows the Navy to leverage a mature material and knowledge enterprise, thus reducing programmatic costs and risks. Life extended missiles will be shared with both the *Ohio*- and *Columbia*-class submarines in the U.S. and, under the auspices of the PSA, with the United Kingdom (UK) *Vanguard*-class and *Dreadnought*-class submarines into the 2040s.

TRIDENT II D5 LIFE EXTENSION AND LIFE EXTENSION 2

The Trident II D5 SWS capability has been deployed on the *Ohio*-class ballistic missile submarines for nearly three decades and is planned to be deployed more than 55 years. This demand to maintain demonstrated high performance while extending the service life past initial design requirements required a missile life extension effort in order to support the *Ohio*-class submarine service life and, in concert with the Shipboard Modernization Program for shipboard systems, to serve as the initial SWS for the *Columbia*-class SSBN. The D5 Life Extension (D5LE) will ensure an effective and credible SWS on both the *Ohio*-class and *Columbia*-class SSBNs into the 2040s.

As the Navy carefully manages the approach to end of life of our *Ohio*-class SSBNs, we must address the viability of the SWS throughout the life of the *Columbia*-class SSBNs. A minimum of twelve *Columbia*-class SSBNs will replace today's 14 *Ohio* SSBNs and beginning in fiscal year 2030, D5LE missiles will support initial

load-outs on *Columbia* (Hulls 1–8). Production of additional D5LE missiles is not practical due to obsolete parts and the lack of a robust industrial base. The Trident II D5 Life Extension 2 (D5LE2) program is required to modernize the SWS to support *Columbia*-class missile inventory starting in fiscal year 2039 (targeting Initial Fleet Introduction—or, IFI—on *Columbia* Hull 9). It will be incorporated on all follow on Hulls as well as Hulls 1–8 during their Extended Refit Period from fiscal year 2039 to 2049 to continue to meet USSTRATCOM requirements. D5LE2 will ensure the weapon system maintains demonstrated performance and remains survivable while facing a dynamic threat environment driven by two near peer competitors until *Columbia* end of life.

D5LE2 is a hybrid of pull-through cost-effective technology (e.g., solid rocket motors, ignitors) and redesigned and updated components (e.g., avionics, guidance, system architecture). D5LE2 is structured to maintain today's unmatched reliability and demonstrated performance, while unlocking untapped system potential to efficiently respond to emerging needs and to maintain a credible Sea Based Strategic Deterrent.

As directed in the 2018 Nuclear Posture review, SSP executed system architecture studies in fiscal year 2020 to 2022 to evaluate solutions to problems associated with emerging threats, supportability, and adaptability required to address challenges in a dynamic threat environment. Additionally, activities focused on missile and guidance technology to determine the effective composition of redesign, remanufacture, and pull-through of highly reliable components. This ensures longer-lead, unique SLBM subsystems are mature for a Preliminary Design Review in fiscal year 2028, Critical Design Review in fiscal year 2032, first flight off a pad in fiscal year 2033, Low Rate Initial Production (LRIP) in fiscal year 2034 and flight testing off a manned platform in fiscal year 2036. fiscal year 2023 activities continue the refinement of systems studies and critical Missile and Guidance Technology work while beginning focused subsystem redesign and industrial base development activities for the D5LE2 program.

Unlike SLBM programs of the past, D5LE2 does not have the benefit of a healthy industrial base that comes from maintaining production and continuous development. These efforts will be critical to reconstituting the SLBM industrial base to restart production on critical components whose production lines were shut down over the last decade and to build a workforce to design and develop subsystems to meet unique nuclear weapons surety requirements. In short, full support of D5LE2 today is vital to achieving 2039 IFI and to embarking on a path that maintains an SLBM deterrent capability through the service life of the *Columbia*-class SSBN.

WARHEAD AND REENTRY BODY ACTIVITIES

The Navy is also working in partnership with the Department of Energy's National Nuclear Security Administration (NNSA) to refurbish our existing reentry systems and develop new reentry systems in response to USSTRATCOM requirements. As the threat environment the nuclear enterprise faces continues to evolve, it is critical that the Navy designs, develops, and deploys programs that meet the needs of the Warfighter. The Trident II D5 missile is capable of carrying two types of warhead families today, the W76 and the W88. The W93/Mk7 warhead will be designed for use on both the D5LE and D5LE2 missiles and, through the Polaris Sales Agreement and Mutual Defense Agreement, will support the United Kingdom's sovereign Replacement Warhead program. In 2019, NNSA completed the W76–1 Life Extension Program (W76–1/Mk4A), marking the U.S. stockpile's first full-scale warhead refurbishment program. The Navy continues to work on modernizing integrated aeroshells that house these warheads through the Mk4B program with the inclusion of a Shape Stable Nose Tip, which reduces reentry variability and improves performance margins.

The W88/Mk5 warhead continues to undergo its refurbishment program (ALT370) on a revised timeline based on capacitor component issues that did not meet reliability requirements. The Navy and NNSA coordinated on tightly coupled schedules for the fleet, the nuclear enterprise weapons complex, and production of affected non-nuclear components to execute an 18-month delay to the original schedule that was approved by the Nuclear Weapons Council (NWC). This program reached the First Production Unit milestone on schedule in 2021 and achieved Initial Operational Capability in January 2022. I am confident that our teams will continue to work together to manage and deliver this program, as we have historically addressed refurbishment challenges with a mission-focused attitude and rigor. The Navy will continue to prioritize meeting our Warfighters' requirements and minimizing disruption to the operational fleet to ensure that the sea-based leg of the triad continues to fulfill its deterrence mission. However, the setback this program

faced illustrates the need to support investments in our nuclear security enterprise and reduce the pervasive risk to our nuclear modernization programs.

In 2021, the Navy entered Phase 1 of the joint DOD—DOE Nuclear Weapons Lifecycle Process with NNSA for the W93/Mk7. This effort will address evolving ballistic missile warhead modernization requirements; improve operational effectiveness for USSTRATCOM; and mitigate technical, operational, and programmatic risk in the sea-based leg of the nuclear triad while simultaneously reinvigorating the atrophied industrial base and modernizing a Cold War era stockpile. W93/Mk7 will provide flexibility and adaptability to meet future warfighter needs. With the near simultaneous age out of the deployed stockpile in the 2040s, the W93/Mk7 will help address production concerns in the weapons complex and ensure an uninterrupted at-sea deterrent for the sea-based leg of the nuclear triad. In fiscal year 2022, the W93/Mk7 program received NWC authorization to proceed into Phase 2, Feasibility Study and Design Options, which will further refine and mature the design of the W93/Mk7 program in a manner that provides an affordable, credible, safe, and secure weapon to the Warfighter. Even with the addition of the W93/Mk7 to the stockpile, we will not increase the deployed stockpile. The Navy will work in close coordination with the Department of Defense, NNSA, the NWC, and the Congress as this effort matures, but we cannot continue to life extend our leftover Cold War era weapons and systems and successfully carry out our national strategy.

INDUSTRIAL BASE AND INFRASTRUCTURE

To borrow again from Admiral Richard's remarks, "maintaining and strengthening deterrence for the long term requires a modern infrastructure and industrial base able to develop credible capabilities necessary for a more challenging security environment." The Nation requires a fully modernized nuclear force and supporting infrastructure to execute our national strategy. Our modernization needs cannot succeed without investing in the research and development (R&D), critical skills, and facilities needed to produce, sustain, and certify our nuclear systems. Ensuring robust defense and aerospace industrial base capabilities—such as radiation-hardened electronics, strategic inertial instrumentation, and solid rocket motors—remains an important priority in conjunction with R&D investment. SSP has placed particular emphasis on the solid rocket motor industry and its sub-tier suppliers and appreciates the support of the Congress to allow for the continuous production of these vital components. Essential to the nuclear deterrent is a national aeroshell production capability. The Navy has not delivered an integrated aeroshell since the 1980s and needs to reinvigorate a production capability that only resides in a small cadre of highly skilled experts in an exceptionally niche industry. Aeroshell investment supports the Navy but will also be cost-effectively leveraged by our colleagues in the Air Force—and also our strategic partners in the United Kingdom as they pursue their independent reentry program endeavors. Finally, R&D investment is critical to today's nuclear modernization needs to ensure that we advance necessary technology ahead of design needs and to train our workforce during the early years of development. If the Nation does not continue to address these concerns, no amount of money will be able to adequately mitigate the risks associated with key stockpile and infrastructure losses.

From an infrastructure perspective, our program is entering unprecedented times. Existing facilities are reaching their 30-year recapitalization windows while we simultaneously face weapons systems modernization periods in order to meet future requirements. Investing in facility sustainment and modernization is required for cradle-to-grave operations. Appropriate Military Construction (MILCON) and Facility Sustainment, Restoration, and Modernization (FSRM) resourcing is critical to the Navy maintaining a credible deterrence posture to include providing more than 70 percent of the Nation's operationally deployed nuclear warheads. We will make smart investments to address through-put constraints and build in surge capacity to address requirements presented by new and emerging threats. The Navy relies on a limited footprint to process missiles and outfit the SSBNs. Maintaining and sustaining facilities is critical to meeting USSTRATCOM and Fleet mission requirements. Our nation, and the Navy, will continue to prioritize and resource the sustainment and modernization of its nuclear infrastructure enterprise to provide an effective and flexible deterrent now and into the future.

As the Navy executes the modernization and replacement of the SSBN and associated SLBM leg of the nuclear triad, DOD and NNSA's infrastructure must be prepared to respond in tandem to the evolving needs of the Nation. Of most importance, we must have an effective, resilient, and responsive plutonium pit production capability. This capability can address age-related risks, support planned refurbishments, as well as prepare for future uncertainty. Additionally, tritium, lithium, and

uranium, and high explosives and energetics, among other strategic materials, are vital to ensuring the Navy can continue to meet its strategic deterrent requirements. Efforts to sustain and modernize deterrent forces must continue. Our strategic forces underpin every military operation around the world, and we cannot afford to delay given the increasing threats facing our nation.

WORKFORCE

History reminds us that the swift, successful creation and execution of the Fleet Ballistic Missile program in the 1950s was truly a result of national commitment, congressional support, and a cadre of hand-selected scientists, engineers, and inspirational leaders. Though process will always underpin our efforts, our dedicated predecessors—civilians, military, and industry partners alike—responded to the national need with focused determination and drove this program with a vision. People are as fundamental to our nuclear deterrent as the SWS itself. Today, SSP and its industry partners are focused on inspiring, growing, and retaining a generation of workforce that did not live through the darkest days of the Cold War. Connecting a new workforce to this fundamental global security mission remains an important task shared among the entire nuclear enterprise. A capable, credible, and affordable strategic deterrent for our Nation for the next 60 years requires not only technical, policy, management, and financial acumen—it requires passion and a commitment to making this our life's work.

SSP has made significant strides in recent years to honor our past, innovate our present, and ensure our future workforce is connected to the fundamental global security mission. In order to create the ideal workforce and workplace, SSP developed the SSP Human Capital Operating Plan (HCOP) in fiscal year 2019. The HCOP is a five-year plan aligning human capital initiatives to SSP's strategic goals. SSP is now in the fourth year of the HCOP execution and is realizing valuable change from these efforts. The five goals and associated successes are outlined below.

Goal 1—Recruitment and Retention: create and implement effective strategies to recruit and retain highly qualified candidates and employees, internal and external, sufficient to ensure that SSP fulfills its mission requirements. Accomplishments toward this end include: developing a comprehensive Talent Pipeline Strategy; Standardizing SSP-enterprise Exit & Stay Interview processes; Established HR Data Analytics position and integrated efforts across HR functions;

Goal 2—Talent Development and Sustainment: support, develop, and strengthen the workforce to continually evolve and successfully execute the mission. Accomplishments toward this end include: developing Science & Technology Subject Matter Expert (S&T SME) career tracks; conducting a staffing study to assess current and future competencies and capacities; implementing robust mentorship programs; Established Career Development Counseling Program; and Developing an SSP Academy.

Goal 3—Leadership Development: strengthen enterprise leadership at all levels through robust leadership development programs and clear assignment and execution of authority, accountability, and responsibility. Accomplishments toward this end include: Implementing robust coaching programs for leaders and developmental employees; delivering supervisory training for hybrid work environments; continuously promoting internal leadership programs; and Developing an HR Management for Supervisors course

Goal 4—Culture: clearly define and communicate SSP culture and values. Reinforce and assess the organizational culture as necessary for continuous improvement at every level. Accomplishments toward this end include: Developing an improved employee recognition and awards process; delivering on-going health and wellness activities; establishing a 'We Heard You' campaign to communicate SSP's responses to feedback; defining SSP Culture and Values (Director's Intent) and developing SSP Culture Videos.

Goal 5—Diversity and Inclusion: create and implement effective strategies to cultivate a diverse and inclusive work environment that promotes employee engagement and the exchange of different ideas, philosophies, and perspectives. Accomplishments toward this end include: Conducting barrier analysis; establishing Diversity and Inclusion Council; increasing use of Individuals with Disabilities Recruitment Program; and connecting a Leadership Learning Series with Special Emphasis Program.

POLARIS SALES AGREEMENT: SUPPORT TO THE UK

Development of the future SWS not only addresses known U.S. risks, it also supports the UK's critical need to recapitalize its deterrent and, given the UK deterrent's contribution and commitment to NATO, this recapitalization is essential to

our NATO partners' overall defense posture. A critical component of the *Columbia*-class Program is the procurement of a Common Missile Compartment (CMC) with the UK under the auspices of the Polaris Sales Agreement. Our partnership with the UK supports production of the CMC in both U.S. and UK build yards. Ensuring that the *Columbia*-class program remains on schedule supports not only our Nation's operational requirements, but also the ability of the UK, one of our most important allies, to maintain its Continuous-at-Sea Deterrent. Similar to the U.S. Navy, the Royal Navy is recapitalizing its four aging *Vanguard*-class ballistic missile submarines (SSBNs) with the *Dreadnought*-class SSBN. The CMC will support today's Trident II D5 SWS, which the U.S. Navy sells to the Royal Navy for deployment aboard its *Vanguard*-class SSBNs, and that will be deployed as the initial loadout on both *Columbia* and the UK *Dreadnought*-class SSBNs. For decades, U.S. policy has recognized that the independent UK nuclear deterrent adds to joint efforts to deter aggression and attack against NATO and thereby positively contributes to global stability. Under the 1958 Mutual Defense Agreement and the 1963 Polaris Sales Agreement, the United States Navy has provided decades of support and material, consistent with international law, to the UK deterrent program. Without this assistance, the cost and schedule risk to maintain the UK's independent deterrent would rise significantly, thus creating additional challenges for the UK in sustaining its nuclear contribution to NATO alongside the United States.

CONCLUSION

Our Nation's sea-based strategic deterrent has been a critical component of our national security since the 1950s and must continue to assure our allies and partners and to deter potential adversaries well into the future. SSP ensures a safe, secure, effective, flexible, and tailorable strategic deterrent, with a steadfast focus on the proper stewardship, custody, and accountability of the nuclear assets entrusted to the Navy. Sustaining and modernizing the sea-based strategic deterrent capability is a vital national security requirement. I am privileged to represent this unique organization as we work to serve the best interests of our great Nation. I thank the Committee for the opportunity to speak with you about the sea-based leg of the nuclear triad and the vital role it plays in our national and global security.

Senator KING. Thank you, Admiral. General Cotton?

STATEMENT OF GENERAL ANTHONY J. COTTON, USAF, COMMANDER, AIR FORCE GLOBAL STRIKE COMMAND

General COTTON. Good afternoon, Chairman King, Ranking Member Fischer, and Distinguished Committee Members. Thank you for the opportunity to be here today and represent the 32,000 men and women of Air Force Global Strike Command.

I would like to express our gratitude for your incredible support as we modernize the ICBM [intercontinental ballistic missile] and bomber legs of the nuclear triad and remain on pace and on time with all of our efforts. As a force provider of strategic and long-range strike, I am proud of the excellence and efforts of our personnel as we deliver safe, secure, reliable nuclear deterrence to this nation.

Today's global environment does not allow for a diminished strategic deterrence. China has modernized at breathtaking speeds, and we expect them to have over 1,000 nuclear warheads by 2030, nested within a modern triad. As the Commander of STRATCOM has asserted, they have achieved strategic breakout. Meanwhile, Russia has recapitalized over 80 percent of their nuclear forces and are developing new weapons capabilities as we speak.

While near-peer competitors garner significant attention, we must not lose sight of the actions of other potential adversaries. North Korea continues to conduct missile tests, invest in hypersonic glide vehicle technologies, manufacture physical materials, and operate a sophisticated cyberattack capability as they maintain the requisite infrastructure to conduct nuclear weapons

testing. Make no mistake: we are locked in an age of long-term strategic competition, informed now by two nuclear-capable peers and the advent of non-nuclear strategic weapon systems.

Throughout all of this, our strategic deterrence continues to hold, as the cornerstone of national security. As the air and leg force provider to STRATCOM, I am constantly balancing the sustainment of legacy equipment with the acquisition of new weapon systems, ensuring deterrence remains credible throughout modernization. To maintain this balance as we build an enduring deterrent for decades to come, we rely upon many partnerships inside and outside the Department of Defense, including our partners in the Department of Energy, the National Nuclear Security Administration, and the Department of Navy.

I must always be ready to present credible and viable forces, and for this reason we maintain constant readiness 24 hours a day. From our missile crews on alert and our bomber crews accomplishing global bomber task force missions, we remain ready to hold our nation's adversaries at bay.

To guarantee continued deterrence into the future, it is imperative that we remain on schedule as we bring new weapon systems online within the triad. I am happy to share we continue to make tremendous progress across our portfolios. We are moving forward from legacy sustainment to modernization and further into operationalizing our new systems.

The scope and scale of this modernization effort cannot be overstated. We must be diligent to remain on track as we evolve through all these phases. Any schedule or cost delays would have a cascading effect on the entirety of our modernization efforts and, in turn, on the credibility of our deterrence force.

I know you understand the historic situation we find ourselves in as we modernize this nation's nuclear triad, and I am confident for the future, as long as we continue to receive the support and funding necessary to remain on schedule. We have a strong foundation of dedicated people, we have thorough and deliberate plans in place, and we have the systems and development necessary to safeguard our Nation for years to come.

We are grateful for our partnership with Congress and especially for the continual support of the defense Committees. Air Force Global Strike Command remains committed to sustaining our bombers and ICBM forces as we bring Sentinel and a B–21 Raider online.

We also remain focused in investing and developing the people of our force with great care, to the enduring legacy of our mission. Our heritage inspires us into the way forward, and we will always be ready to provide convention or nuclear strategic long-range strike anytime, anywhere.

I look forward to your questions. Thank you very much.

[The prepared statement of General Cotton follows:]

JOINT PREPARED STATEMENT BY GENERAL ANTHONY J. COTTON

INTRODUCTION

Chairman King, Ranking Member Fischer, and Distinguished Members of the Subcommittee, thank you for this opportunity to discuss the sustainment and modernization of the air and land-based legs of the nuclear triad. It is an honor to rep-

resent the Air Force Global Strike Command (AFGSC) and the contributions the Air Force delivers to our national and global security through Air and Land Based Strategic Deterrence.

On behalf of the 32,000 men and women of AFGSC, I would like to offer my sincere thanks to Congress for your longstanding support and commitment to ensuring our total force service s have the resources needed to provide credible deterrence and ultimately defend the Nation. I would also like to take the opportunity to commend our airmen, known as strikers, who have persevered with professionalism and dedication during a global pandemic and shifting geopolitical landscape. Our command's Strikers, including our civilian workforce and total force personnel, are always ready to respond while ensuring the cornerstone of our national security remains safe, secure, and reliable.

Strategic security is rapidly evolving and increasing in complexity across the geopolitical landscape. Our nation's reality now includes potentially facing two nuclear peers in the coming years. We must continue to posture our strategic capabilities for the dynamic challenges we face today and in the years to come. China has accelerated its military growth and is rapidly expanding its nuclear capabilities. Simultaneously, Russia has spent the last 14 years recapitalizing its nuclear forces and continues to invest in new technologies. In this context, maintaining a safe, secure and reliable nuclear posture continues to be of paramount importance to the Nation and AFGSC.

As Commander of AFGSC, my four lines of effort focus on our people, our mission, modernizing our force and proactive engagement. These four areas are essential as we transition into an era of great power competition. We move firmly into the future by developing and equipping them to execute the mission even in ambiguity. We must provide them with the weapon systems needed to compete in this era and the communities necessary to support them and their families. This will include increasing the quality of life of our personnel. We must build relationships with leaders and policymakers across local, State and international communities to do this.

THREATS

The current global context is dynamic and unprecedented, marked by the reemergence of long-term strategic competition with Russia and now China. Both possess capabilities and intent to advance their interests at the expense of the U.S. and our allies. AFGSC remains committed to providing a safe, secure and reliable deterrent even as our Nation faces challenges in a multipolar world. China continues rapid nuclear expansion as it constructs hundreds of intercontinental ballistic missile silos, operationalizes a nuclear bomber, and fields a third generation SSBN fleet. In addition to this, China is also developing fractional-orbit bombardment systems and long-range anti-aircraft missiles demonstrating increasing strategic conventional capabilities.

Russia similarly continues provocations, including the development of anti-satellite weapons, hypersonic technologies, and malign cyberspace activities. Russia conducted a reckless and irresponsible direct-ascent anti-satellite missile test on 15 November 2021.Russia has also violated international rules and norms with their recent invasion of Ukraine, and its willingness and capacity to conduct offensive malicious cyber activities threatening the networks of U.S., ally and partner nations. Furthermore, Russia possesses approximately 2,000 non-strategic nuclear weapons, which are not covered or limited by New START, and cites U.S. withdrawal from the Anti-Ballistic Missile Treaty among its supposed justifications for developing five new nuclear weapon delivery capabilities, including two unique hypersonic weapons. AFGSC will not waver in our focused contributions to integrated deterrence, ensuring two-thirds of the triad continues to underpin the capabilities our Nation brings to bear.

PEOPLE

Our Strikers are the foundation of AFGSC and our greatest asset. The core of our competitive advantage will always come from our people. We have several ongoing initiatives that safeguard our airmen and their families to help build community and support resiliency. Furthermore, AFGSC has implemented several initiatives to help attract, recruit, develop, and retain a high-performing and diverse force. Our installation-level Pathways to Inclusion Councils have collaborated with local communities to bring resources to our Strikers. These resources, combined with our diversity, equity, inclusion, and accessibility programs, buildupon and create initiatives that bolster opportunity for everyone. For example, Ellsworth AFB improved accommodations for those with physical disabilities, increasing employment and installation access opportunities. The Kirtland AFB Sexual Assault Prevention and

Response (SAPR) and the Violence Prevention Integrator established a Violence Prevention Board tasked with educational oversight and victim advocacy. Another initiative within the command nominates and trains individuals as "Mental Health Heroes" for the base community charged with reducing mental health stigmas and encouraging help-seeking behaviors within organizations.

We have many quality of life initiatives across the Command, ranging from childcare to education. We share the Department of the Air Force's commitment for quality and affordable childcare. Even as we face challenges of availability, staffing, and capacity, we are taking measures to improve access to childcare for our airmen and their families. We continue to explore expanding capacity through alternative means, including the Family Child Care program, which provides greater flexibility in scheduling childcare for military families. We also seek to provide additional educational opportunities for our personnel throughout their career. Our School Liaison Program continues to work with community stakeholders to increase awareness and support initiatives for military families in their communities. Through Education Community Partnerships, AFGSC installations are improving educational support programs by leveraging the installation resources at local schools. Engagement with State officials and community stakeholders has resulted in positive legislative outcomes in education for military families including:

- Advanced enrollment and registration,
- Homeschool student participation in public school activities and athletics,
- Post-secondary in-State tuition rates approved for military member and dependents, and
- Purple Star Programs recognizing military-friendly schools.

To ensure we remain the world's premier long-range precision strike team, we continue to provide professional strategic deterrence education, leadership training, and opportunities to produce well-prepared and critical thinking leaders at every level. The Command works with academic and industry partners to buildupon the leadership education efforts of the broader Air Force. The Command's Senior Leaders Course, in partnership with the Air University Leadership Development Course Command Module, prepares incoming squadron command teams for the challenges of command and further develops them into successful Air Force leaders. Our Senior Leader Development Program targets commanders and senior headquarters' staff by providing them with an understanding of successful leadership traits and equipping them with the tools to improve their personal leadership skills.

Our leadership development efforts reach airmen of all experience levels as we provide several major programs and initiatives that provide airmen the opportunity for continued development and growth in Nuclear Deterrence Education and Nuclear Command, Control and Communications (NC3). For those who require a first nuclear deterrence education "touchpoint," our Strategic Deterrence Basic Course and our Nuclear 150 Course orient personnel with little or no experience with the nuclear deterrence mission.

We have also developed a congruent NC3 150 course designed specifically to educate our airmen with little to no exposure to the NC3 mission. We provide Nuclear and NC3 200, 300, and 400 level courses for our mid-range and more advanced airmen. The Air Force Institute of Technology's Strategic Force College at Kirtland AFB and Barksdale AFB host these courses, providing our Strikers progressive educational experiences supporting the Air Force's nuclear deterrence and NC3 missions. We have graduated over 3,000 students from Nuclear and NC3 Courses, and over 2,500 students from the Strategic Deterrence Basic Course.

Our command deliberately develops airmen through the internship programs known as Striker Pathfinder, Striker Titan, Striker Trailblazer and Striker Airman Coders. Striker Pathfinder provides officers an in-depth view of strategic studies from various academic institutions such as Harvard University, Missouri State University, AFIT and more. This program exposes officers to a wide variety of staff functions and provides unique developmental opportunities at National Labs, units across the USAF and USN, and the National Capital Region for exposure to strategic level and national leadership, academic forums, and allied foreign nations for exposure to the broader implications of the AFGSC mission.

Striker Titan is an enlisted professional development program allowing NCOs to see a broad perspective of the Air Force's long-range precision nuclear and conventional strike capabilities, how other agencies integrate into the mission, and strategic/nuclear educational opportunities. Titans receive leadership development and mentorship through assigned Chief Master Sergeant mentors at their bases and regularly interface with the Command Chief. They receive similar exposure as Striker Pathfinder, traveling widely and seeing firsthand the scope of the nuclear enterprise.

Striker Trailblazer provides civilian members with a 1-year deliberate developmental opportunity consisting of strategic deterrence, leadership education, professional development, and experiential TDYs. The Trailblazers remain assigned to their current duty location, and receive developmental education accomplished through periodic learning opportunities every 5 weeks. At the end of the program, Striker Trailblazers gain a solid foundation and understanding of the nuclear enterprise, ultimately promoting effective advocacy for the Air Force Nuclear Enterprise.

We formed Striker Airmen Coders to recognize the innovation of our airmen and provide them with opportunities to gain state-of-the-art technical skills in areas such as software coding, data analytics, and artificial intelligence through the online Air Force Digital University. Last, we have collaborated with the United States Navy (USN) to form the Striker Trident Exchange program, targeting nuclear operators at the O–3 level. The program aims to provide a greater breadth and depth of experience for future planners and leaders in the nuclear deterrence mission. These rigorous programs allow our interns to gain a broad perspective on senior leader decisionmaking and provide them the opportunity to accomplish developmental and experiential education.

Fostering a culture of diversity, equity, inclusion and accessibility for all Strikers ensures we retain the best, brightest, and most talented airmen. We are on the right path moving forward, but we know there is always more work to do. In 2021, AFGSC secured training resources for diversity and inclusion through numerous universities and forums. In addition, we instituted Barrier Analysis Working Groups (BAWGs) to identify and eliminate existing barriers and to create opportunities within the civilian and military workforce regardless of race, ethnic background, gender and disabilities.

The Command has taken the negative impacts of the COVID–19 pandemic and molded them into positive outcomes. Our Strikers are innovative and found ways to ensure our mission continued seamlessly in the face of challenges. The Missile Wings adopted a squadron deployment construct where each missile squadron deploys to the field 1 week at a time. When COVID–19 prevented travel, our team stood up a Mobile Training Team to conduct and complete annual assessments. Resiliency within our Wings remains a focus as we navigate our return to normalcy following COVID. However, we must ensure we introduce and integrate airmen assessed during the pandemic to pre-COVID in-person processes. We will continue leveraging technology to ensure mission accomplishment as we transition from remote work to increasingly in-person operations. Our Strikers have revised how we operate as needed to ensure we emerged from this pandemic more flexible and adaptable than before.

MISSION

Most AFGSC Strikers serve within two numbered Air Forces, 8th AF and 20th AF. The 8th houses our bomber aircraft, and the 20th AF is the home of our Minuteman III ICBM forces, including the future Sentinel community. Both numbered Air Forces also have the all-important support aspects that keep our missions running smoothly. The Strikers of 20th Air Force continue to operate and maintain the Minuteman III and defend the nation—providing strategic deterrence and standing ready to respond at a moment's notice. For more than 50 years, the Minuteman III has been on nuclear alert 24 hours a day, 7 days a week, and 365 days a year. Strikers met the evolving challenges of the COVID–19 pandemic head-on and maintained the highest readiness levels across the entire Department of Defense (DOD). Minuteman III maintainers keep this aging weapon system on 24/7 alert, performing 599 major maintenance actions, covering 17.2-million miles traveled across gravel roads and interstates in Montana, North Dakota, Colorado, Nebraska and Wyoming.

Defenders and helicopter aircrew continue to secure the weapon system across an Area of Responsibility geographically larger than South Carolina. In coordination with our teammates at the Department of Energy and the numerous local law enforcement agencies, our airmen conducted 292 safe, secure, and effective weapons convoys. Additionally, the 576th Flight Test Squadron conducted nine operational tests on the Minuteman III weapon system in 2021, including two operational test launches from Vandenberg Space Force Base. Every minute of every day, the men and women of 20th AF keep watch over the United States, ensuring we are always ready to defend the Nation and our allies.

Current operations in 8th Air Force are equally high-paced. In 2021, AFGSC bombers successfully executed ten deployments, 18 CONUS-to-CONUS missions, and seven cross-combatant command missions. We accomplished this in concert with the divestiture of 17 B–1Bs and the maintenance stand-downs of B–1 and B–2 plat-

forms in the summer and fall of 2021. Missions were flown during all 12 months, and our bombers integrated with 29 NATO allied countries, five European partner nations, and seven Middle Eastern partners. We also conducted our first ever bomber deployment to Norway while B–1s became the first American bomber to land in India in over 75 years.

Bomber Task Forces (BTF) missions are currently integrating the 4-Bin Force Generation Model and the Agile Combat Employment (ACE) concept to achieve Combatant Commander and Chief of Staff of the Air Force (CSAF) objectives. After 30 years of continuous combat deployments to the Middle East, adopting the 4-Bin Model enables the Air Force to present combat-ready forces in a predictable and sustainable manner that supports the 2022 National Defense Strategy. In addition, with the global footprint reduction, adversarial technological advances in intelligence, surveillance, and reconnaissance and all-domain long-range fires have placed traditional air bases at significantly increased risk. ACE provides a proactive and reactive operational scheme of maneuver executed within threat timelines to increase survivability while generating combat power. AFGSC is partnering with our overseas major commands to accomplish multiple site surveys of airfields and air bases around the world to determine their suitability to support bomber operations. During Fiscal Year 2022, the Command will serve five potential operating locations on four separate continents to enable ACE. Ongoing planning between Combatant Commands will allow bombers more flexibility with smaller deployment footprints.

Given the magnitude of their mission to secure two-thirds of the Nation's nuclear triad, twenty-five percent of all Air Force Security Forces are assigned to AFGSC. At present, AFGSC has 53 Joint Lightweight Tactical Vehicles (JLTV) awaiting installation of mission support equipment with delivery to AFGSC installations in early Fiscal Year 2023. The arrival of the new JLTVs will address the current fleet's shortfalls and will enhance the security of AFGSC's strategic resources. In a parallel move, AFGSC recognized the need for a mixed fleet of armored vehicles to sufficiently support the unique operating environments and varying mission sets across AFGSC. The addition of a lighter tactical suite of vehicles allows commanders the ability to tailor their responses to an incident while ensuring the safety of Defenders across AFGSC. Our Nation charges us to maintain a safe, secure, and reliable nuclear triad. The importance of this mission cannot be overstated, so we must modernize our strategic forces while we conduct our daily operations.

BALANCING SUSTAINMENT & MODERNIZATION

We are at a pivotal moment in U.S. history facing a critical choice: modernize our nuclear force or allow our Nation to lose its strategic advantage. Our conventional and nuclear platforms are as relevant as ever, but lifecycles dictate the need to modernize and ensure we continue to be effective and lethal. Over the next decade, delays in modernization program timelines and programs that do not meet expectations will put our Nation's security at risk. Moreover, there are no allied bomber forces or allied ICBM forces to rely upon—the free world's ability to hold potential adversaries at bay with two-thirds of the triad rests on our shoulders.

AFGSC is currently undertaking one of the largest nuclear modernization efforts in our Nation's history. However, we must balance our modernization efforts with maintaining the lethality and effectiveness of our current conventional and nuclear forces until replacements can arrive. Until Sentinel and B–21 are fully operationally capable, Minuteman III, B–1, and B–2 sustainment must continue. This balance between no-fail sustainment and on-cost, on-schedule modernization is the primary focus of my headquarters. Minuteman III remains an effective deterrent in the near term as we begin preparations for its replacement, Sentinel. Sentinel bed-down preparations have commenced this year with the Re-entry Vehicle Maintenance Facility and the Stage Processing Facility MILCON projects at Vandenberg Space Force Base to support Sentinel flight tests. Since 2017, Sentinel has consistently met all acquisition milestones as we approach the first flight test in the next 16 to 18 months.

AFGSC continually updates the Bomber Roadmap, reflecting current conditions, ensuring continued support to operational plans while transitioning from a three-bomber fleet to a two-bomber fleet of B–52s and B–21s. The effective and on-time modernization of the B–52 while we sustain a sufficient number of B–1s and B–2s will be critical until an adequate number of B–21s are available. Continued B–52 effectiveness and lethality are dependent upon the completion of the Commercial Engine Replacement (CERP) and the Radar Modernization programs.

B–52 CERP is a top priority and replaces the aging and obsolete TF33-PW–103 (TF33) engines with Rolls Royce F130 turbofans. Legacy TF33 engines, fabricated six decades ago, do not meet current environmental emissions regulations and

standards. Retrofitting modern engines on the B–52 embraces the tenets of an aggressive, clean energy transformation posture by tremendously reducing the carbon and noise footprints of the aircraft. Furthermore, a newer engine significantly reduces the emissions of unburned hydrocarbons, carbon dioxide, nitrogen oxides, and smoke numbers. In addition to the air pollutants emitted by the TF33 engine, its noise pollution fails to meet International Civil Aviation Organization standards.

Without re-engining the B–52, we put the backbone of our bomber forces at risk. The costs of sustaining the current engine are enormous, and there are no further options for finding parts due to vendors that are no longer in the business of producing parts for this 70+ year-old aircraft. We cannot sustain the TF33 engine for the expected future life of the B–52, which makes our CERP modernization effort much more critical. CERP is transitioning from Middle Tier Acquisition to a Major Capability Acquisition this year. It will complete Preliminary Design Review and issue a Development Request for Proposal, with a milestone B target date of May 2023.

Concurrently, the B–52 Radar Modernization program will dramatically improve B–52 lethality. The system will exponentially increase B–52 radar reliability, provide more precise navigation solutions, offer the ability to detect and track moving targets, and perform all-weather self-targeting. The radar program reached Milestone B in June 2021 and will complete the first install in 2023.

We are committed to protecting requirements and funding stability on the baseline acquisition program for both the Sentinel and the B–21 Raider. Since the B–21 program's inception, the top-level key system attributes and key performance parameters have remained unchanged. The Air Force awarded the Engineering and Manufacturing Development (EMD) contract in 2016. Since then, the B–21 program has remained under acquisition program baseline (APB) target costs and within its APB target schedule for both the start of production and required assets available for initial operational capability. The next major milestones for the program are the first flight and the beginning of low rate initial production. Leveraging modular systems and open standards, as we have done with the B–21 will enable us to have a technology that matures naturally through continuous upgrades.

In the calendar year 2021, the Acting Secretary of the Air Force confirmed Ellsworth AFB as the first B–21 Main Operating Base. Ellsworth has not hosted a stealth or nuclear mission since the early 1990's when the B–1B was still nuclear capable. Military construction at Ellsworth is on the critical path to B–21 nuclear certification. The Air Force needs the facilities and workforce at Ellsworth to support the nuclear deterrence mission and meet USSTRATCOM requirements. The Air Force will work to integrate the capabilities that underpin nuclear certification into future budget requests.

Last calendar year, the Joint Staff approved an enduring Capability Development Document (CDD) for the B–21. This enduring CDD paves the way for a proactive and streamlined B–21 modernization process, which starts in parallel to EMD, to mature and then rapidly integrate advanced capabilities at the earliest opportunity. The enduring CDD coupled with B–21's open architecture design, built-in growth margin, and the Air Force's decision to procure technical data rights during EMD will keep this platform relevant, affordable and adaptable as the threat picture and mission set evolve. The initial B–1 divestiture of 17 B–1s was completed on 23 September 2021, a week ahead of the congressional deadline. All divested aircraft selected for storage are now in the 309th Aerospace Maintenance and Regeneration Group following standard practices. Other locations and agencies supporting various B–1 test and evaluation programs received the remaining divested aircraft.

Safe and secure nuclear storage and maintenance are the cornerstone of Air Force nuclear generation capabilities and remain a high priority for the greater nuclear modernization effort. However, AFGSC operations currently rely on 1960's and 1970's era Weapons Storage Areas (WSAs) that have exceeded their designed service lives. With the on-going B–21, Sentinel, LRSO, and B61–12 programs, these new and modern weapon systems drive a need to diversify our assets and locations. To meet this need, the command is working to recapitalize our weapons storage and maintenance capacity by consolidating weapons storage, maintenance, and generation operations at select installations into newly constructed Weapons Generation Facilities (WGFs). WGFs eliminate exposure of nuclear assets to outside environmental elements and external observation, thus significantly increasing both maintenance capability and security. In addition, the WGF's design ultimately provides greater security features and operational flexibility than all current WSAs.

The first WGF construction project is underway at F.E. Warren Air Force Base, followed by construction at Malmstrom and Barksdale Air Force Bases. The command synchronized the B–21 WGF construction with the B–21 fielding locations and timelines to provide certified facilities to support B–21 full operational capability

target dates. Conceptually, the ICBM and bomber WGFs are similar, consisting of a hardened facility envelope containing all storage, maintenance, and generation functions. Recapitalizing the WGFs for the safety and security of weapons remains a pressing priority for the Air Force, as the aging infrastructure is operating well beyond designed life and outside of modern safety and security requirements. While many factors influence WGF costs, every effort is underway to ensure efficient and fiscally responsible facilities that will deliver increased capability for maintenance, storage, and generation of our Nation's nuclear arsenal.

The UH–1N Replacement Program was born out of the Air Force Common Vertical Lift Support Platform. The CSAF signed the UH–1N Replacement Program Capabilities Production Document on 3 May 2016, and the VCJCS signed the Joint Requirements Oversight Council (JROC) Memo on 22 Jun 2016. Congressional and OSD guidance was for full and open competition "utilizing the robust American helicopter industry." As a result, the USAF awarded the contract to Boeing-Leonardo in 2018 to provide up to 84 MH–139A helicopters at a program cost of $2.38B, resulting in a $1.7B savings to the taxpayer compared to the program's initial Independent Cost Estimate. The USAF received the first four MH–139A Air Vehicles between December 2019 and March 2020.

The MH–139A is a military commercial derivative aircraft and airworthiness certification relies heavily on civil certifications issued by the FAA. The program has faced some challenges recently, including delays for elements of the FAA certification known as Supplemental Type Certifications (STC). STC delays directly affected the completion of the initial Developmental Test and Evaluation, which is a prerequisite to the arrival of aircraft to Malmstrom AFB, the first operational base, now projected to be the end of Fiscal Year 2023. However, Initial Operational Test and Evaluation will continue into Fiscal Year 2024, which will allow for Full-Rate Production, Required Assets Available and Initial Operational Capability in Fiscal Year 2025.

AFGSC continues to transition from a legacy to a modern NC3 enterprise. The Air Force has begun recapitalizing the aging E–4B with the Survivable Airborne Operations Center (SAOC) program. The E–4B is a vital link in the National Military Command System, providing NC3 and C2 of the triad. To fund the program through the FYDP, the SAOC program has received funding from the OSD Cost Assessment and Program Evaluation for $5.36 billion. AFGSC authored an Air Force validated SAOC Capabilities Development Document that gained JROC validation in March 2022.

The Air Force continues to refine the SAOC acquisition strategy, leveraging modernization opportunities, open system architecture, and digital engineering to reduce overall program costs. The SAOC will achieve Full Operational Capability in the early to mid-2030's. While AFGSC leads one of the Nation's largest nuclear modernization efforts in decades, we must also maintain a safe, secure, and reliable nuclear triad. As the Air Component to USSTRATCOM, and as stewards of two-thirds of the nuclear triad, we must employ a specific and strategic approach to modernize our capabilities in the face of 21st century global competition. Our command is committed to delivering improved weapon systems as efficiently and affordably as possible by pursuing mature technologies, stabilizing requirements, and owning the technical baseline of our weapons systems—a formula that has proven successful in our acquisition efforts thus far.

NUCLEAR WEAPONS STOCKPILE

While today's stockpile is safe, secure and effective, we cannot allow the reliability or performance of the bedrock of our national security to degrade. We are at a point where we are modernizing delivery platforms, weapons, and supporting infrastructure simultaneously, and our ability to properly modernize hinges not only on DOD program execution, but also on our partners at the Department of Energy's (DOE) National Nuclear Security Administration (NNSA).

The NNSA plays a critical role in modernizing the nuclear security enterprise, including the recapitalization of our pit production infrastructure. Prioritizing essential NNSA infrastructure and modernization programs of record is a national imperative and fundamental to safeguarding our deterrent force. Any delay in stockpile modernization will have a cascading effect on the schedule. NNSA is cognizant of the fact that a faster, more comprehensive overhaul is necessary to maintain schedule alignment. Significant investments are being undertaken in recapitalizing infrastructure to build resiliency and re-establishing production capabilities lost in the post-cold war period and require sustained funding from Congress to complete in a timely manner.

As we shift attention from life extension efforts to modernizing our remaining weapons, we must identify and overcome any obstacles that could delay program execution. Understanding stockpile modernization programs take many years to fully execute, it is critical that we find avenues to reduce these timelines. Failure to do so will increase the operational risk to Sentinel and other major modernization efforts, putting our nuclear deterrent force at risk.

WIND FARM ENCROACHMENT

As our country expands its energy resilience through the development of various alternative energy sources, the dramatic growth in the wind energy sector has created unanticipated challenges for ICBM security. Since the deployment of Minuteman III, a 1,200-foot easement around all missile launch and alert facilities has helped keep structures at a minimum safe distance from private and commercial encroachment. However, when we fielded Minuteman III 50 years ago, we did not foresee wind turbines would 1 day share the same operational space as our ICBMs. Unfortunately, some wind turbines create a significant mission impact on helicopter and security operations. At present, existing wind turbines at 46 launch and missile alert facilities across our three missile wings affect flight safety and security operations.

Helicopter operations form an integral part of day-to-day security operations and security incident response within the ICBM complexes. Wind turbines near these facilities interfere with security operations by restricting helicopter approach avenues, limiting turning radius, severely affecting air-to-ground security response integration, and creating hazards for infiltration and exfiltration of responding forces. These activities are all necessary components that ensure the security of ICBM operations and vital national assets. The construction of wind turbines within a two nautical mile radius of launch and alert facilities poses a tremendous risk to helicopter and security operations, is exacerbated by the weather, time of day, and lighting conditions, places aircrew and facility personnel at greater risk, and extends security response time in critical situations.

We fully support renewable energy initiatives to ensure energy security for our Nation. AFGSC works closely with DOD's Military Aviation and the Installation Assurance Siting Clearinghouse and is engaged with multiple energy developers as we look for collaborative solutions to existing and proposed wind turbine projects. In addition, Strikers at our ICBM wings and 20th Air Force have met with local legislators and spoken with wind energy developers to explain the risks to our mission and people imposed by the construction of wind farms within a two nautical mile radius of these launch and alert facilities.

CONCLUSION

Today we face competitors who have the ability to escalate conflict across the globe in any domain and at any time. We as a Nation have not faced this reality at any point in history, and our approach must be continually adapted as the strategic environment evolves. We appreciate our partnership with the defense Committees and across the entire defense enterprise to ensure the continued protection of our Homeland.

AFGSC is the home of nuclear and conventional long-range precision strike for the United States and the free world. We continue to sustain legacy systems while modernizing our force to meet the challenges inherent in an increasingly complex global security environment. Our airmen, the very core of our mission, ensure we provide safe, secure and lethal combat-ready forces to the Combatant Commanders. It is because of our people, we are always ready to provide long-range conventional or nuclear precision strike anytime, anywhere.

Senator KING. Thank you all, and I want to address a question to our general and our admiral, and advise you that what we are looking for at this Committee is your best military judgment, not an answer that is tailored to the desires of any particular administration.

Two changes in the Nuclear Posture Review. One is the elimination of the sea-launched cruise missile (SLCM), and the other is the elimination of the B–83–1, the heavy gravity bomb.

Admiral, let's talk about Ukraine and the threat that we are all aware of, of Putin using tactical nuclear weapons. Are we making a mistake by cancelling the sea-launched cruise missile, which

gives us a comparable tactical weapon in response to potential use? I worry that we could be in a situation where it is mutually assured destruction or no response. Give me your thoughts on the cancellation of the sea-launched cruise missile.

Admiral WOLFE. Yes, Senator, thanks for the question. So here is what would say. Sir, I would tell you that in my position I do not advise on requirements to USSTRATCOM [United States Strategic Command] nor do I advise OSD on policy, or the Administration. As the acquisition lead, my job actually is to execute any program that the Administration and the Department——

Senator KING. Yeah, you are the customer. I want to know what you think you need.

Admiral WOLFE. Actually I am not the customer, sir. USSTRATCOM is the customer. I am the acquisition leg that once STRATCOM requests their requirements and once policy decides what it is we are going to execute, I actually execute those programs as they Navy's acquisition lead and technical lead on how we would meet those requirements.

Senator KING. So you do not want to express an opinion on the cancellation of this weapon system.

Admiral WOLFE. Sir, my personal opinion would not be something that I would want to share, because again, that is not my role in the United States Navy of advising either one of those organizations on either policy or requirements.

Senator KING. General Cotton, are you going to give me the same answer on the B–83–1, or do you have a military opinion as to whether we need a bunker-buster of that nature?

General COTTON. Senator King, what I would tell you, as the Joint Forces Air Component Commander to STRATCOM——

Senator KING. Could you speak up a little, General?

General COTTON. As the Joint Forces Air Component Commander to the Commander of STRATCOM, what I would like to do is, I would be able to present him with a portfolio of weapon systems of which he can choose. So if that is not in the portfolio, then that is one weapon system that he would be able to choose for planning purposes.

Senator KING. I think we are going to have to have a different set of generals and admirals.

[Laughter.]

I understand. I am not criticizing you all but I am trying to get at an important policy question, and if you are not the right people to answer then we will have to have another hearing to try to get at that question.

Admiral Wolfe, how are we doing on the development of the *Columbia*-class? For example, have they solved the missile encasement issue, the welding issue that was slowing things down some time ago?

Admiral WOLFE. Yes, sir. I would tell you the *Columbia* program is moving forward. They remain on schedule. To your specific question about the welding issues that we saw early on with the missile tubes, they have made progress. Those tubes are coming out as we predicted. The amount of rework that is required on those tubes continues to go down, and Admiral Scott Pappano, who is PEO SSBN, continues to push that program forward. Yes, sir.

Senator KING. General Cotton, a similar question. You are going to be engaged in an enormous project in developing the new ground-based deterrent. Give me a picture of where that project stands, what the progress is, and what the calendar looks like.

General COTTON. Thanks for the question, Chairman. I am happy to say that GBSD [ground based strategic deterrent], now known as Sentinel for the weapon system, is in a really, really good place. So I will say it is a mega-project. It is a mega-project. So I do not want to overstate the fact that what we are talking about is not just the replacement of a missile. We are talking about the replacement of the entire weapon system, the Minuteman weapon system.

The good news is F.E. Warren is the first base that we have already started to break ground in regards of what we are doing for F.E. Warren, Francis E. Warren in Cheyenne, Wyoming. Everything is on time, on schedule. I am not concerned of what we are seeing right now in regard to the program. The prime contractor is doing a tremendous job in regard to using digital engineering, as far as using open mission systems, as far as digital twins, that they are actually using from the B–21 program as well, and being able to carve out some of the best practices seen there.

So I think we are in a really, really good place, sir.

Senator KING. Are original budget—not original, but are recent budget estimates holding up?

General COTTON. It is, sir. So it is on time and on schedule and on budget at this point. I am very happy about that.

Senator KING. Thank you, General. Senator Fischer.

Senator FISCHER. Thank you, Mr. Chairman, and I want to thank all of you gentlemen for the work that you do each and every day, and please thank those that work with you on this. You keep our country safe and you keep our allies safe and secure as well.

I am going to give it a shot, what the chairman tried to do. Admiral, I think we know that Admiral Richard, the combatant commander at STRATCOM, has been very forthright in speaking about a deterrence gap and being able to provide his job of providing the President with options that would be at his disposal to counter or to address the threats that we face as a country. He has been supportive of the option of SLCM. You are aware of that, sir, right?

Admiral WOLFE. Yes, ma'am, I am aware of that.

Senator FISCHER. I will not put you in a bad spot. General Cotton, I will save that for you. You and I had a conversation this morning and I think you answered the chairman in saying that those options are valuable for any commander in chief to have at their disposal in making wise decisions on the defense of our security. Would you agree with that?

General COTTON. Yes, ma'am, I would.

Senator FISCHER. Okay. Thank you. Admiral Richard talks about that deterrence gap and assurance gap, and General Cotton, this morning you were visiting with me about our deterrent and stressing how important it was to have a credible deterrent. I appreciate your emphasis on that, because that really boils it down to being able to have those options for our commander in chief so that he or she can make wise decisions. So I am going to steal that "cred-

ible deterrent" from you for the rest of my time here in the United States Senate.

General, you know that I am an advocate for recapitalizing our E–4B fleet, and I was very glad to see the Air Force's budget significant resources to developing a replacement. This is an issue that has been studied well over a decade, and the challenges of maintaining an outdated airframe are only getting harder as time passes.

Can you talk about the Air Force's plan to replace the E–4B with the Survivable Airborne Operations Center (SAOC) and give your perspective on how important it is that we replace that system?

General COTTON. Senator Fischer, that you for the question. It is absolutely critical. As you know, the National Airborne Operations Center, of which the E–4B, the airframe is an older airframe, of which we only have four. Based out of Omaha, Nebraska, now at Lincoln, Nebraska, until the runway is completed. Incredible men and women that fly that mission every single day.

I am happy to say I think we are in a pretty good place on where we are going to move forward in regard to SAOC, its replacement. I know that it has just recently went through a JROC [Joint Requirements Oversight Council], as we had kind of restudied what the requirements are. I am happy with the adjustments to the requirements. I think the final product of what we are going to see as far as fleet size is going to be very manageable for the President, for the Secretary, as well as the Chairman, moving forward. So I think we are in a very good place in regard of what we are going to see for the SEOC, ma'am.

Senator FISCHER. Great. It is a good mission that we have there at Offutt. When the runway is completed there at Offutt I know that in the future that is an opportunity that we have to expand that mission right there at Offutt Air Force Base as well. So I look forward to working with you on that.

As I mentioned in my opening statement, the $63 million for Minuteman-III sustainment on the Air Force's list of unfunded mandates, that $63 million. Can you talk about the importance of sustaining the Minuteman-III, both the system and the facilities, and how that helps reduce risk associated with transitioning to the Sentinel?

General COTTON. Thank you for the question, Senator. What is very unique is where we are with the nuclear portfolio. Where we are with the nuclear portfolio is we are going to have to maintain our legacy systems until we transition into the new. So that being said, I need to make sure that I have a safe, secure, effective, and credible legacy weapon system as we transition into Sentinel, and that is what the sustainment request is in regard of making sure that we sustain our legacy system, known as the Minuteman-III. We just celebrated its 50-plus years on alert.

So by able to do that, we are safeguarding, as a bedrock the for the nation, for our allies and our partners to understand that they have a credible deterrent, one that is still safe, secure, and effective, until we get to the full transition of GBSD Sentinel in the 2036 time frame.

Senator FISCHER. Thank you. Thank you, Mr. Chairman.

Senator KING. Dr. Adams, not so long ago I visited Oak Ridge and I came away with two impressions. The people are fantastic. The facilities are pretty tired, and we using, I understand, manufacturing capabilities that literally go back to the 1940s. As we move into these major, new projects and the upgrade across the nuclear enterprise, are there plans afoot, and are there activities underway to modernize the manufacturing process at places like Oak Ridge and Los Alamos?

Mr. ADAMS. Thank you. Thank you, Chairman King, for the question. The short answer is yes, we are working on that. The more nuanced answer is we have processes that we know work. They are qualified. They are proven. They produce the product that we know we need. In many cases that product was a warhead that was tested underground.

If you change a process to one that, by all measures, looks better, there is a stringent quality standard and certification standard that has to be met, and we have to convince ourselves and skeptical observers that this thing will still work if it we make it a different way.

We are doing that, though. We are doing that work to convince ourselves that these things will still work when we make them different ways that are more efficient and that will ultimately give us a greater capacity.

Senator KING. This is one of the collateral effects of not being able to test. We have to be sure, as you say, that what we are doing, even though it may be a more modern manufacturing capability, will produce equivalent quality results, and that is the direction you are moving in.

Mr. ADAMS. That is the direction we are going.

Senator KING. General Cotton, in the fiscal year 2021 National Defense Authorization Act we required that the new B–21 be capable of hosting a long-range standoff missile to replace the 1980s cruise missile. Is that still in the planning stages? Is that part of a requirement that you accept as part of the B–21 process?

General COTTON. So as you mention, as LRSO comes online, of which you mentioned, for the air launch cruise missile replacement, it will be a threshold weapon on the B–52 as well as, since we are going to a two-bomber fleet, as well as have its capability on the B–21 down the road as well.

Senator KING. I have had several classified meetings on the status of the B–21 process. In an unclassified setting can you give me a bird's eye view? Are we still making good progress, still on budget, and do you feel confident about that process?

General COTTON. Sir, I think it is a model acquisition program for the Department. What we are doing and where it is, it is on time. I would love to host you to a couple of facilities so you can kick the tires yourself and see what is happening in regard to its development. I am very satisfied with where we on the progress of the B–21 program. It is on time and on budget.

Senator KING. One additional question on the B–21 and that is, to what extent are we developing good estimates, solid recognition of sustainment costs? As you know, one of the problems with the F–35 has turned out to be very high sustainment costs into the in-

definite future. Is that a factor in the design and manufacture and contractual relations that are part of the B–21?

General COTTON. Absolutely, sir. So we looked to see what kind of did not work there and tried to eliminate all of those for the B–21 program. One is the fact that the modern technologies that we are seeing in the development of this platform, even when compared to how the B–2 was designed, everything is kind of captured in the new, modern ways of how our acquisition partners are developing this platform. So we took all of that into consideration so we would not restage into the past. So that was all taken into consideration for the B–21 program, and I am very satisfied that we will not replow that ground, on what you are talking about with the other weapon systems.

Senator KING. With the concurrence of my co-chair I am going to cede myself an extra minute. Senator Fischer, you will get it too, yes.

Question for both the admiral and the general, and that is, intellectual property with regard to the B–21 and the *Columbia.* To what extent will the Department of Defense own the intellectual property so that in the future we can 3D print or otherwise acquire parts rather than having to go through the OEM process? I foresee a day, and hope there is a day when every depot, every hangar, every military facility has its own 3D printing capability, which would be an enormous availability boost. So are we buying the intellectual property on those two programs to the extent that we will be able to create our own parts without having to go back through the manufacturer? General?

General COTTON. Chairman King, I am glad you asked that question. That is what makes us very, very proud of the B–21 program. We own the baseline. We own the baseline. So what that does for us, it gives us open architecture. It allows us, understanding that we are designing a weapon system that is going to last for decades, that you can, by having open architecture and owning the baseline, that you do not have to kind of re-haggle, if you will, to do some improvements as the weapon system progresses in its timeline.

So I am happy to say that yes, we do own the operational baseline for the B–21.

Senator KING. Excellent. Thank you. Admiral, how about *Columbia?*

Admiral WOLFE. Sir, although I do not know to the level of how much IP is actually owned, because again, that is not in my portfolio, but let me answer it in a different way because I think your question about are we able to get the data that we need to 3D print and do some of that stuff, I would tell you already in the United States Navy and in the Submarine Service we are to the point where we are starting to use 3D printing and we are starting to understand what is available to all of our depot facilities and even to our individual platforms to be able to do that type of real-time maintenance that I think you are really getting at.

So I would like to take a question for the record on the actual amount of IP that we are going to own for *Columbia.* But we are getting after that in many areas.

Senator KING. I think that ought to be the standard for whenever we are buying something, we get the IP along with the platform.

Admiral WOLFE. Yes, sir. I would tell you, in the strategic program that I do manage, back to what General Cotton said, it is the same way. We do own the technical baseline. As a matter of fact, in our program we are the systems integrator. So we do not have a separate entity that does all of the system integration for the entire system. That is the U.S. Navy and that is our program.

Senator KING. Good. Thank you. Thank you very much. Senator Fischer.

Senator FISCHER. Thank you, Mr. Chairman. General Cotton, earlier today we spoke about the importance of modernizing the B–52, in particular the CERP [Commercial Engine Replacement], the engine replacement, and the radar modernization programs. It is my understanding the Air Force has changed its acquisition structure for the re-engineering effort. How confident are you that we will be able to complete that project on time?

General COTTON. Ma'am, I am very confident. Thank you for the question. What is unique about the program is what I am seeing from the prime. As you know, we have just let that contract for the engine replacement for the B–52, the Civilian Engine Replacement Program, known as CERP, and Rolls-Royce was awarded that contract.

The integration efforts that we are already beginning to see with our contractor, Boeing, on being able to integrate that engine as well as the other upgrades that will come along with that engine upgrade is short of fantastic. You probably have even seen on the news where we were able to take a bird from the boneyard. They actually split it in half, from nose to tail, and kept the left side of the jet. It is in a warehouse in Tinker right now, where they can form-fit as they do integration with—no kidding—a jet. So that is the innovative thinking that they are thinking through, because even using 3D technology on your computer does not replace having an airman or a maintainer kind of say, "Hey, engineer, that is probably not the right place to put that component, because now I do not have access to it," as they are doing the integration piece. So I am very, very satisfied in what I am seeing with the CERP program.

You also mentioned the radar modernization program. Radar modernization program is also going to be very, very instrumental for the B–52 as it gets at some of our faults that we see in our radar systems currently and upgrades the radar system there.

I would like to talk a little bit about CERP, if you do not mind, on what it brings to the fight.

Senator FISCHER. Can I first ask you a question about the radar system that you are modernizing?

General COTTON. Yes, ma'am.

Senator FISCHER. I do not know if you can discuss it in an unclassified setting, but can you share the mean time between failure for the current radar system?

General COTTON. Yes. It should around 300 and it is sitting around 46 right now.

Senator FISCHER. Okay, and then if you want to just do briefly on CERP so I can ask the admiral and Mr. Adams questions as well.

General COTTON. Well, part of the two-bomber fleet that we are going to have here in the United States Air Force with the B–21 and the B–52, the B–52 is going to be a formidable standoff, long-range strike weapon through 2050, and I am very confident, as much as folks talk about the B–52 and its age, once we do this upgrade she is going to be a very formidable weapon system through 2050.

I am really looking forward. I just need to make sure that the funding stays steady so we can get that done, because the limiting factor for the B–52 is its current engines that are sitting on it right now. So we must replace the engines on the B–52. Thank you, Senator.

Senator FISCHER. Good. It is important to know that we not only stay on schedule but the funding, like you said, is steady and we do not see the peaks and valley. Thank you.

Admiral Wolfe, thank you for everything that you, as I said earlier, that you do and that your team does. I would like to revisit some of our discussion yesterday about your life extension efforts with the LE2, for the Trident missile. Can you talk about how reductions to the program increase long-term risk and make your ability to meet the delivery date more challenging?

Admiral WOLFE. Yes, Senator. Thank you for the question. I will expand a little bit to our discussion from yesterday.

Every time we do not get budgeted to our request we have a very tight timeline. We understand the technologies that not only we need to re-invigorate today to make sure that our system and LE2 gets to where we need to get but there are also technologies that we need to develop. Because as we all talked about, our strategic competitors have changed—we have gone from one to two—how we look at these systems, some of the requirements that we talked about.

Every time that we take a decrement it causes us to either give up on a technology, which means we are going to rely on something that is not going to be cutting edge because we have got to maintain schedule, because we are very tight in making sure that we continue to support our portion of the triad, or we push that, when then reduces the amount of time we have to really develop that technology, develop the workforce to understand that.

So the most important thing to us is keeping the stability so that we can stay on schedule, we can develop the technologies to meet not just today's requirement but where we need to be in the future as we continue to watch things evolve.

Senator FISCHER. We certainly do not want to underfund these programs and have it end up like a lot of modernization programs that we are looking at right now, where there is no room. There is no room for delay, and we all know that things can happen that would put production into delaying situation, and I certainly do not want it to be because we have not funded at the proper levels. So thank you.

Mr. Adams, we have focused primarily on plutonium pit production over the last few years. Can you update on NNSA's other challenges with respect to strategic materials and discuss what you see as the next major challenge after pit production?

Mr. ADAMS. Thank you for the question, Senator Fischer. I do not know that I would say "after" because we have to do these things simultaneously. So the lithium facility at Y–12 comes to mind. Of course, we have to finish the uranium processing facility. There is a tritium facility that is needed at Savannah River. There are high-explosive facilities that are needed at Pantex. All of these things are underway. They are all in flight now, and we have to have all of them in order to do the modernization work that we are asked to do, and deliver the warheads that DOD needs.

Senator FISCHER. When we look at the expansion, I believe it is production at the TVA's Watts Bar Unit 2. Is that expansion going to be sufficient to meet our long-term needs?

Mr. ADAMS. Thank you for that question. That is where we make our tritium. It is actually Watts Bar Unit 1 and Unit 2 now. We have both of those going. We put 1,792 tritium-producing, burnable absorber rods in each core. We can go up to that much at this point, and that will meet the needs of the program for tritium as long as there are not serious interruptions.

We have a good thing going. We have demonstrated all the way through the extraction at Savannah River and the placement of the tritium into gas transfer systems. My view is that that program is doing a great job right now. We could use more margin, and our team is now looking at putting more burnable absorber rods in each of those cores in Unit 1 and Unit 2. We are looking at licensing amendments that would allow that in case we need it later.

Senator FISCHER. Okay. Thank you very much. Thank you, Mr. Chair.

Senator KING. I want to thank all of our witnesses. This has been a very informative hearing. I appreciate the testimony both from our first panel and our second panel, the answer to our questions. Thank you very much. We looking forward to continuing to work with you on these important topics.

The hearing is adjourned.

[Whereupon, at 6:01 p.m., the Subcommittee adjourned.]

APPENDIX

U.S. Department of Energy
Office of Inspector General
Office of Audit Services

Special Report

Meeting Medical and Research Needs for Isotopes Derived from Uranium-233

DOE/IG-0795 May 2008

Department of Energy
Washington, DC 20585

May 29, 2008

MEMORANDUM FOR THE SECRETARY

FROM: Gregory H. Friedman
Inspector General

SUBJECT: INFORMATION: Special Report on "Meeting Medical and Research Needs for Isotopes Derived from Uranium-233"

BACKGROUND

As part of its program to produce isotopes for medical, research and industrial purposes, the Department of Energy (Department) has used its unique nuclear facilities to produce thorium-229 isotopes from its inventory of uranium-233. Thorium-229 is used to create actinium-225 and its progeny isotope, bismuth-213. Both actinium and bismuth are extremely rare isotopes that are now being used in clinical trials and cancer research at organizations such as the Memorial Sloan-Kettering Cancer Center in New York. Early research results have been promising, showing improved cancer survivability rates in test populations. Consistent with these research results, a 2001 Departmental Report to Congress underscored the importance of maintaining a supply of these isotopes to support promising medical research and treatment. Specifically, the report stated that "the supply of actinium-225/bismuth-213 available as uranium-233 decay products will be inadequate if therapeutic applications for leukemia become even moderately successful and will become woefully inadequate if successfully applied to other types of cancer including prostate, breast, lymphomas, and various forms of brain cancer."

The Department's inventory of uranium-233 resides primarily at the Idaho National Laboratory (Idaho) and the Oak Ridge National Laboratory (ORNL). The Department determined that these inventories are no longer needed to meet agency mission requirements. In 2003, to aid in isotope production, Congress authorized the extraction of thorium-229 from ORNL's uranium-233 inventory prior to its disposal. Subsequently, however, Congress directed that the Department terminate the extraction process. Responsibility for disposition of uranium-233 was transferred to the Environmental Management (EM) program. Accordingly, in October 2007, at the recommendation of the Department's Nuclear Materials Disposition and Consolidation Coordination Council, the Department decided to prepare the ORNL inventory beginning in 2012 for disposal. Further, the Department decided to dispose of the Idaho uranium-233 inventory at the Nevada Test Site as low-level waste and began shipments of the material in January 2008. Because of its importance to medical and other research activities, we initiated a review to evaluate whether the Department's planned disposition of its uranium-233 inventories would permit it to meet projected domestic medical and research needs for actinium and bismuth. Shortly after initiating this review, we received information alleging that the Department was disposing of uranium-233 that had significant potential use.

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RESULTS OF AUDIT

We concluded that the Department's current disposal plans provide no assurance that sufficient quantities of uranium-233 and its valuable progeny isotopes will be available to support U.S. medical and scientific research needs. We noted that:

- The Department is the only domestic producer of progeny isotopes from uranium-233 and current production is insufficient to meet medical and scientific research needs. Once the planned disposal of uranium-233 is complete, the Department will not have the means to increase isotope production to meet the dramatic projections of future needs for actinium and bismuth;

- At present, no viable alternative methods of production of actinium and bismuth have been demonstrated or proven; and,

- Uranium-233 also is used to support other Department missions such as the National Nuclear Security Administration's Test Readiness Program.

The importance of and continuing need for uranium-233 and related isotopes was confirmed by The National Academy of Sciences in its September 20, 2007, report entitled "*Advancing Nuclear Medicine Through Innovation.*" The National Academy was asked by the Department and the National Institutes of Health (NIH) to review the state of the science of nuclear medicine. The study concluded that the Department and NIH need to focus research on the development of new radionuclide production facilities and technologies as well as the development and use of targeted radionuclide therapeutics that will allow cancer treatments to be tailored for individual patients. The report also stated that several of these radionuclides, including actinium-225, are not being produced in sufficient quantities to meet existing research demand. The supply/demand balance is also affected by recent reports from researchers asserting that problems with quality and availability prevent them from using isotopes from foreign sources for human trials. The vulnerability of obtaining radionuclides from foreign sources was also underscored by the recent shutdown of a Canadian reactor, which provided many of the isotopes used in medical diagnosis and treatment.

According to senior program managers, the inventory of uranium-233 is being disposed of because there is a lack of programmatic authority to maintain the material and the infrastructure necessary to continue extracting the actinium and bismuth. Currently, the uranium-233 inventory is controlled and managed by the EM program, whose mission is to dispose of the Department's unwanted materials. The EM program tried to transfer the uranium-233 to other programs, such as the Office of Nuclear Energy (NE). However, according to NE management, which currently manages the Department's Isotope Programs, funding restrictions prohibit NE from taking possession of the inventory.

We recognize that the Department has, as a matter of policy, committed to providing isotopes only when there is no U.S. private-sector capability or when the available supply is insufficient to meet U.S. needs. In the case of uranium-233, the Department appears to offer the only viable domestic production capability. Yet, even its existing production capacity is insufficient to meet demand. Further, security and proliferation concerns

prohibit the Department from providing the source material directly to universities or industry to permit the development of a viable private sector source. Based on our consultations with program officials within the Department, we learned that given appropriate authorities and the available funding, several alternatives exist for assuring a viable inventory of these important radioisotopes. As was initially proposed for the inventory maintained at Oak Ridge, thorium-229 could be extracted from the uranium-233 prior to disposition. Alternatively, the Department could retain some portion of the uranium-233 inventory, or develop alternative methods of producing actinium-225 and its progeny isotope, bismuth-213. It should also be noted that other options are being pursued by private sector entities in an effort to create these isotopes; however, it is not yet known when or if these technologies will prove viable.

To its credit, the Department's Fiscal Year 2009 budget proposes to transfer the Nation's isotope program to the Office of Science and seeks to increase research and development in isotope production. The budget request mentions that future research and development efforts will specifically consider the results of the recent National Academy of Science report on nuclear medicine. However, without the feed material from which to produce actinium and bismuth, the research must necessarily focus only on alternative production methods -- efforts that at the least will significantly delay delivery of these potentially beneficial isotopes to the medical research community.

Should the Department elect to proceed as planned, it may dispose of a national resource that is irreplaceable. The potential for isotopes produced from uranium-233 to help save the lives of thousands of American cancer patients is widely accepted, and one top Departmental official estimated that isotopes production from ORNL stocks alone could be used to treat about 6,000 patients annually. While we are sensitive to the complex public policy implications associated with this matter, including significant budgetary issues, we believe that the Department should explore alternatives for ensuring a stable domestic supply of the important isotopes produced from uranium-233.

MANAGEMENT REACTION

Management did not concur with our recommendations but instead proposed alternative actions designed to address certain issues described in our report. Notably, the Department indicated that a merit-based peer review would be conducted to examine the needs and priorities for actinium and bismuth. Management also noted that it planned to work with NIH to address the recommendations of the National Academy of Sciences. Citing concerns with cost, security, safety and Congressional mandates, management stated that it would continue with the disposition of the uranium-233 inventories at Oak Ridge and Idaho. Management also stated that it had largely addressed our recommendation to evaluate the cost and benefits of harvesting thorium-229 from uranium-233 prior to its disposal. Should Congress direct a new strategy for the disposition of uranium-233, the Department pledged to work to establish a new framework for the disposition of the material. Management's comments are contained as Appendix 3 to our report and provide additional details regarding uranium-233 disposition decisions.

We are encouraged that the Department is taking steps to conduct a merit-based peer review to examine the needs and priorities for production of progeny isotopes discussed

in the report and working with the NIH to address medical and research isotopic needs. Management's comments, however, were not fully responsive in one important respect. While the Department has completed several evaluations regarding uranium-233 disposition alternatives for the Oak Ridge inventory, these evaluations were completed several years prior to the National Academy of Sciences report and did not consider recent medical successes, the increasing demand for these isotopes, or address alternative technologies for providing them.

Given the past and current role of the Department of Energy in supporting medical and research activities, an evaluation needs to be completed to provide Congress, the Office of Management and Budget and other stakeholders with up-to-date information on which to base important public policy decisions regarding the Department's role in producing medical and research isotopes. Management could also consider and address cost and security concerns as a part of such a study.

Attachment

cc: Acting Deputy Secretary
Under Secretary of Energy
Under Secretary for Science
Chief of Staff
Assistant Secretary for Environmental Management
Assistant Secretary for Nuclear Energy
Director, Office of Science
Manager, Idaho Operations Office
Manager, Oak Ridge Operations Office
Team Leader, Audit Liaison Team, CF-1.2

SPECIAL REPORT ON MEETING MEDICAL AND RESEARCH NEEDS FOR ISOTOPES DERIVED FROM URANIUM-233

TABLE OF CONTENTS

Ensuring a Viable Domestic Supply of Isotopes

Details of Finding 1

Recommendations and Comments 6

Appendices

1. Objective, Scope, and Methodology 9
2. Prior Audit Reports 11
3. Management Comments 13

ENSURING A VIABLE DOMESTIC SUPPLY OF ISOTOPES

Department Plans To Dispose of Uranium-233

Should the Department of Energy (Department) carry out its disposition plans to dispose of its uranium-233, there is no assurance that a viable inventory of progeny isotopes (actinium-225 and bismuth-213) will be available to meet domestic medical and scientific research needs. Currently, the domestic production of actinium-225 is approximately 650 millicuries per year. This supply has been provided through a small inventory of thorium-229 maintained at the Oak Ridge National Laboratory (ORNL) that was extracted from uranium-233. However, according to the National Institutes of Health's (NIH) projections, demand is far greater. Specifically, NIH projects a demand for actinium-225 of 1,700 millicuries in 2008 and 6,000 millicuries in 2009. With the decision to dispose of ORNL's inventory of uranium-233, the production capability will be inadequate to meet increasing domestic demands. Further, disposal of the Idaho National Laboratory's (Idaho) uranium-233 inventory will effectively eliminate the possibility of producing isotopes from that source.[1]

The loss of the uranium-233 will have significant impact on medical research which is now requiring a greater supply of progeny isotopes than ever before. For example, ongoing research includes Phase II clinical trials for the treatment of acute myeloid leukemia at Memorial Sloan-Kettering Cancer Center in New York. The results of Phase II trials showed increased survivability of those receiving the treatment, where patients had no other treatment options. Due to the limited availability of isotopes currently being produced from uranium-233, only one Phase II trial may be done at a time. Accordingly, researchers at Memorial Sloan-Kettering have decided to focus their current research on using the actinium-225 for alpha-particle immunotherapy trials, and to postpone research work using bismuth-213.

In addition to myeloid leukemia, research is being conducted using uranium-233 progeny isotopes to treat Non-Hodgkin Lymphoma, bone marrow transplants, AIDS, as well as cancers of the lungs, pancreas, and kidneys. Each treatment application requires separate clinical trials to obtain U.S. Food and Drug Administration (FDA) approval. Unfortunately, Memorial Sloan-Kettering decided to delay Phase III clinical trial efforts for myeloid leukemia due to the extremely short supply of bismuth. Without the Department's inventory of uranium-233, there will not be adequate domestic supplies to support the Phase III clinical trial

[1] It should be noted that actinium-225 has been extracted from Idaho's inventory of uranium-233 only on a laboratory scale. Planning for pilot, and ultimately production levels, is currently ongoing.

necessary to obtain FDA approval. According to the principal researcher at Memorial Sloan-Kettering for acute myeloid leukemia, if the Department continues with its plans to dispose of its inventory of uranium-233, then all research using actinium and bismuth will be lost due to the lack of supply. The president of a medical isotope supply company has noted that the medical industry will be able to use all of the progeny isotopes that could be produced from the Department's inventory should these clinical trials prove successful.

While limited foreign supplies are available for the progeny isotopes, researchers told us that such products have quality and reliability concerns. For example, Memorial Sloan-Kettering Cancer Center has obtained actinium-225 from foreign sources; however, due to quality concerns, the Center's representatives stated that they will not use foreign sources for cancer treatment in humans, but may continue to use it in research. Further, effective treatment requires a reliable supply because, once the patient begins treatment, it must be available on an uninterrupted basis. Although we were unable to specifically verify these assertions, researchers informed us that foreign sources are not reliable enough to meet this need.

The need for uranium-233 was recently confirmed by The National Academy of Sciences in its September 20, 2007, report entitled "*Advancing Nuclear Medicine Through Innovation*." The National Academies were asked by the Department and NIH to review the state of the science of nuclear medicine and future scientific areas of research for the Department's Medical Applications and Sciences Program. The study concluded that the Department and NIH need to focus their research on the development of new radionuclide production facilities and technologies as well as the development and use of targeted radionuclide therapeutics that will allow cancer treatments to be tailored for individual patients. The report specifically mentions the promise and need for actinium-225, one of 2 alpha emitters and one of 12 therapeutic radionuclides listed as being essential to nuclear medicine research. The report also states that several of these research radionuclides are not being produced in sufficient quantities to meet the research demand.

Several alternatives exist for assuring a viable inventory of these important radioisotopes. One alternative is to extract the thorium-229 prior to dispositioning the uranium-233. The contractor at ORNL responsible for disposition estimated the cost to extract the thorium-229 at $13.7 million prior to the termination of the extraction project. Another alternative is to retain some portion of the Department's inventory of uranium-233. It is important to note, however, that due to safety and security concerns, uranium-233 will not be transferred outside of the Department. Conversely, thorium-229 and actinium-225 can be transferred and sold outside of the Department. There are also a number of other processes being considered to produce these isotopes using, for example, accelerators, cyclotrons, and reactors. Various private enterprises are in the early stages of investigating these opportunities in order to meet the market demand. Each of the processes under investigation have their respective costs and benefits but it is not known when or if any of these will prove to be useful and affordable to the medical and research community. At present, none of the alternative technologies being considered have resulted in the actual production of actinium and bismuth.

Finally, we noted that uranium-233 also has value to support other Department missions such as the National Nuclear Security Administration's Test Readiness Program. According to the pre-decisional draft Implementation Plan for the Disposition of Surplus uranium-233, the decision to dispose of the ORNL inventory of uranium-233 was made, in part, based on the sufficiency of the uranium-233 in Idaho to meet potential future needs. However, in October 2007, the Department approved the Nuclear Materials Disposition and Consolidation Coordination Committee's recommendation to dispose of the Idaho inventory as well; therefore, there will no longer be any inventory to meet on-going programmatic needs.

Programmatic Authority

Based on our discussion with several Department program officials, we learned that there is currently a lack of programmatic authority to maintain the material and infrastructure necessary to continue providing progeny isotopes from uranium-233. Both the Idaho and ORNL uranium-233 inventories are now controlled and managed by the Office of Environmental Management (EM) whose mission is to dispose of these unwanted materials. Given this responsibility, EM is proceeding with short-term

actions to dispose of these materials as waste. EM's decision-making process considers various issues crucial for deciding whether to dispose of materials. One of the decision points is whether the material should be retained as a national resource. EM determined that uranium-233 should not be retained as a national resource because there is no program with an identified current use and funding to take custody of the inventory. Further, EM is under pressure to dispose of the Idaho inventory quickly since the license for a disposal cask to transport the uranium-233 expired on November 30, 2007. To avoid the cost of constructing and licensing a new cask, the Department is taking steps to extend this license for one year and is trying to dispose of the uranium-233 by September 30, 2008.

Prior to reaching its disposal decision, EM tried to transfer the uranium-233 to other programs, such as the Office of Nuclear Energy (NE). However, no programs stepped forward to take control of the material since EM required the adopting program to assume responsibility for managing the uranium-233 and paying for the disposition costs. To retain this material, programs must have current projects with current funding sources – a circumstance that does not currently exist.

NE currently manages the Department's Isotope Programs and would appear to be a likely Programmatic Secretarial Office to take custody of the uranium-233 inventory at Idaho. However, according to NE management, it lacks a Congressionally-approved programmatic mission and appropriated funds to take possession of the inventory. Additionally, NE has no program that can assume the disposition costs. For example, NE's Isotope Program has placed the need for isotopes derived from uranium-233 as one of its top priorities. However, the Isotope Program does not have the budget or programmatic authority to take control of uranium-233 feedstock materials that are necessary to produce these isotopes.

The Department's Fiscal Year (FY) 2009 budget request, however, seeks to transfer management of the Isotope Program to the Office of Science and devote more funding and attention to meeting the demand for research and medical isotopes. Under the proposal, all isotope-related facilities and funding would be transferred to the Office of Science and a number of research-related initiatives not funded in FY 2008 by NE would be funded at nominal

amounts. The FY 2009 budget request mentions that future research and development efforts will specifically consider the results of the recent National Academy of Science's report on nuclear medicine. Without the feedstock material from which to produce actinium and bismuth, however, research must necessarily focus only on alternative production methods – efforts that will at the least significantly delay delivery of these valuable isotopes to the medical research community.

Disposal Impacts

By pursuing disposition of its uranium-233, the Department is poised to dispose of a national resource. Although other means of producing these isotopes are currently under investigation by the research community, it is not yet known whether any of these will come to fruition. The facilities that originally produced this material have all been closed and decommissioned. To produce uranium-233 using existing facilities, such as the Idaho National Laboratory's Advance Test Reactor, program officials indicated that it would take approximately 1,000 years to replace the 320 kg of uranium-233 stored at Idaho. Another alternative is to produce the actinium-225 using accelerators or reactors; however, this requires chemical processing and/or separation steps that are yet to be determined. The current cost estimate to dispose of Idaho's inventory of uranium-233 is approximately $5 million. Alternatively, the current cost to store Idaho's inventory of uranium-233 is approximately $60,000 per year. However, the maintenance and storage costs of uranium-233 will grow over time because, due to the radioactive decay process, the material becomes increasingly more difficult to manage.

More important than the cost to replace or retain this material, is the potential for it to contribute to vital national interests. There is real promise for it to help save the lives of thousands of American cancer patients – in fact one top Departmental official estimated that these isotopes could be used to treat 6,000 patients annually. Also, should the nuclear renaissance expand to include research into proliferation resistant thorium cycle reactors, this material could be vital. Further, this material could help the nation explore space, offering an alternative to the plutonium powered radioisotope thermoelectric generator technology

that is currently deployed on NASA's deep space missions, as well as other important uses. However, if the Department continues with its plans to dispose of the uranium-233 none of these will come about.

RECOMMENDATIONS

We recommend that the Under Secretary of Energy, working with the Under Secretary for Science:

1. Prior to final disposal of the Department's inventory of uranium-233, evaluate the costs and benefits of:

    a. retaining the uranium-233 for the production of progeny isotopes;
    b. extracting the thorium-229 and continuing with disposition of the uranium-233; or,
    c. producing progeny isotopes using other technologies, such as an accelerator or reactor.

2. Work with the Office of Management and Budget and Congress, as necessary, to identify funding sources and approaches to meet demands for the isotopes discussed in this report.

3. Identify an appropriate Programmatic Secretarial Office to take responsibility for the material or identify means whereby industry can assume custody of the material if the decision is made to retain or extract isotopes from the uranium-233

MANAGEMENT REACTION

Management expressed concerns that many of the recommended corrective actions directed in this report have been previously implemented. Further, it noted that the current disposition strategy for the Oak Ridge uranium-233 had been directed by Congress. Alterations to the current strategy would have a significant impact on the safety and security postures in Building 3019 at ORNL and would require a change in Congressional mandate.

As to Recommendation 1, management stated that the analysis called for has been largely addressed through previous evaluations. Management stated, however, that the Office of Science will employ a merit-based peer review process to examine the needs and priorities for production of progeny isotopes discussed in this report, in the context of the broader needs for other research isotopes, and alternative production technologies. Regarding Recommendation 2, the Department stated it is working with the National Institutes of Health (NIH) to address the

recommendations of the National Academy of Sciences pertaining to the production of research isotopes in the broader context of needs across both industry and research. Should Congress direct an alternative strategy for the disposition of uranium-233, the Department will work to establish a new framework for the production of progeny isotopes. Management felt that this approach was consistent with Recommendation 3, which directs the Department to identify an appropriate Programmatic Secretarial Office to take responsibility for the material if a decision is made to use uranium-233 for isotope production.

AUDITOR COMMENTS

We are encouraged by management's proposals but remain concerned that the planned actions are not fully responsive to our recommendations. While we recognize that management previously evaluated disposition options for the Oak Ridge uranium-233 inventory, these evaluations were completed prior to the recent National Academy of Sciences report and did not consider the latest medical successes or the significant increase in projected demand for the isotopes discussed in the report. For example, one cost study referenced by management, "*Evaluation of the Options for Disposition of the U-233 Inventory at Oak Ridge National Laboratory,*" was completed in April 2005. Another study, "*Environmental Assessment for the U-233 Disposition, Medical Isotope Production, and Building 3019 Complex Shutdown at the Oak Ridge National Laboratory,*" was issued in December 2004.

Both of the studies (provided to us by management after we received its comments on our draft report) supported thorium extraction over continued storage of the Oak Ridge inventory. None of the studies, however, compared the cost of producing progeny isotopes through alternative technologies such as accelerators. This evaluation needs to be completed to provide Congress, the Office of Management and Budget and other stakeholders with up-to-date information on which to base an important public policy decision regarding the Department's role in the production of medical and research isotopes. The evaluations also could be useful in examining the security and cost concerns that management identifies as one of the primary drivers for declining to interrupt the Oak Ridge disposal efforts.

Finally, we are pleased that the Department now intends to work closely with NIH. Such interaction could be critical in identifying funding and authorization sources for producing these valuable isotopes. Management's comments on the third recommendation are responsive. However, the efficacy of this recommendation is

dependent upon the Department successfully interacting with Congress and the Office of Management and Budget as advocated in Recommendation 2.

Appendix 1

OBJECTIVE

The objective of this audit was to evaluate whether the Department of Energy's (Department) planned disposition of its uranium-233 inventories would permit it to meet projected domestic medical and research needs for actinium and bismuth isotopes.

SCOPE

The audit was performed from March 2007 to May 2008 at the Idaho Operations Office, Battelle Energy Alliance, LLC, and CH2M-WG Idaho, LLC in Idaho Falls, Idaho. We also obtained information from the Oak Ridge Operations Office in Oak Ridge, Tennessee; and the Isotope Program in Washington, D.C. The audit scope was limited to the disposition plans of uranium-233.

METHODOLOGY

To accomplish the audit objective, we:

- Reviewed Federal regulations and Departmental directives and guidance related to isotopes and uranium-233;
- Reviewed prior reports issued by the Office of Inspector General;
- Reviewed reports by the National Academy of Sciences and American Nuclear Society on isotopes;
- Reviewed the Idaho National Laboratory's Cooperative Research and Development Agreement to use Idaho's uranium-233;
- Held discussions with a researcher at Memorial Sloan-Kettering Cancer Center;
- Held discussions with companies in the isotope supply industry;
- Held discussions with program officials from Department Headquarters and sites reviewed, including representatives from the Office of Nuclear Energy, the Office of Science, and Environmental Management; and,
- Analyzed information provided by the organizations reviewed to determine disposition plans and other uses for uranium-233.

Appendix 1 (continued)

We conducted this performance audit in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objective. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objective. Specifically, we assessed internal controls regarding the Department's disposition plans for uranium-233. Because our review was limited, it would not necessarily have disclosed all internal control deficiencies that may have existed at the time of our audit. Also, we examined the establishment of performance measures in accordance with the Government Performance and Results Act of 1993 as it related to the audit objective. Performance measures were identified at the Idaho National Laboratory and the Isotope Program. Finally, we did not rely on computer-processed data during the audit; therefore, we did not conduct reliability assessments on the data.

An exit conference was held on May 23, 2008, with the Associate Under Secretary for Energy, as well as representatives from the Offices of Environmental Management, Nuclear Energy, and Science.

Appendix 2

PRIOR AUDIT REPORTS

Office of Inspector General Reports

Management of the Department's Isotope Program (DOE/IG-0709, November 2005). The Department of Energy (Department) had not always provided researchers with the isotopes needed to conduct planned research. Since 1998, independent reviews, many of which were sponsored by the Department, have noted that the Isotope Program did not fully support production of research isotopes and that it had not adequately served the needs of the research community. Even though the Department recognized in the 2005 Isotope Program Plan that the current structure of the Program has had a "severe chilling effect on several promising areas of medical research in the United States," it did not take what we considered to be adequate action to address production issues. The Isotope Program Director stated that the Program is receiving frequent requests for other research isotopes that it will be unable to fulfill, including actinium, lutetium, and barium. For example, the Department is at its production limit for actinium, and the Director stated that the Program would sell more of this isotope if more could be produced. The price of actinium-225, from Fiscal Year (FY) 2002 to FY 2003, increased from about $580 to $1,203 per unit. According to the FY 2005 Isotope Program Plan, if the Department could produce a reliable supply of certain isotopes, there would be immediate use for them in medical research with some moving to clinical trials and widespread application. Further exacerbating this problem, the National Cancer Institute and the Society of Nuclear Medicine expect there to be a dramatic increase in the use of medical isotopes by the research community for a broad range of efforts.

Other Reports

Advancing Nuclear Medicine Through Innovation (National Academy of Sciences, September 2007). Advances on the horizon in nuclear medicine could substantially accelerate, simplify, and reduce the cost of delivering and improving health care. However, the Department's Nuclear Energy Isotope Program is not meeting the needs of the research community because the effort is not adequately coordinated with National Institutes of Health activities or with the Department's Office of Biological and Environmental Research. Public Law 101-101, which requires full-cost recovery for Department-supplied isotopes, whether for clinical use or research, has restricted research isotope production and radiopharmaceutical research. For targeted radiopharmaceuticals to have a larger role in cancer treatment, the following key issues must be resolved: more stable labeling methods for alpha emitters, particularly actinium-225 and astatine-211, to maximize the therapeutic potential of therapeutics labeled with these radionuclides. The radionuclides most frequently described as being essential to nuclear medicine research includes actinium-225. Several of the research radionuclides are not being produced in sufficient quantities to meet the research demand.

The U.S. National Isotope Program: Current Status and Strategy for Future Success (American Nuclear Society, March 2005). Overall, this report found that the U.S. isotope program is in a state of crisis, and immediate action is needed to address the major program issues. The issues specifically directed at the Department include:

Appendix 2 (continued)

- Research & Development (R&D) isotopes are not available at reasonable prices due to declining resources and policy change in the Department's Isotope Program.
- Elimination of Department R&D funding is impacting development of future isotope applications; and,
- Failure to provide the necessary leadership to reverse the decline of the Department's Isotope Program.

Appendix 3

Department of Energy
Washington, DC 20585

MAR 2 7 2008

MEMORANDUM FOR GREGORY FRIEDMAN
INSPECTOR GENERAL

FROM: C.H. ALBRIGHT, JR.
UNDER SECRETARY OF ENERGY

RAYMOND L. ORBACH
UNDER SECRETARY FOR SCIENCE

SUBJECT: Draft Report on "Meeting Medical and Research Needs for Isotopes Derived from Uranium-233"

This memorandum is in response to the subject draft report issued on February 12, 2008. We appreciate the opportunity to comment on the findings identified in, and the recommendations resulting from, the Inspector General's (IG) review. We have reviewed the IG's recommendations and have concerns that many of the corrective actions directed in the report have been previously implemented. Further, the current disposition strategy of the Uranium-233 material has been directed by Congress. Alterations to the current strategy would have a significant impact on the safety and security postures in Building 3019 at ORNL and would require a change in Congressional mandate.

Recommendation 1, which calls for analyses to assess the costs and benefits associated with using Uranium-233 to produce progeny isotopes, has been largely addressed through previous evaluations. The Office of Science (SC) will employ a merit-based, peer review process to examine the needs and priorities for production of progeny isotopes discussed in this report, in the context of the broader needs for other research isotopes, and alternative production technologies.

SC's proposed peer review process for determining needs and priorities for research isotopes is consistent with Recommendation 2, which directs the Department to identify funding sources to meet the demand for isotopes discussed in the report. In addition, the Department is working with the National Institutes of Health to address the recommendations of the National Academy of Sciences pertaining to the production of research isotopes in the broader context of needs across both industry and research.

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Appendix 3 (continued)

Should Congress direct a new strategy for the disposition of Uranium-233, DOE will work to establish a new framework for the disposition of the material. This approach is consistent with Recommendation 3, which directs the Department to identify an appropriate Programmatic Secretarial Office (PSO) to take responsibility for the material if a decision is made to use Uranium-233 for isotope production,

The attached comments on the draft report include the perspectives of the Office of Nuclear Energy, the Office of Science, and the Office of Environmental Management.

Attachments

cc: T. Harms, S-3
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bcc: J. Boone, EM-6
J. Venneri, SC-41
J. Miller, ORO

Appendix 3 (continued)

Comments on
Inspector General Draft Report
"Meeting Medical and Research Needs for Isotopes Derived from Uranium-233"

We recommend that the Under Secretary of Energy, working with the Under Secretary for Science:

Recommendation 1

Prior to disposal of the Department's inventory of Uranium-233, evaluate the costs and benefits of: a.) retaining the Uranium-233 for the production of progeny isotopes; b.) extracting the Thorium-229 and continuing with disposition of the Uranium-233; or c.) producing progeny isotopes using other technologies, such as an accelerator or reactor.

Management Comment

The current course of action for disposition of Uranium-233 has been recently reviewed and endorsed by the Department; in addition, there are significant safety and national security drivers for the disposition project. Subsections a) and b) of this recommendation are not supportable since the report does not fully explore or properly recognize these actions.

The Department has evaluated and documented costs associated with retaining the Uranium-233 for the production of progeny isotopes, as well as extracting the Thorium-229 and continuing with the disposition of the Uranium-233. In 2005, at the direction of Congress, the Department re-scoped the Uranium-233 project to terminate isotope extraction and expedite down blending and disposal of this material. It must be noted that Congress has registered its opposition to continued extraction of Thorium-229 from Uranium-233 prior to disposal. The facility design is being finalized and facility construction is scheduled to begin in 2009; Uranium-233 processing activities are scheduled to begin in 2012. The Nuclear Materials Disposition and Consolidation Coordination Committee (NMDCCC) undertook a rigorous process in consultation with all elements of the Department which reviewed the disposition plans for Uranium-233 and recommended continuation of the disposition activities; this recommendation was accepted by the Department. There are no additional facts in this report that provide a basis for further studies or estimates prior to proceeding with disposal of the Uranium-233 material. Moreover, there is no mandate, nor is funding available, to alter the current disposition strategy for Uranium-233.

Changing the current strategy would invite significant cost, schedule, safety and national security issues. For example, if it is decided that the Thorium-229 extraction process should be revisited, the Department would incur costs for the revised design, as well as costs associated with the resulting delays to the current project schedule. In addition to those project costs attributable to schedule delays, any delay in the project will increase safety and security costs dramatically.

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Appendix 3 (continued)

In the area of safety, timely completion of this project is required in partial response to the Defense Nuclear Facilities Safety Board (DNFSB) recommendation 1997-1 which identified concerns with the integrity of packaging of the Uranium-233 materials, and required an extensive program of inspection and repackaging to ensure the continued long-term safety of the material in storage. Subsequent inspection activities have satisfied the DNFSB's concerns regarding the long-term safety of the material. However, delays in the project will re-open the question of long-term safety and force the Department to revisit the DNFSB recommendation.

In the area of security, approximately $5M per year is expended to deal specifically with the security issues associated with Building 3019. Delay in the execution of this project will not only result in incurring these costs over a longer, indefinite period but require significant additional one-time security costs (~$25M) as well as an escalation of the $5M annual costs to about $15-20M per year. This is because the execution of this project in a timely fashion is a key to satisfying the requirements for meeting the design basis threat (DBT) in Building 3019. Delays in the project will result in the need to re-open this issue and will require additional security expenditures.

The Department's FY 2009 Congressional budget request transfers responsibility for the Medical Isotopes program from the Office of Nuclear Energy to the Office of Science, and includes additional funds for research isotope development and production in response to the needs of the scientific community for commercially-unavailable research isotopes. The Department's current policy for production of isotopes, including research isotopes, is that the production costs must be fully recovered from the customers; as such, the Department does not produce isotopes speculatively. The Office of Science, beginning in FY 2009, will examine the production of progeny isotopes discussed in this report using other technologies, such as an accelerator or reactor. The ultimate decision on whether to produce research isotopes will depend upon a merit-based peer review process. However, a decision to use Uranium-233 to produce isotopes will also require a new Congressional mandate.

Recommendation 2

Work with the Office of Management and Budget and Congress, as necessary, to identify funding sources and approaches to meet demands for the isotopes discussed in the report.

Management Comment

The Department's FY 2009 Congressional budget request transfers responsibility for the Medical Isotopes program from the Office of Nuclear Energy to the Office of Science. If approved by Congress, SC will determine the development and production of research isotopes by peer review, consistent with other basic research efforts within SC. The peer review will be based on established criteria including, but not limited to, non-proliferation and national security concerns, prioritized interest by the nuclear medicine and broader research community, costs, safety concerns, whether specific isotopes can be

DM#182228

Appendix 3 (continued)

obtained through more desirable alternative methods, programmatic interests, and budget needs and constraints.

SC, working with NE, has established a Working Group with the National Institutes of Health to address the recommendations of the National Academy of Science's report, and has initiated preparations for a workshop to bring together industrial, federal, and research stakeholders to discuss the needs, priorities, and potential paths-forward for meeting the U.S. commercial and research isotope needs.

Peer review and NIH working group activities designed to identify funding sources and approaches to meet demands for research isotopes will take place during FY 2008 and FY 2009. The earliest the outcome of these efforts may be reflected with regards to the Office of Management and Budget and Science will be the FY 2011 budget formulation process.

Recommendation 3

Identify an appropriate Programmatic Secretarial Office to take responsibility for the material or identify means whereby industry can assume custody of the material if the decision is made to retain or extract isotopes from the Uranium-233.

Management Comment

The Office of Environmental Management (EM) currently has responsibility for the disposition of the material, and will continue to move toward disposal, as directed by Congress, until such time that Congress directs an alternative disposition pathway. Should Congress provide new direction and funds to the Department to pursue the production of progeny isotopes using Uranium-233 (either through extraction of Thorium-229 or other means) then DOE will establish a new framework for the disposition of the material.

DM#182228

IG Report No. DOE/IG-0795

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Office of Inspector General
Office of Audit Services

Audit Report

The Disposition of Uranium-233 at Oak Ridge National Laboratory

DOE/IG-0834 February 2010

Department of Energy
Washington, DC 20585

February 18, 2010

MEMORANDUM FOR THE SECRETARY

FROM: Gregory H. Friedman
Inspector General

SUBJECT: INFORMATION: Audit Report on "The Disposition of Uranium-233 at Oak Ridge National Laboratory"

BACKGROUND

As a result of the Department of Energy's nuclear weapons program legacy, its Oak Ridge National Laboratory (ORNL) stores about 1.4 metric tons of uranium containing 450 kilograms of uranium-233 (U-233). The material is currently stored in a deteriorating facility at ORNL that is over 60 years old. Because of its highly radioactive and dangerous properties, the U-233 is stored in a shielded storage location and must be handled in hot cells to protect workers from exposure. Since there were no programmatic uses for the material, the Department initiated efforts to dispose of it in 2001. In 2003, however, the conferees to the Fiscal Year 2003 Omnibus Appropriations Act authorized the extraction of thorium-229, a material that is useful in medical and research isotope production, prior to disposal of the U-233.

In response, the Office of Nuclear Energy (NE) developed a three-phased approach for the thorium extraction process. In October 2003, NE awarded a contract to Isotek Systems, LLC (Isotek), to plan and design the facilities needed to extract the thorium and process the U-233 into a stable form for storage. In November 2005, however, the conferees to the Fiscal Year 2006 Energy and Water Appropriations Act directed the Department to terminate thorium extraction and to transfer responsibility for management and disposition of the U-233 to the Office of Environmental Management (EM), effectively ending any potential for obtaining medical research isotopes from this process. EM began managing the project and the Isotek contract, focusing on the processing and subsequent disposal of the U-233 at the Department's Waste Isolation Pilot Plant (WIPP). EM approved the project's $384 million performance baseline on May 25, 2007, and authorized long-lead procurements and dismantlement activities in preparation for facility construction. Due to the risk associated with this disposition effort, we initiated this audit to determine whether the Department had adequately managed the U-233 disposition project.

RESULTS OF AUDIT

The Department's U-233 disposition project had encountered a number of design delays, may exceed original cost estimates, and will likely not meet completion milestones. In particular, our testing revealed that:

- Despite four years of effort by EM and the expenditure of about $36 million, project planning and design had yet to be completed; and,

- The cost baseline was approved relying on inaccurate assumptions and, thus, is likely to be unreliable.

EM initially established the performance baseline and authorized long-lead procurements and dismantlement activities in preparation for facility construction based on Isotek's claim that the project's design satisfied the Department's requirement for maturity, i.e., the design was 60 percent complete. Even though the Department's project management order requires the completion of a design review prior to baseline approval, EM elected to approve the baseline, a critical project milestone, without validating the status of the design work. EM officials told us that they had considered previous design reviews that were completed prior to the change in project scope.

When EM ultimately completed the required design review in December 2007, some seven months after it approved the performance baseline, it discovered that the design was more likely in the early preliminary design stage rather than at the 60 percent design threshold. At that point, reviewers concluded that the contractor had based portions of the design on unverified assumptions in certain areas, and that once safety analyses were completed, additional review and possible design rework would be required. Further, it was not until July 2008 that the Department realized it had inaccurately assumed and reported to Congress in February 2006 that the deletion of thorium extraction would have very little effect on design. In fact, not extracting thorium had a significant effect on the amount of shielding that is now required and led to considerable design changes, including the construction of a new annex facility. EM completed another design review in September 2009 and concluded that additional work was still needed to reach the 60 percent design stage of maturity.

Problems with Federal leadership of the project, at least in part, contributed to delays in completing design and establishing a viable cost baseline. For example, after the direction to abandon thorium-229 extraction, EM had not ensured that the contract with Isotek was consistent with the new scope of work, a situation that impacted its ability to hold the contractor accountable. Further, since taking over the project in 2005, EM had assigned 5 different Federal project directors, with 4 different managers involved in the first 22 months of the project. The frequency of the change in leadership contributed to EM not providing a timely review of the contractor's preliminary design. Finally, program officials did not ensure that the contractor implemented controls necessary for timely completion of the design phase of the project. For example, even though it determined in 2006 that the contractor did not have a certified earned value management system to measure actual performance against baselines, EM did not compel the contractor to take effective corrective action. Notably, Isotek did not have a certified system in place until September 2009.

In addition to performance and monitoring problems, we also learned that the project now faces additional challenges related to the radioactive constituents believed to be contained in the U-233. Program officials indicated that reconsideration of the design was necessitated by a January 2009 discovery that despite previous assumptions regarding the U-233 inventory, the material did not contain a sufficient amount of plutonium to qualify it for disposition in WIPP. In

March 2009, EM changed the waste process and the disposition path deciding instead to send the material to the Nevada Test Site. EM is continuing efforts to develop a waste form that will meet the Nevada Test Site Waste Acceptance Criteria. In addition to cost considerations, further disposition delays could potentially increase environmental and safety risks associated with the U-233.

EM management has recently acted to provide consistent management oversight to the project and has worked with the contractor to correct long-standing problems such as the absence of a certified earned value management system. To address the issues described in our report, we made several recommendations intended to increase the likelihood that the project is completed in a timely and successful manner.

MANAGEMENT REACTION

EM concurred with the report's recommendations but noted that actions necessary to correct issues with project leadership and management had been completed. However, management agreed that it would closely monitor contractor performance until recent concerns that have surfaced with the project's design and cost controls can be adequately addressed. Specifically, recent U-233 project status reports indicate that there are still major concerns with the contractor's final design progress, its ability to meet cost or schedule milestones for final design, the confidence that can be placed in the contractor's earned value management system, and concerns in the areas of design configuration control, subcontractor oversight, and procurement. Management's proposed actions, designed to help ensure the contractor's design and project baseline can be successfully completed and approved, are generally responsive to our recommendations.

Attachment

cc: Deputy Secretary
Under Secretary of Energy
Chief of Staff
Assistant Secretary for Environmental Management, EM-1
Manager, Oak Ridge Office
Audit Liaison, Environmental Management, EM-33
Audit Liaison, Oak Ridge Office, SC-OR

REPORT ON THE DISPOSITION OF URANIUM-233 AT OAK RIDGE NATIONAL LABORATORY

TABLE OF CONTENTS

Management of the Uranium-233 Project

Details of Finding 1

Recommendations and Comments 4

Appendices

1. Objective, Scope, and Methodology 6
2. Prior Audit Report 8
3. Management Comments 9

MANAGEMENT OF THE URANIUM-233 PROJECT

Project Design and Implementation

Despite the expenditure of about $36 million and four years of effort by the Office of Environmental Management (EM), project planning and design had yet to be completed for the Department of Energy's (Department) uranium-233 (U-233) disposition project. In particular, the project had encountered a number of design delays, may exceed original cost estimates, and will likely not meet completion milestones. Additional design issues may develop because original assumptions regarding waste constituents have proven to be incorrect.

Facility Design and Baseline Development

Although EM approved the U-233 disposition project performance baseline and authorized the start of long-lead procurements and dismantlement activities in May 2007, design of the disposition facilities has not progressed as planned. Major factors impacting performance were that the project's cost baseline was approved based on inaccurate assumptions, and as such was not being used by EM to manage the project at the time of our review.

EM approved the performance baseline and granted Isotek Systems, LLC (Isotek), approval to start long-lead procurements and dismantlement activities in May 2007 despite the fact that the project lacked a mature design. Even though the Department's project management order requires the completion of a design review prior to baseline approval, EM elected to approve the baseline, a critical project milestone, based on the results from prior design reviews and did not validate the status of the design work. These reviews were performed by the Office of Nuclear Energy (NE) prior to changes in project scope that were mandated by Congress in November 2005. When EM ultimately completed the required design review in December 2007, some seven months after it approved the performance baseline, it discovered that the design was more likely in the early preliminary design stage rather than at the 60 percent design stage. Reviewers concluded that the contractor based portions of the design on unverified assumptions in the civil/structural, mechanical and piping, and the electrical and instrumentation and control areas. The review report noted that once safety analyses were complete, these areas would require review and potential design rework.

While design work had matured to some extent by July 2008, EM determined that the design of components for the final processing and packaging of the waste form component of the project was still only about 30 percent complete. Specifically, the Department realized it had inaccurately assumed and reported to Congress in

February 2006 that the deletion of thorium extraction would have very little effect on design. In fact, not extracting thorium had a significant effect on the amount of shielding that is now required. This resulted in significant design changes and the decision to move drying and packaging operations to a new annex facility. These operations were moved from the original location in Building 3019A because the building structurally could not support the shielding requirements. In September 2009, after an additional year of effort, EM gained sufficient confidence in the design to begin another review. However, EM completed that review and concluded that additional work was still needed to reach the 60 percent design stage of maturity. The Department indicated that it would not complete another life cycle cost estimate until it conducts a 90 percent design review, an event expected to begin in 2010.

Project Management

Delays in completing the design and uncertainty about the eventual cost of the project were caused, at least in part, by inconsistent Federal leadership resulting in inadequate contractor oversight. Additionally, EM did not ensure that the contractor's partnership was properly structured to manage the project.

Consistent Federal Leadership

Since taking over the project in 2005, EM has not ensured that appropriate Federal leadership was applied to the project. Notably, EM assigned five different Federal project directors in the four plus years that it has managed the effort. The project was managed by 4 separate directors in the first 22 months of its life. In some cases, the project director had other responsibilities which prevented adequate oversight of the project. An August 2006 External Independent Review, for example, noted that the project did not have a permanent Federal project director. Rather, the assistant site manager was the designated Federal project director. Because of the extent of his other duties, this individual was not able to devote the requisite attention to Federal project director's tasks.

Federal project director continuity problems impacted EM's ability to complete a timely review of the contractor's preliminary design and to ensure that the contractor had controls in place necessary for timely completion of the design phase of the project. As previously noted, EM did not review the contractor's design, as required by the Department's project management order 413.3A, before approving the performance baseline. In fact, EM did not perform the design review until seven months after approving the

baseline. Additionally, EM did not ensure that the contractor implemented quality assurance and earned value management systems. EM determined in 2006, for example, that in spite of specific requirements to the contrary, the contractor did not have a certified earned value management system to measure actual performance against performance baselines. The Department's project management order specifically conditions approval of the project baseline on having such a system in place. EM also did not ensure that Isotek took effective corrective action to resolve the previously observed weakness. A particularly troubling example of this lack of action was the fact that the contractor did not have a certified earned value management system until September 2009.

Finally, EM had not ensured that the contract with Isotek was consistent with the scope of work actually being performed by the contractor, a situation that impacted its ability to hold the contractor accountable. Since taking over the project in November 2005, EM had been managing the project under the contract negotiated with Isotek by NE. This contract required thorium extraction and storage rather than the treatment and disposition of the U-233. It was not until September 2007 that EM modified the contract to properly reflect the changed scope of work that eliminated thorium extraction and focused work on processing the inventory for disposal.

Contractor Structure

Even though it assumed responsibility for managing the Isotek contract in 2005, EM did not act promptly to ensure that Isotek, a limited liability company, was organized to effectively manage the project. Specifically, Isotek was a partnership composed of three companies with no single partner having a controlling interest in the company until November 2007. We concluded that the lack of clear lines of authority in the partnership structure contributed to known quality assurance problems in the design phase of the project. Isotek had an inadequate oversight infrastructure in place to resolve a continuing deficiency in the design partner's implementation of an appropriate quality assurance program. In fact, it was not until September 2008 that the contractor's management structure was changed to better oversee the project. After the management restructure, Isotek acted in October 2008 to correct problems with the design partner, including the lack of a quality assurance program that they first detected in 2004.

Impact on Cost and Risk

In addition to performance and monitoring problems, we learned that the project now faces additional challenges related to the radioactive constituents believed to be contained in the U-233. Program officials indicated that reconsideration of the design was necessitated by a January 2009 discovery that despite previous assumptions regarding the U-233 inventory, the material did not contain a sufficient amount of plutonium to qualify it for disposition at the Department's Waste Isolation Pilot Plant. In March 2009, EM changed the waste process and the disposition path to the Nevada Test Site and is continuing efforts to develop a waste form that will meet the Nevada Test Site Waste Acceptance Criteria.

As we have demonstrated in a number of contract management reviews in the past, poor project administration and performance frequently increase total project costs. In November 2008, for example, the project's contractor proposed a revised cost baseline of $477 million, a cost increase of approximately $93 million. Because the project baseline was approved based on faulty assumptions related to design maturity, we were unable to specifically determine whether these increases will ultimately materialize. EM has not approved the contractor's proposal pending its decisions regarding process design changes and the outcome of future design reviews, and as such, cannot determine the total cost of the project. In addition to cost and schedule impacts, further disposition delays also potentially increase environmental and safety risks associated with U-233 identified by the Defense Nuclear Facilities Safety Board in 1997.

RECOMMENDATIONS

EM management has recently acted to provide consistent project management oversight to the project and has worked with the contractor to correct long-standing problems such as the absence of a certified earned value management system. In order to help ensure the timely and successful completion of the U-233 disposition project, we recommend that the Assistant Secretary, Environmental Management, ensure that:

1. Consistent and adequate Departmental leadership is maintained;

2. The contractor's performance on the U-233 disposition project provides a sound basis for final design and baseline approval, as required by Departmental project management orders; and,

3. Future limited liability companies have a majority ownership partner and are structured to provide adequate leadership over the project.

MANAGEMENT AND AUDITOR COMMENTS

EM concurred with the report and its recommendations and stated that all actions necessary to close Recommendations 1 and 3 were complete. Regarding Recommendation 1, EM stated that the current Federal project director has provided consistent leadership for more than 20 months. In response to Recommendation 3, EM explained that they evaluate the management structure of limited liability companies as an element in the Request for Proposal evaluation criteria. Additionally, EM requires the limited liability companies to identify a single point of contact to address contract and project matters.

During an exit conference to discuss management's comments on a draft of this report, regarding Recommendation 2, EM asserted that the U-233 disposition project is currently being managed in accordance with Departmental project management orders; however, continuing concerns identified in the area of project management were the direct result of poor contractor performance. In December 2009, the Federal project director informed EM of major concerns with the contractor's progress on the project's final design. Specifically, the project director noted that the contractor will not meet its cost or schedule milestones for final design, an issue that, in our opinion, calls into question the confidence that can be placed in the ability of the contractor's earned value management system to keep the project on track. In January 2010, additional concerns were identified in the areas of design configuration control, subcontractor oversight, and procurement.

We clarified Recommendation 2 to more accurately emphasize the role that the contractor's performance has played in project delays and cost increases. As a result, EM agreed to keep Recommendation 2 open until the contractor's 90 percent design review and project baseline can be successfully completed and approved, respectively.

We consider management's comments generally responsive to our recommendations.

Appendix 1

OBJECTIVE

The objective of this audit was to determine whether the Department of Energy (Department) had adequately managed the Uranium-233 (U-233) project.

SCOPE

We conducted the audit from November 2008 to December 2009 at Department Headquarters in Washington, D.C., and the Oak Ridge Office in Oak Ridge, Tennessee. The audit scope included U-233 disposition efforts since November 2005 when the project was transferred from the Office of Nuclear Energy to the Office of Environmental Management (EM).

METHODOLOGY

To accomplish the audit objective, we:

- Reviewed regulations, directives, contract requirements, and performance measures relating to the U-233 disposition project;
- Determined and evaluated the current status of the U-233 disposition project;
- Reviewed the baseline and other project management tools associated with the disposition project;
- Evaluated internal controls associated with the U-233 project;
- Reviewed prior audits and reviews relating to the disposition project; and,
- Held discussions with key Department and contractor officials responsible for dispositioning the U-233.

We conducted this performance audit in accordance with generally accepted Government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objective. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objective. The audit included tests of controls and compliance with laws and regulations necessary to satisfy the audit objective. Because our review was limited, it would not necessarily have disclosed all internal control deficiencies that may have existed at the time of our audit. The U-233 disposition project did not meet all of its specific

Appendix 1 (continued)

performance measures in 2009 associated with the *Government Performance and Results Act of 1993*. Also, we did not rely upon computer processed data to accomplish our audit objective.

An exit conference was held with EM's Deputy Assistant Secretary for Program and Site Support on February 3, 2010.

Appendix 2

PRIOR AUDIT REPORT

- *Meeting Medical and Research Needs for Isotopes Derived from Uranium-233* (DOE/IG-0795, May 2008). The Office of Inspector General determined that the Department of Energy (Department) would not have sufficient quantities of uranium-233 (U-233) and its progeny isotopes to support U.S. medical and research needs. The Department is the only domestic producer of progeny isotopes from U-233 and current production is insufficient to meet medical and scientific research needs. At present, no viable alternative methods of production of actinium and bismuth have been demonstrated or proven. U-233 also is used to support other Department missions such as the National Nuclear Security Administration's Test Readiness Program.

Department of Energy
Washington, DC 20585
January 15, 2010

MEMORANDUM FOR GEORGE W. COLLARD
ASSISTANT INSPECTOR GENERAL
FOR PERFORMANCE AUDITS
OFFICE OF INSPECTOR GENERAL

FROM: INÉS R. TRIAY
ASSISTANT SECRETARY FOR
ENVIRONMENTAL MANAGEMENT

SUBJECT: Draft Audit Report on "The Disposition of Uranium-233 at Oak Ridge National Laboratory"

This memorandum responds to your December 16, 2009, memorandum requesting review and comments on subject draft audit report (IG-32 A09ET008). The Office of Environmental Management (EM) appreciates the opportunity to provide comments. EM has no comments on the report.

EM concurs with all three of the recommendations contained in the draft audit report. EM has been working closely with the Department of Energy, Office of the Inspector General (DOE-IG) on this audit; therefore, we believe that the actions taken to date are in-line with the recommendations received from the IG and the recommendations are considered to be complete.

Currently, the Uranium-233 (U-233) Material Downblending and Disposition Project at Oak Ridge National Laboratory (ORNL) is operating to the November 2008 proposed baseline as an interim baseline until design reaches 90 percent maturity. At that time, a new estimate and baseline change proposal will be developed.

RECOMMENDATIONS

Recommendation 1: Consistent and adequate Departmental leadership is maintained.

Action Plan: *The current Federal Project Director (FPD) was appointed in April 2008 and has provided consistent project leadership for over 20 months. In addition, a Deputy FPD position was added to the team in November 2008 and has been filled by the same person for the last 14 months. This has provided project continuity while also supporting succession planning in the event other changes in project management (i.e., retirement, promotion, or other career opportunity) take place.*
Estimated Completion Date: *Complete.*

Printed with soy ink on recycled paper

Recommendation 2: Project management complies with Departmental management orders.

Action Plan: *The U-233 Material Downblending and Disposition Project is currently being managed under DOE Order 413.3. The current Federal Project Director (FPD) was certified as a Level 3 FPD through the Project Management Career Development Program (PMCDP) in September 2008; this is the appropriate level of certification for the project. The Deputy FPD and another full-time project staff member were certified as Level 1 through the PMCDP in November 2009. To maintain certification, 60 hours of continuing education must be completed every two years.*
Estimated Completion Date: *Complete.*

Recommendation 3: Future limited liability companies have a majority ownership partner and are structured to provide adequate leadership over the project.

Action Plan: *The approach that EM has taken with respect to limited-liability companies (LLC) is to evaluate the LLC management make-up as an element in the Request for Proposals (RFP) evaluation criteria. This is included as part of the management plan. EM-HQ also has a clause for the LLC to identify a single point of contact (POC) to address contract and project matters. With respect to the U-233 contractor, EM has ensured the voting rights of Isotek Systems, LLC member companies were restructured so EnergySolutions had majority voting rights. As a result, EnergySolutions became the single point of accountability for the Department on this project.*
Estimated Completion Date: *Complete.*

If you have any further questions, please contact Mr. Fred Butterfield of my staff at (202) 586-3110.

cc:
G. Boyd, ORO
J. Echenberg, ORO
T. Pooler, ORO
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IG Report No. DOE/IG-0834

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CHINESE ACADEMY OF SCIENCES AND U.S. DEPARTMENT OF ENERGY

COOPERATION IN NUCLEAR ENERGY SCIENCES AND TECHNOLOGIES

FIRST EXECUTIVE COMMITTEE MEETING

October 22, 2012
Shanghai, China

Summary Meeting Report

Table of Contents

1. INTRODUCTION 3

2. EXECUTIVE COMMITTEE MEETING HIGHLIGHTS 5

3. WORKING GROUPS ACTIVITIES SUMMARY 8

3.1 MOLTEN SALT COOLANT SYSTEMS 8

3.2 FUEL RESOURCES 13

3.3 NUCLEAR HYBRID ENERGY SYSTEMS 17

ATTACHMENT A: NUCLEAR ENERGY COORPRATION AGREEMENT BETWEEN THE CAS AND DOE 19

ATTACHMENT B: ORGANIZATIONAL OVERVIEW AND CO-CHAIRS RESPONSIBILIYTIES 29

ATTACHMENT C: EXECUTIVE COMMITTEE MEETING AGENDA 32

ATTACHMENT D: LIST OF MEETING ATTENDEES 34

ATTACHMENT E: OVERVIEW PRESENTATION FROM TECHNICAL COORDINATION CO-CHAIRS 36

ATTACHMENT F: MOLTEN SALT COOLANT SYSTEMS WORKING GROUP PRESENTATIONS 47

ATTACHMENT G: FUEL RESOURCES WORKING GROUP PRESENTATIONS 70

ATTACHMENT H: NUCLEAR HYBRID ENERGY SYSTEMS WORKING GROUP PRESENTATION 95

1. Introduction

Nuclear energy is an indispensable energy source for mitigating the threats of climate change as well as ensuring energy security. In June 2011, Dr. Peter Lyons, Assistant Secretary for Nuclear Energy, U.S. Department of Energy (DOE) met with Dr. Mianheng Jiang, then Vice President of the Chinese Academy of Sciences (CAS) in Beijing, China. Drs. Lyons and Jiang both recognized the growing need for developing nuclear energy as a clean and emission-free energy sources and the importance of nuclear safety. Both sides also agreed that further collaboration in nuclear science and technology will advance innovative nuclear technology developments and enhance nuclear safety objectives for both countries.

Subsequently, Dr. Zhiyuan Zhu of CAS and Dr. Stephen Kung of DOE were appointed as the lead contact persons to explore and develop an implementation mechanism for the collaboration. In September 2011, a draft Memorandum of Understanding (MOU) Agreement for Cooperation in Nuclear Energy Sciences and Technologies between DOE and CAS was presented by Dr. Kung to CAS in Shanghai. In November 2011, a CAS delegation led by Dr. Zhiyuan Zhu visited Washington D.C. and Oak Ridge National Laboratory in Tennessee, USA. During this visit, the MOU agreement was finalized by both sides.

Dr. Peter Lyons and Dr. Jinghai Li, CAS Vice President, representing the respective country, signed the MOU agreement in Washington D.C. and Beijing, respectively, in December 2011. A copy of the signed CAS-DOE Nuclear Energy Sciences and Technologies agreement is included in Attachment A. The agreement establishes an official framework to enhance cooperation in nuclear energy sciences and technologies and is expected to foster nuclear energy collaborations among scientists, laboratories, research institutes, and universities of both the United States and China.

The execution of the agreement is guided by an Executive Committee consisting of a co-chair from DOE and CAS, respectively. The Executive Committee co-chairs represent their respective country to provide high-level management oversight of the cooperation activities, which are approved by the Executive Committee co-chairs on an annual basis. One technical coordinator from each country is designated to manage and oversee the execution of the approved cooperative activities. Two cooperation areas: (1) nuclear energy for non-electric applications, including materials and chemistry of molten salt coolant systems, (2) nuclear fuel resources with a focus on direct extraction of dissolve uranium from seawater, were identified as initial collaboration activities under the agreement. The area of cooperation may be expanded and revised by the Executive Committee via written consent.

Drs. Mianheng Jiang and Peter Lyons serve as the inaugurate co-chairs of the Executive Committee. Drs. Zhiyuan Zhu and Stephen Kung are designated as technical coordinators to jointly plan, coordinate, facilitate, monitor, and assess the cooperative activities that are approved by the Executive Committee. Three working groups are currently established under the auspices of the CAS-DOE Nuclear Energy Sciences and Technologies MOU agreement. They are: Molten Salt Coolant Systems Working Group, Nuclear Fuel Resources Working Group and Nuclear Hybrid Energy Systems Working Group. Working group co-chairs are

tasked to organize and implement approved collaborative activities. A current management organization structure of the MOU agreement is provided in Attachment B.

It should be noted that although the Nuclear Hybrid Energy Systems working group was managed under the nuclear energy MOU agreement, its work scope is formally governed by a Science Protocol Agreement signed between CAS and DOE in January 2011. Initially, it was the intent of both countries to include all collaborative activities under the Science Protocol Agreement. However, DOE Office of General Counsel advised that the Molten Salt Coolant Systems and the Fuel Resources activities should not be included in the Science Protocol Agreement. This is because the nuclear energy technologies may involve nuclear export control issues which are not currently covered by the scope under the DOE-CAS Science Protocol Agreement. Nevertheless, the co-chairs of the Nuclear Hybrid Energy Systems Working Group attended a Joint Coordinating Committee meeting under the Science Protocol Agreement in April 2012 in Beijing, China. At the Protocol agreement meeting, both countries agreed to continue exploring the development of hybrid system designs and identification of hybrid systems related technology gaps, needs, and potential collaboration activities.

The first Executive Committee meeting under the auspice of CAS-DOE Nuclear Energy Sciences and Technologies agreement took place at CAS' Institute for Advanced Studies Conference Center on October 22, 2012. The inaugural Executive Committee co-chairs, Drs. Mianheng Jiang and Peter Lyons, presided over the meeting. Two technical coordinators, Drs. Zhiyuan Zhu and Stephen Kung, served as the meeting moderators. Working group co-chairs from both China and U.S. delivered presentations in their pertinent areas of common interests. Working group co-chairs also summarized their past achievements and future cooperation plan. A discussion session followed immediately after the presentations from the working groups. The Executive Committee meeting agenda is provided in Attachment C with the list of meeting attendees in Attachment D.

The Executive Committee co-chairs reviewed and discussed the current status and progress of each working groups, and approved their proposed future collaborative activities. This report provides the meeting highlights and summarizes the working groups' activities.

2. Executive Committee Meeting Highlights

The Executive Committee meeting under the auspices of the CAS-DOE Nuclear Energy Sciences and Technologies MOU agreement was held on October 22, 2012, in Shanghai, China. The objectives of the meeting were for the Executive Committee co-chairs (1) to review the status and progress under the CAS-DOE Nuclear Energy Sciences and Technologies agreement, and (2) to approve future collaborative activities. Dr. Mianheng Jiang, President of the Shanghai branch, Chinese Academy of Sciences served as the official host of the Executive Committee meeting and co-chaired the meeting with Dr. Peter Lyons, Assistant Secretary for Nuclear Energy, U.S. Department of Energy. After a brief logistics announcement by Dr. Zhiyuan Zhu, the Executive Committee meeting started at 9:10 AM with an introduction of delegation members from each side.

Dr. Mianheng Jiang, on behalf of CAS, first welcomed Dr. Lyons and the U.S. delegation to the first CAS-DOE Nuclear Energy Sciences and Technologies Executive Committee meeting. In his opening remarks, Dr. Jiang indicated that CAS and DOE shared not only common interests in energy sciences, but also the forward-looking vision in addressing long-term energy challenges. The CAS-DOE Nuclear Energy Sciences and Technologies Cooperation agreement fits well with the strategic interests of both organizations.

Dr. Jiang emphasized the importance of China-U.S. nuclear energy science and technology cooperation and expressed his confidence to continue achieving success through joint efforts. He especially thanked the scientists and researchers from both sides for zealously participating in the cooperation engagements. Dr. Jiang encouraged all attendees to actively engage in the meeting discussion and provide actionable plans to strengthen the cooperation for the benefits of both countries.

Dr. Lyons, on behalf of U.S. delegation, thanked Dr. Jiang for hosting the inaugural DOE-CAS Nuclear Energy Sciences and Technologies Executive Committee meeting. Dr. Lyons stated that the Executive Committee meeting reaffirmed the commitment between the U.S. DOE and CAS in civil nuclear energy cooperation. As the two largest energy consumers in the world, the U.S. and China share the view that nuclear energy is indispensable as an energy source for combating climate change as well as ensuring energy security.

Dr. Lyons emphasized that it is the U.S. DOE's commitment to further strengthen and expand the cooperation in peaceful use of nuclear energy with China. Dr. Lyons further noted that both countries need to work together to continue enhancing nuclear safety and security so we can advance together. He very much looked forward to the progress reports and future plans presentations from the three working groups.

Mr. Jinghua Cao, CAS International Cooperation Bureau, made an added welcome speech immediately after the opening remarks. Then, Dr. Zhiyuan Zhu presented the background and timeline for the development of the Nuclear Energy Sciences and Technologies MOU agreement. Dr. Zhu's presentation also highlighted areas of cooperation, current working group breakout structure, organizational management and co-chairs responsibilities. The presentation

entitled "The CAS-DOE Cooperation in Nuclear Energy Sciences and Technologies Overview" is provided in Attachment E.

For the remainder of the day, working group co-chairs from CAS and DOE delivered presentations in their pertinent area of common interests and current activities. The three working groups also summarized the progress and future plans for the Executive Committee's review and approval. A general discussion session followed after the working groups' presentations. Detail information for each working group and its activities is documented in the next section entitled "Working Groups Summary."

The Executive Committee co-chairs recognized and commended the efforts and achievements made by the three technical working groups under the cooperation. The Executive Committee approved the proposed future collaboration activities, including the implementation details, presented by the working groups at the meeting. The technical coordinators are charged to jointly develop and oversee the approved working groups' activities.

In the closing remarks, both Drs. Lyons and Jiang noted that substantial collaborative activities have started since the agreement was signed. Both co-chairs expressed their satisfaction of the excellent teamwork and the full collaborative spirit; they were particularly encouraged to see the world's recognized experts working together to advance nuclear energy science and technology.

In their remarks, both co-chairs reemphasized that the collaboration between China and the U.S. on civil nuclear energy is a very high priority and that the CAS-DOE Nuclear Energy Sciences and Technologies MOU agreement enables both countries to further benefit by leveraging resources, scientific knowledge, and technical capabilities. They encouraged the researchers from DOE and CAS to continue coordinating and expanding joint efforts in nuclear energy developments for mutual benefits.

It is agreed that next year's Executive Committee meeting will be held in the United States. Dr. Lyons, on behalf of the U.S. DOE extended his most sincere invitation to all participants for attending the meeting next year. Currently, it is tentatively planned to hold the next meeting in October 2013 at Oak Ridge National Laboratory in Tennessee, USA. Both Drs. Jiang and Lyons look forward to another year of productive cooperation.

The first CAS-DOE Nuclear Energy Sciences and Technologies Executive Committee meeting ended at 4:00 PM. A group photo of the meeting participants was taken inside the meeting room immediately after the meeting was adjourned and is shown in Figure 1.

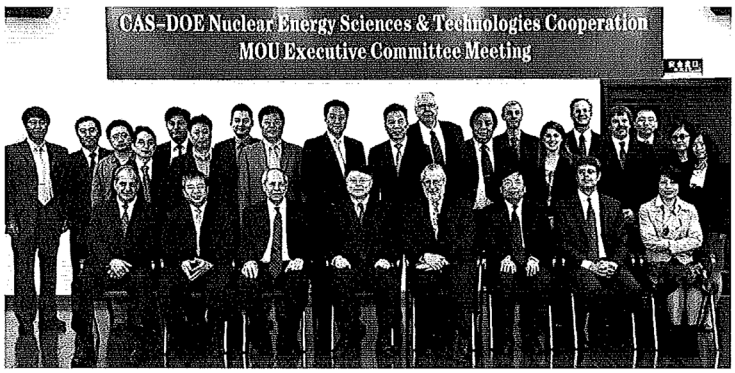


Figure 1. Participants in the first CAS-DOE Nuclear Energy Sciences and Technologies Cooperation MOU Agreement Executive Committee Meeting in Shanghai, China

On October 23, 2012, following the Executive Committee meeting, Dr. Lyons and the U.S. delegation visited the Jiading campus of the Shanghai Institute of Applied Physics (SINAP) where most of the DOE-CAS cooperative activities have been conducted. SINAP is a CAS institute of comprehensive researches in photon science, nuclear science and technology, and interdisciplinary studies, and in promoting industrial development of the scientific and technological achievements. The visit provided an opportunity to conduct a technical tour of the CAS' thorium molten salt reactor system. The U.S. delegation visited the coolant loop hydraulic and testing labs, materials research and testing facilities, molten salt chemistry and processing labs, reactor safety and computation facilities.

Accompanied by Dr. Jiang and his CAS colleagues, Dr. Lyons and some of the U.S. delegates traveled to visit the Sanmen nuclear power plant site in Sanmen County, Zhejiang Province following the SINAP visit. The Sanmen power plant site, where two Westinghouse AP1000 reactors are under construction, is the largest joint undertaking in nuclear energy between the U.S. and China. The Sanmen visit included tours of the containment and turbine buildings.

3. Working Groups Summary

This section provides a summary of the activities of each working group under the auspices of CAS-DOE Nuclear Energy Sciences and Technologies Cooperation MOU Agreement. It highlights key cooperation plans and accomplishment to date. It also documents the Executive Committee meeting presentations and discussion results, including specific proposed cooperation plans for each working group.

3.1 Molten Salt Coolant Systems

The Molten Salt Coolant Systems (MSCS) Working Group under the CAS-DOE agreement was formed to foster collaboration in areas of common interests for nuclear energy systems that use molten salt as coolant. The objectives of this working group are (1) to identify challenges and potential solutions in the areas of materials and components, salt chemistry, instrumentation, and safety for molten salt coolant systems; and (2) to jointly develop and implement research areas that will advance salt coolant technology maturity and facilitate technology deployment. This working group aims at promoting and facilitating cooperation in molten salt coolant technologies to further advance innovative high temperature nuclear energy applications.

Four technical experts currently serve as co-chairs for this working group. They are: Dr. Hongjie Xu of Shanghai Institute of Applied Physics (SINAP), Dr. Weiguang Huang of Shanghai Advanced research Institute (SARI), Dr. Cecil Parks of Oak Ridge National Laboratory (ORNL) and Dr. Charles Forsberg of Massachusetts Institute of Technology (MIT). The first information exchange meeting took place at ORNL in November 2011.

During the information exchange meeting, a 10-member Chinese delegation, led by Drs. Zhiyuan Zhu and Hongjie Xu of CAS, engaged with the U.S. researchers in a series of technical exchange presentations. Experts from each side also described the research and development (R&D) programs and highlighted technology deployment plans. The Chinese delegation toured several pertinent ORNL research facilities including the Chemistry and Materials Research labs, Molten Salt Loop Technology lab, the Spallation Neutron Source, High Flux Isotope Reactor, and the Radiochemical Engineering Development Center.

After the DOE-CAS Nuclear Energy Sciences and Technologies agreement was signed in December 2011, the first joint technical working group meeting was held in ORNL on April 11-12, 2012. During the April meeting, Dr. Hongjie Xu and his SINAP staff presented their most current program plans and shared potential collaboration scopes with the researchers from the U.S. side. The meeting identified common interests in collaborating on development and use of molten salt hydraulic test loops, conceptual plans for test reactors, component development and testing for molten salt systems, qualification of material for high temperatures (> 700 C), molten salt chemistry, and system safety and licensing issues.

The following proposed collaborative activities were discussed at the April 2012 meeting.

The US DOE has sponsored a three-year integrated research project (IRP) at universities to develop a pre-conceptual design of a fluoride-salt cooled high-temperature test reactor (FHR). As a follow up, the IRP planned to conduct workshops on FHR technologies

materials at the University of Wisconsin at Madison on August 29-30 and the test reactor requirements at MIT on November 1-2, 2012. CAS experts actively participated in these workshops and were involved in the FHR technical design discussions.

The CAS invited and hosted eight technical experts from U.S. national labs and academia to attend a technical review meeting on July 11-13 in Shanghai. The experts reviewed the CAS R&D plans for molten salt experimental flow loops and subsequent test reactors. The review team prepared a report of their observations and feedback that was submitted to CAS in October 2012. Dr. Jess Gehin of ORNL led/chaired the review team.

Dr. George Flanagan, the U.S. lead on safety and licensing of FHRs, invited CAS experts to participate in an organizing meeting on consensus of FHR safety standards. This activity was initiated under the auspices of the American Nuclear Society. The organizing meeting took place on June 24 in Chicago, IL, and a subsequent meeting was held on November 10, 2012 in San Diego, CA. Dr. Zhimin Dai of SINAP and Dr. Ed. Blandford of the University of New Mexico were named Co-Chairs for this standards activity.

The CAS is interested in utilizing Hastelloy-N, a high-temperature and corrosive-resistant material, to build a molten salt loop. Initial discussions between CAS and Haynes International on purchasing the material took place in China via Haynes' sales representatives. Since the purchase may involve U.S. export control issue, ORNL staff provided Haynes International with information on the CAS research program, and planned technology use for the material.

The CAS expressed an interest in exchange of students and early-career staff with US universities on collaborative research activities. An initial discussion was held with Dr. Per Petersen of the University of California – Berkeley (UC-B). One collaborative activity is to develop models to investigate any potential safety issues associated with the reactivity feedback mechanisms for the solid fuel Thorium Molten Salt Reactor (TMSR) baseline design. In particular, the enrichment of Li-7 was evaluated to assure a negative temperature reactivity coefficient. The possibilities of using other salts with attractive neutronic properties were also investigated. All of the UC-B analysis results were shared with the CAS. A workshop between UC-B and CAS was held on November 5-7 at UC-B to discuss molten salt heat transfer issues.

The implemented results of these activities were reported during the Executive Committee meeting on October 22, 2012. Lead working group co-chairs, Drs. Hongjie Xu and Cecil Parks also presented area of common interests and current activities from each country in the area of molten salt coolant systems during the Executive Committee meeting. The slides of the co-chairs' presentation are included in Attachment F.

The proposed future collaboration activities in the areas of molten salt coolant system development and design, FHR safety and licensing including tritium management, and studies on materials and components salt compatibility took place during the presentations. During the follow-up discussion, it was agreed that the safety standards which are applicable to molten salt cooled systems should be continued under the on-going ANS FHR Safety Standard Committee activities. In addition, it was decided that researchers should develop a joint collaboration and

evaluation plan to address the FHR hydraulic design and testing tools. A plan for experimental data and model validation needs should also be jointly pursued.

A student exchange internship program between CAS and US universities engaged in molten salt cooled reactor R&D was also discussed. Both sides decided to first develop a list of projects for the exchange students /staff to conduct. The activity may start once a mutually agreed implementation schedule is reached. It is agreed that exchange visits should be continued to strengthen the cooperation activities.

To strengthen the common interest in nuclear safety, CAS expressed a desire to explore adopting U.S. developed safety-related software for the reactor design and construction. The U.S. DOE agreed to investigate the software access options and plans to hold further discussions with CAS to identify a mutually agreeable mechanism. To further facilitate the development and deployment of CAS' Thorium Molten Salt Reactor (TMSR) program, CAS intends to establish a Cooperative Research and Development Agreement (CRADA) with ORNL in FY2013. ORNL and SINAP have initiated discussions on the implementation process. The CRADA may include activities such as review and analysis of TMSR test reactors and associated test loops designs, development of the flow meter and fission chamber, establishing a computer server at ORNL for SINAP researchers to access remotely.

CAS is also interested in exploring the study of rare earth and actinide halides chemical behaviors in molten salt during pyroprocessing. Both sides agreed to discuss the cooperation opportunity through visit of research facilities at Argonne and Idaho National Laboratories. A tutorial workshop on actinide/lanthanide concentration measurement in molten salt systems is planned to further explore the cooperation opportunity.

The agreed-to events under the auspices of Molten Salt Coolant System Working Group are shown in the table below.

China–USA Molten Salt Coolant System Working Group: Planned Milestones and Deliverables			
Task/Deliverable	**Subtask/Details**	**Location**	**Date**
Technical Meetings	Technical Information Exchange Meeting – exchange current activities in molten salt coolant systems	Oak Ridge, TN	Nov.7-8, 2011
	Working Group Meeting – experts meeting to explore potential cooperation	Oak Ridge, TN	April 12-13, 2012
	CAS program review meeting	Shanghai, China	July 11-13, 2012
	FHR Materials Workshop	Madison, WI	August 29-30, 2012
	FHR Test Reactor Requirements Workshop	Boston, MA	Nov. 1-2, 2012
	Molten Salt Heat Transfer meeting	Berkeley, CA	Nov.5-7, 2012
	2012 Executive Committee meeting	Shanghai, China	Oct. 22, 2012
	Lead Working Group Co-chairs meeting – planning of cooperation activities	San Francisco, CA	Jan. 28, 2013
	Technical visit & Information Exchange meeting	Shanghai, China	Feb. 25-26, 2013
	Working Group Meeting – discussion of current program status and development	China	April 2013
	FHR Workshop	US	TBD
	Executive Committee meeting	Oak Ridge, TN	Oct 2013
Exchanging Researchers	Initial discussion on staff exchange	US/China	2012
	UC-Berkeley staff starts working at CAS	Shanghai, China	2013
	CAS staff starts working at UC-Berkeley	Oak Ridge, TN	2013
FHR Safety Materials and Components for Molten Salt Loop	Initial Discussion on Consensus of FHR Safety Standards	Chicago, IL	June 24, 2012
	Meeting on FHR Safety and Licensing	San Diego, CA	Nov. 10, 2012

China–USA Molten Salt Coolant System Working Group: Planned Milestones and Deliverables			
Task/Deliverable	**Subtask/Details**	**Location**	**Date**
	Meeting on FHR Safety Standard and ASME Committee	TBD	2013
Materials, Chemistry and Components for Molten Salt Loop	Initial discussion on CAS Procurement of Hastelloy-N via Haynes International & Developing Purchase	US/China	2012 & 2013
	Review and Analysis of Molten Salt Test Reactors and Test Loops Designs	US/China	2013
	Evaluation and Testing of Salt Coolant Flow Meter and Fission Chamber	US/China	2013
	Discussions on TRISO Fuel and Salt Interactions	US/China	2013
	Safety and Hydraulic Analysis Software for Molten Salt Coolant Systems	US/China	2013
Molten Salt Chemistry for Pyrochemical Separations	Attending the 2012 International Pyroprocessing Conference	Fontana, WI	Aug. 26-29, 2012
	Meeting on Separation of Rare Earth and Actinide Halide in Salt and Pyro-facility Tour	Idaho falls, ID	May 2013
	Meeting for On-Line Monitoring in Molten salt and Pyro-facility Tour	Argonne, IL	May 2013
	Pyroprocessing Tutorial Workshop	Shanghai, China	2013

3.2 Fuel Resources

For nuclear energy to remain a sustainable energy source there must be assurance that an economically viable supply of nuclear fuel is available. Although uranium is present in very low concentrations in seawater (3.3 part per billion), the oceans contain over 4,500 million tons of uranium, which would last for centuries even with aggressive nuclear energy growth. Economic extraction of uranium from seawater could ensure a feasible fuel supply for nuclear power for millennia to come.

The Nuclear Fuel Resources Working Group was formed to jointly pursue the development of uranium extraction from unconventional resources. This group focuses on efforts to develop seawater uranium harvesting method. Initial cooperation centers on the following three specific topics: (1) molecular level understanding of uranium binding and computational design of new selective ligands; (2) development of advanced adsorbent materials (by radiation grafting); and (3) marine testing of the adsorbents capacity and kinetics of extraction of uranium from seawater.

Two technical experts from each country currently serve as the working group co-chairs. They are: Dr. Zhimin Dai of Shanghai Institute of Applied Physics (SINAP), Dr. Biao Jiang of Shanghai Advanced research Institute (SARI), Dr. Phil Britt of Oak Ridge National Laboratory (ORNL) and Dr. John Arnold of the University of California-Berkeley (UC-B).

Technical experts from both countries met at two information exchange meetings, one on Nov.7-8, 2011, in Oak Ridge, TN, and the other on August 20-21, 2012, in Philadelphia, PA. During the ORNL meeting in November 2011, researchers from CAS visited the Materials and Chemistry labs that are used for the development and testing of advanced adsorbents for the extraction of uranium from seawater. After the DOE-CAS Nuclear Energy Sciences and Technologies agreement was signed in December 2011, the first joint technical working group meeting was held at ORNL on April 11-12, 2012. Detailed technical information and research plans on the preparation and testing of polymeric and nanoporous carbon sorbents for the extraction of uranium from seawater were discussed during these working group and information exchange meetings.

At the Executive Committee meeting in October 2012, Dr. Phil Britt and Dr. Guozhong Wu of SINAP presented the most current R&D activities from each country. Fuel Resources Working Group also reported the following major accomplishments:

(1) Advanced Adsorbents Sample Exchange:

CAS provided four polymer samples (untreated ultrahigh molecular weight polyethylene (UHMWPE), two amidoxime functionalized UHMWPE fibers, and a poly(acrylonitrile) fiber after amidoximation) to the U.S. side for laboratory screening and marine testing of uranium adsorption. The objective is to evaluate the performance of CAS samples with the adsorbent samples prepared by ORNL.

(2) Comparison of Polymer Grafting Techniques:

Radiation grafting methods developed by the ORNL team were used to functionalize the untreated UHMWPE with amidoxime ligands. The uranium adsorption capacity of the ORNL prepared UHMWPE samples were studied side-by-side with the materials prepared by CAS in marine test experiments. ORNL also investigated the impact of radiation dosage on the mechanical properties of UHMWPE fibers obtained from CAS.

(3) Marine Sorption Kinetics Studies :

Adsorption capacity of the CAS and ORNL polymers for uranium adsorption was tested using laboratory screening methods and real seawater at the Pacific Northwest National Laboratory Marine Science Laboratory. Kinetics of uranium sorption along with other major elements found in seawater was conducted for the CAS polymers in batch and flow modes in late 2012.

(4) Exchange Information and Testing Results:

Preliminary performance results of adsorption and mechanical tests for the CAS and ORNL polymer samples were presented and discussed during the information exchange meeting in Philadelphia, PA on August 20-22, 2012.

Future plans proposed and approved during the Executive Committee meeting in Shanghai include:

(1) CAS and ORNL researchers will continue to exchange information and explore methods to synthesize polymeric adsorbents to extract uranium from seawater using e-beam and radiation induced grafting of amidoxime ligands, to test adsorbent capacity and kinetics in marine environment, and to scale up experiments.

(2) Continue the exchange of polymer samples. Both sides plan to further exchange their best samples for marine testing to determine capacity and kinetics of adsorption of uranium from seawater.

(3) Continue the planning and implementation of staff exchange in computational design. CAS plans to identify an early-career staff member to conduct research in the area of computational ligand design to improve the uranium extraction capacity. The exchange staff will start the assignment at ORNL in 2013 (under the supervision of Dr. Ben Hay).

(4) CAS and ORNL researchers are planning to publish a peer-reviewed paper on the adsorption of uranium from seawater using amidoxime functionalized UHMWPE fibers.

The agreed-to events under the auspices of Fuel Resources Working Group are shown in the table below.

China–USA Fuel Resources Working Group: Planned Milestones and Deliverables			
Task/Deliverable	**Subtask/Details**	**Location**	**Date**
Technical Meetings	Information Exchange Meeting – Exchange current activities in extraction of uranium from seawater	Oak Ridge, TN	Nov.7-8, 2011
	Working Group Meeting – Experts meeting to explore potential cooperation	Oak Ridge, TN	April 12-13, 2012
	Information Exchange Meeting – Exchange information on current activities in extraction of uranium from seawater	Philadelphia, PA	August 20, 2012
	Symposium for Seawater Uranium Extraction – Technical presentations and discussion during the American Chemical Society annual meeting	Philadelphia, PA	August 21, 2012
	Executive Committee meeting	Shanghai, China	Oct. 22, 2012
	Working Group Meeting – discuss of current program status	Sanya, Hainan, China	April 2013
	Marine Testing Site Visit	Sequim, WA,	May/June 2013
	Information Exchange Meeting – Exchange information on recent technical development	Shanghai, China	July/Aug. 2013
	Executive Committee meeting	Oak Ridge, TN	Oct. 2013
Exchanging Researchers	Exploring the mechanisms of exchanging researchers/short term visit in the areas of computation modeling and radiation grafting	US/China	2012
	CAS staff starts working at ORNL on computational ligand design	Oak Ridge, TN	2013
	ORNL staff starts working at CAS	Shanghai, China	2014
Joint Development of Adsorbent Materials	CAS prepared and shipped the adsorbent materials to ORNL for evaluation	Shanghai, China	June 2012
	ORNL functionalized UHMWPE with amidoxime ligands & investigate the impact of radiation dose on the mechanical properties	Oak Ridge, TN	July – August 2012
	Perform laboratory tests to quantify uranium sorption capacity and conducted a side-by-side tests with real seawater on CAS and ORNL UHMWPE samples	US	2012
	Discussion of the preliminary results at the information exchange meeting	Philadelphia, PA	August 20, 201
	Determine the sorption capacity and kinetics of CAS and ORNL UHMWPE samples	Sequim, WA	2012 – 2013

China–USA Fuel Resources Working Group: Planned Milestones and Deliverables			
Task/Deliverable	**Subtask/Details**	**Location**	**Date**
	Marine Science Laboratory site visit and information exchange on grafting parameters for UHMWPE	Sequim, WA	May/June 2013
	Conduct marine testing of best U.S. samples	Sanya, Hainan, China	2014
Joint Publication	Provide a list of papers published by U.S. Working Group to CAS	US	Oct. 2012 & 2013
	Develop and publish a joint peer-reviewed paper on UHMWPE materials and marine testing results	US & China	2014

3.3 Nuclear Hybrid Energy Systems

Hybrid energy systems may enable greater usage of nuclear energy and could potentially open a new opportunity for nuclear power deployment. For example, nuclear energy can be used for the hybrid of cogeneration high temperature process heat for industrial applications and electricity. Through hybrid systems, nuclear energy could potentially play an important role in the cost-effective integration of renewable energy and more efficient use of fossil energy. The goal of Nuclear Hybrid Energy Systems Working Group is to realize the full potential of hybrid concepts, to develop implementation strategies, and to conduct research activities.

Currently, work scope of the Hybrid Energy Systems Working Group is formally governed by a Science Protocol Agreement signed between CAS and DOE in January 2011. In April 2012, a Joint Coordinating Committee meeting under the Science Protocol Agreement between CAS and DOE took place in Beijing, China. The co-chairs of the Nuclear Hybrid Energy Systems Working Group, Dr. Steve Aumeier of Idaho National Laboratory (INL) and Dr. Zhiyuan Zhu of CAS attended the meeting. It was agreed that both sides will continue exploring the development of hybrid system designs and identification of hybrid systems related technology R&D gaps, needs, and potential collaboration activities. At least two workshops were conducted in the past year to develop paths forward. At present, internet conference calls between CAS and INL researchers are on-going. Short term goals are (1) to complete process analysis, (2) to explore staff exchange, and (3) to write joint journal article.

In 2012, INL and CAS held two internet conference calls to discuss collaboration interests which include: (1) Develop and analyze architectures for HES conversion of coal to synfuels; (2) Evaluate and compare the technical and environmental benefits of Light Water Small Modular Reactors (SMR), Thorium Molten Salt Reactors (TMSR), High Temperature Gas-Cooled Reactors Results (HTGR); (3) Share models and results of High Temperature Steam Electrolysis (HTSE) tests; and (4) Publish a research paper together on the outcomes of the analysis and impact on cost of energy, environmental benefits, and water savings. Both sides tentatively agree to consider the following topics for the near-term cooperation: (1) Hydrogen production by high temperature electrolysis; and (2) Simulating of Hybrid Energy System.

The agreed-to events under the auspices of Nuclear Hybrid Energy Systems Working Group are shown in the table below.

China–USA Nuclear Hybrid Energy Systems Working Group: Milestones and Deliverables			
Task/Deliverable	**Subtask/Details**	**Location**	**Date**
Technical Meetings	CAS-DOE Science Protocol Joint Coordinating Committee meeting	Beijing, China	April 19-20, 2012
	SINAP Staff visited INL – discussion on hydrogen production	Idaho falls, ID	March 19-22, 2012

China–USA Nuclear Hybrid Energy Systems Working Group: Milestones and Deliverables			
Task/Deliverable	**Subtask/Details**	**Location**	**Date**
	Hybrid Energy System Workshop	Salt Lake City, UT	April 3-4, 2012
	INL staff visited SINAP and SARI	Shanghai, China	June 11, 2012
	Tele Video Conference - Review and Discuss potential Work Statement	US/China	July 12, 2012
	Web-Based Information Exchange Video Conference	US/China	Sept.6, 2012
Phase I of Hybrid Energy System Study	HES Analysis	US/China	Nov 30, 2012
	Conclusion Phase I technical and economical assessments	US/China	March 30, 2013
	Prepare a Journal Publication	US/China	June 30, 2013
	Wrap-up Discussions and Memorandum	US/China	Sept.30, 2013

Attachment A:

Signed CAS-DOE Cooperation in
Nuclear Energy Sciences and Technologies
Memorandum of Understanding Agreement

MEMORANDUM OF UNDERSTANDING

BETWEEN

THE DEPARTMENT OF ENERGY
OF THE UNITED STATES OF AMERICA

AND

THE CHINESE ACADEMY OF SCIENCES

ON COOPERATION IN NUCLEAR ENERGY SCIENCES AND TECHNOLOGIES

The Department of Energy (DOE) of the United States of America, and the Chinese Academy of Sciences (CAS) of the People's Republic of China, hereinafter referred to as the "Participants":

NOTING their desire to enhance communication and cooperation on nuclear energy-related matters of common interest and to foster collaboration among scientists, laboratories, research institutes and universities of the Participants' countries and to facilitate and promote cooperation in research and development in a broad range of nuclear energy sciences and technologies; and

NOTING the Agreement for Cooperation between the Government of the United States of America and the Government of the People's Republic of China Concerning Peaceful Uses of Nuclear Energy, signed at Washington on July 23, 1985,

Have reached the following understanding:

Section 1
Objective

1. The objective of this Memorandum of Understanding (Memorandum) is to promote and facilitate cooperation on the scientific and technical aspects of nuclear energy technologies.

2. By their joint determination, the Participants may invite other entities to participate in the cooperative activities carried out in the framework of this Memorandum: governmental agencies, universities, science and research centers, institutes and institutions, private sector firms, and other entities of the Participants' respective governments. The costs of such participation are the responsibility of the entities that incur them.

3. The Participants' cooperation under this Memorandum is intended for peaceful purposes only.

Section 2
Forms of Cooperation

1. Forms of cooperation under this Memorandum may include: exchange of publicly available technical information, data and experience; exchange of technical and managerial personnel for visits and short-term assignments; exchange of equipment, materials and instrumentation; joint conferences, seminars or workshops; and such other forms of cooperation as the Participants may jointly decide in writing.

2. The terms of visits and assignments, and the exchange of equipment, materials, and instrumentation should be the subjects of appropriate written agreements between the sending and receiving entities.

Section 3
Areas of Cooperation

1. Priority areas of cooperation may include the following:

   Nuclear Energy for Non-electric Applications
   Nuclear power could be used to displace greenhouse gas emitting fuels in the industrial sector. Petroleum refining, for example, requires temperatures in the range of 250-500°C while steam reforming of natural gas requires process heat in the 500-900°C range. Achieving higher output temperatures requires switching to a new coolant technology such as molten salt. With advanced coolants, it is possible to achieve outlet temperatures ranging from 500°C to over 900°C.

Potential subjects of collaborative activities may include materials and chemistry of fluoride salt coolant systems.

Nuclear Fuel Resources
Nuclear energy can help alleviate the concern over greenhouse gases and global warming, energy supply security, and high and volatile fossil fuel prices. For nuclear energy to remain a viable and sustainable energy source, there must be assurance that economical sources of nuclear fuels are available. The focus of this cooperation is direct extraction of dissolved uranium from seawater. Although uranium is present in very low concentrations in seawater, 3.3 parts per billion, the oceans contain over 4500 million tonnes of uranium, which would provide essentially unlimited supply of nuclear fuel. Potential subjects of collaborative activities may include: (a) molecular-level understanding of the coordination modes, sorption mechanisms, and kinetics of uranium extraction; (b) new functional ligands; and (c) advanced sorbent materials.

2. The areas of cooperation may be expanded and revised by the written consent of the Participants.

3. The Participants intend to conduct research and development on mutually determined subjects under appropriate written agreements therefor. Such agreements should include, among other matters, provisions for the protection and allocation of intellectual property.

Section 4
Management

1. Execution of this Memorandum is to be guided by an Executive Committee (EC) consisting of one co-chair from each Participant: DOE Assistant Secretary for Nuclear Energy and Vice President of CAS.

2. The EC co-chairs should designate one technical coordinator from each Participant to organize technical activities under this Memorandum. The technical coordinators should jointly plan, identify, and coordinate cooperative activities. Specific working groups may be established to collaborate on mutually determined topics.

3. Working groups and/or EC meetings should take place on an annual basis or as otherwise mutually decided, alternately in the United States and in the People's Republic of China.

4. The host Participant should choose the meeting site and bear the costs for the arrangements associated with the meeting. Representatives from each Participant attending the meetings are to be responsible for their own travel and lodging expenses.

5. The technical coordinators should jointly prepare written reports of the meetings. Each Participant may disseminate the written meeting report without prior notification to the other Participant, after the record has been approved by EC. The report should document the progress of activities and the next year's plans for continuation of cooperation.

6. The technical coordinators may invite representatives of other organizations within their countries to attend joint working groups and/or EC meetings.

Section 5
General Considerations

1. This Memorandum does not constitute a legally binding agreement.

2. Each Participant should implement this Memorandum in accordance with the laws, regulations and other requirements of its respective country and international agreements to which its government is party.

3. Any questions relating to this Memorandum arising during its term should be resolved by consultations between the Participants.

4. Each Participant is responsible for the costs of its participation in all cooperative activities carried out in the framework of this Memorandum, unless they determine otherwise in writing. Each Participant's participation in the cooperative activities is subject to the availability of funds, resources, and personnel.

Section 6
Commencement, Modification, and Discontinuation

1. The Participants' implementation of cooperative activities within the framework of this Memorandum may commence on the date of signature.

2. This Memorandum may be modified by mutual determination of the Participants in writing.

3. The Participants may discontinue this Memorandum at any time in writing. Alternatively, a Participant that wishes to discontinue its participation in the activities under this Memorandum should endeavor to provide at least six (6) months' written notice to the other Participant.

Signed, in duplicate, at Washington on the 21 day of December, 2011, and at Beijing on the 29 day of December, 2011, in the English and Chinese languages.

FOR THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA:

FOR THE CHINESE ACADEMY OF SCIENCES:

谅解备忘录

美利坚合众国 能源部

与

中国科学院

关于核能科学与技术合作

美利坚合众国能源部（能源部）和中华人民共和国科学院（中科院），以下简称"双方"：

注意到双方对在核能方面共同关注事宜加强沟通与合作，促进双方的科学家、实验室、研究机构和大学间的合作，和实现广泛的核能科学与技术领域的研发合作上的愿望；并

注意到于 1985 年 7 月 23 日在华盛顿签署的美利坚合众国政府与中华人民共和国政府关于和平利用核技术的合作协议，

达成以下谅解：

一、目标

1. 本谅解备忘录（备忘录）旨在推进和加快核能技术领域的科技方面的合作。

2. 经共同确认后，双方可以邀请其他单位参与在此备忘录框架下开展的合作活动，包括：政府机构、大学、科研中心、研究院所、私人企业和双方各自政府下的其他单位。其所需费用由参与单位自行负担。

3. 双方在此备忘录下的合作均仅限于和平目的。

3. 双方将在以书面协议形式共同确定的领域进行研究和开发工作。此类协议其中，须载的其他事宜当中，应包括保护和分配知识产权的条款。

四、管理

1. 对本备忘录的执行将受执行委员会的监督，执行委员会包括双方各一名主席，即能源部核能助理部长和中科院副院长。

2. 执行委员会主席应从本方各自指派一名技术协调员执行本备忘录下的相关技术活动。双方技术协调员应共同计划、确定和协调合作活动，并可针对双方共同确立的课题成立相关工作组。

3. 工作组和/或执行委员会会议每年举办一次或按双方商定择期举办，会议轮流在美国和中国举行。

4. 主办方应负责选择会议的地点并承担会议相关的费用。参与会议的双方代表应承担各自的旅费和住宿费用。

5. 双方的技术协调员应共同撰写会议报告，经执行委员会批准后，双方均有权发布会议书面报告，无需事先通知对方。会议报告应包含双方合作活动的进展情况，以及下一年延续合作的实施计划。

6. 技术协调员可以邀请其本国其他机构的代表参加工作组和/或执行委员会会议。

五、总体考虑

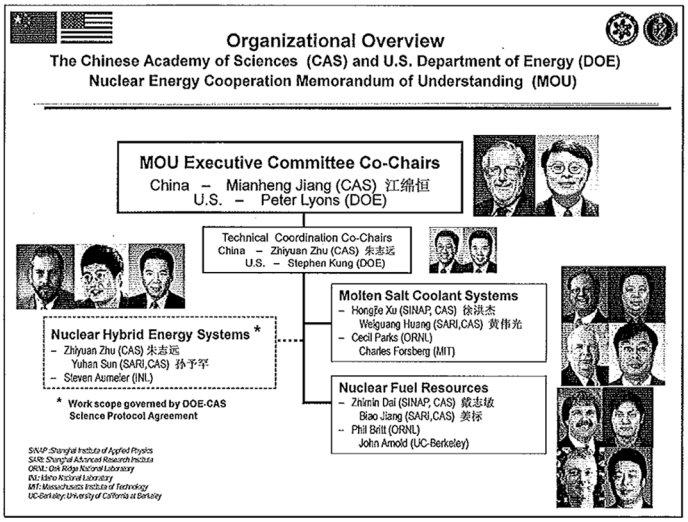
1. 本备忘录将不受法律约束。

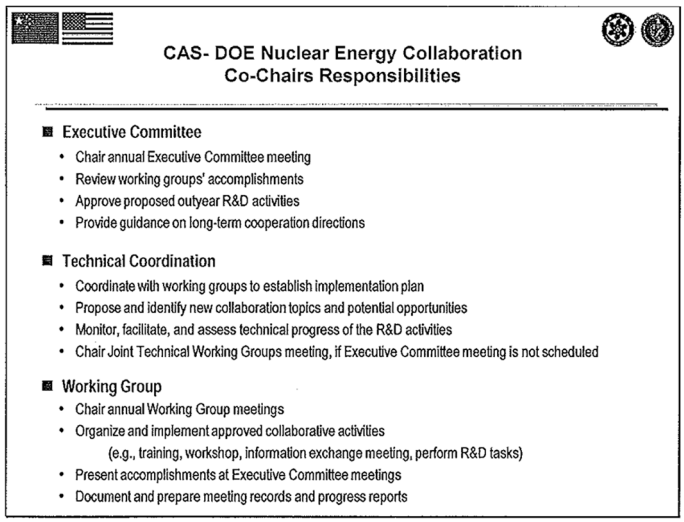
2. 任何一方在本备忘录下所开展的活动均须遵守其相关法律、规定和要求，以及本国所加入的国际协议。

3

Attachment B:

CAS-DOE Nuclear Energy Cooperation Agreement Organizational Overview and Responsibilities


Organizational Overview
The Chinese Academy of Sciences (CAS) and U.S. Department of Energy (DOE)
Nuclear Energy Cooperation Memorandum of Understanding (MOU)
MOU Executive Committee Co-Chairs
China – Mianheng Jiang (CAS) 江绵恒
U.S. – Peter Lyons (DOE)
Technical Coordination Co-Chairs
China – Zhiyuan Zhu (CAS) 朱志远
U.S. – Stephen Kung (DOE)
Molten Salt Coolant Systems
– Hongfe Xu (SINAP, CAS) 徐洪杰
Weiguang Huang (SARI,CAS) 黄伟光
– Cecil Parks (ORNL)
Charles Forsberg (MIT)
Nuclear Hybrid Energy Systems *
– Zhiyuan Zhu (CAS) 朱志远
Yuhan Sun (SARI,CAS) 孙予罕
– Steven Aumeier (INL)
* Work scope governed by DOE-CAS Science Protocol Agreement
Nuclear Fuel Resources
– Zhimin Dai (SINAP, CAS) 戴志敏
Biao Jiang (SARI,CAS) 姜标
– Phil Britt (ORNL)
John Arnold (UC-Berkeley)
SINAP: Shanghai Institute of Applied Physics
SARI: Shanghai Advanced Research Institute
ORNL: Oak Ridge National Laboratory
INL: Idaho National Laboratory
MIT: Massachusetts Institute of Technology
UC-Berkeley: University of California at Berkeley


CAS- DOE Nuclear Energy Collaboration
Co-Chairs Responsibilities
Executive Committee
Chair annual Executive Committee meeting
Review working groups' accomplishments
Approve proposed outyear R&D activities
Provide guidance on long-term cooperation directions
Technical Coordination
Coordinate with working groups to establish implementation plan
Propose and identify new collaboration topics and potential opportunities
Monitor, facilitate, and assess technical progress of the R&D activities
Chair Joint Technical Working Groups meeting, if Executive Committee meeting is not scheduled
Working Group
Chair annual Working Group meetings
Organize and implement approved collaborative activities
(e.g., training, workshop, information exchange meeting, perform R&D tasks)
Present accomplishments at Executive Committee meetings
Document and prepare meeting records and progress reports

Attachment C:

Executive Committee Meeting Agenda

Executive Committee Meeting Agenda

CAS-DOE Nuclear Energy Sciences & Technologies Cooperative Agreement
Co-Chairs: Drs. Mianheng Jiang and Peter Lyons

October 22, 2012
Shanghai, China

Moderators: Zhiyuan Zhu and Stephen Kung		
9:00 - 10:15	Introduction and Announcement	Zhiyuan Zhu
	Welcome and Opening Remarks	Mianheng Jiang
	Opening Remark	Peter Lyons
	Added Welcome Speak	Jinghua Cao
	Agenda Overview, Meeting Goal and CAS-DOE Nuclear Energy Collaboration Overview	Zhiyuan Zhu Stephen Kung
10:15 - 11:00	Working Group Presentation (1) Molten Salt Coolant Systems Working Group Status and Accomplishments Future Plan and Discussion	Lead co-chairs: Hongjie Xu Cecil Parks
11:00 - 11:30	Coffee break	
11:30 - 12:15	Working Group Presentation (2) Fuel Resources Working Group Status and Accomplishments Future Plan and Discussion	Lead co-chairs: Guozhong Wu Phil Britt
12:15 - 13:30	Working Lunch	
13:30 - 14:15	Working Group Presentation (3) Nuclear Hybrid Energy Systems Working Group Status and Accomplishments Future Plan and Discussion	Lead co-chairs: Zhiyuan Zhu
14:15 - 15:00	General Discussion FHR Safety Standard	 Zhimin Dai
15:00 - 15:30	Coffee break	
15:30 - 16:00	Closing Remarks	Peter Lyons Mianheng Jiang
16:00	Adjourn	
16:00 - 16:20	Group Photograph	
18:00 - 19:30	Welcoming dinner hosted by Dr. Mianheng Jiang	

Attachment D:

List of Executive Committee Meeting Attendees

Attendees List
Executive Committee Meeting
CAS-DOE Nuclear Energy Sciences & Technologies Cooperative Agreement

China

Jiang, Mianheng	President, Shanghai Branch CAS, Executive Committee China Co-chair
Liu, Minghua	Director, Bureau of Basic Research, CAS
Cao, Jinghua	Deputy Director, Bureau of International Cooperation, CAS
Liu, Guiju	Deputy Director, Bureau of High-Tech Research and Development
Zhu, Zhiyuan	Vice President, Shanghai Branch CAS, Technical Coordination Committee China Co-chair
Xu, Hongjie	Director, TMSR Center, SINAP, Molten Salt Coolant Systems Working Group China Co-chair
Dai, Zhimin	Deputy Director, SINAP and TMSR Center, Nuclear Fuel Resources Working Group China Co-chair
Sun, Yuhan	SARI Vice President, Nuclear Hybrid Energy Systems Working Group China Co-chair
Jiang, Biao	SARI Vice President, Nuclear Fuel Resources Working Group China Co-chair
Wu, Guozhong	Division Director, Radiation Chemistry, SINAP
Yu, Xiaohan	Division Director, Reactor Physics, SINAP
Zhang, Qinqquan	Director for America and Oceania Partners, CAS Bureau of International Cooperation
Xie, Leidong	Deputy Division Director, Molten Salt Chemistry and Engineering, SINAP
Chen, Kun	Deputy Division Director, Nuclear Safety, SINAP
Wang, Jiang	Staff, CAS Shanghai Branch
Zhu,Tailai	Staff, CAS Shanghai Branch

U.S.

Pete Lyons	DOE Assistant Secretary, Executive Committee US Co-Chair
John Kelly	Deputy Assistant Secretary for Nuclear Reactor Technologies, DOE
Liz Ramsay	Special Policy Advisor, DOE Office of Nuclear Energy
Stephen Kung	DOE Program Manager, Technical Coordination Committee US Co-Chair
Thom Mason	Laboratory Director, Oak Ridge National Laboratory
Cecil Parks	ORNL Division Director, Molten Salt Coolant Systems Working Group US Co-Chair
Phil Britt	ORNL Division Director, Nuclear Fuel Resources Working Group US Co-Chair
Charles Forsberg	Massachusetts Institute of Technology, Molten Salt Coolant Systems Working Group US Co-Chair
John Arnold	Univ of California-Berkeley, Nuclear Fuel Resources Working Group US Co-Chair
Martin Schoenbauer	Office Director, DOE-Beijing
Jun Shao	Senior Analyst, DOE-Beijing
Seth Patch	ESTH Consul, US Consulate General Shanghai

Attachment E:

CAS-DOE Cooperation in Nuclear Energy Sciences and Technologies Overview Presentation

Slide 1

CAS-DOE
Cooperation in Nuclear Energy Sciences and Technologies

Overview

Technical Coordination Co-Chairs
Zhiyuan Zhu, CAS
Stephen Kung, DOE

October 22, Shanghai

Slide 2

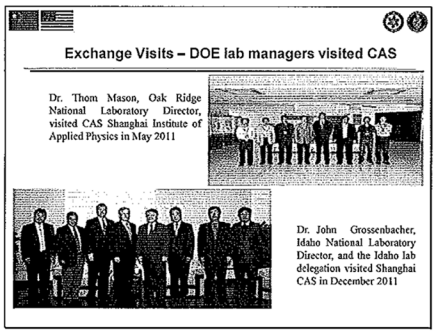
Significant Moment for the China-U.S Bilateral Collaboration

Dr. Mianheng Jiang and Dr. Steven Koonin signed *the Protocol Agreement between the U.S. Department of Energy and P.R. of China Chinese Academy of Sciences for Cooperation In Energy Sciences* on Jan.19, 2011 in Washington, D.C.
This is the first Science Protocol Agreement between CAS and DOE to promote and facilitate the bilateral collaboration in broad energy sciences.

Slide 3

Slide 4

Slide 5



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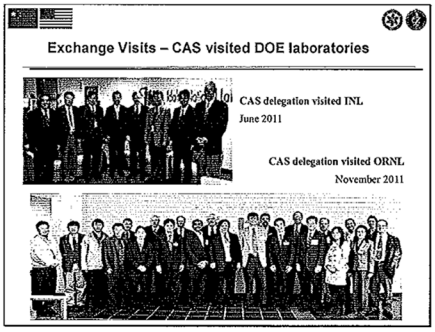

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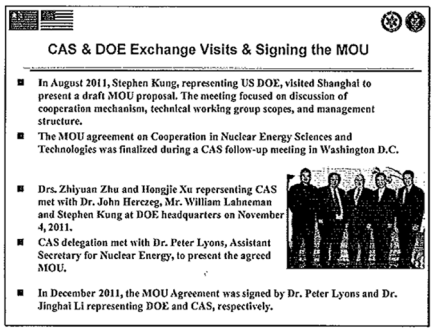

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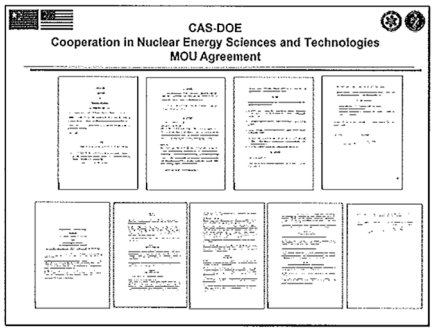

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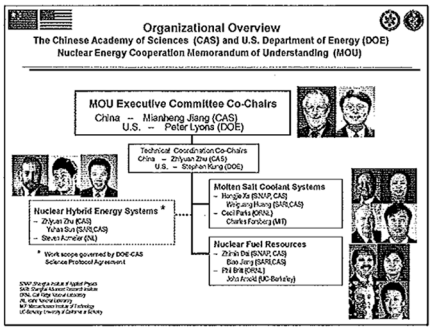

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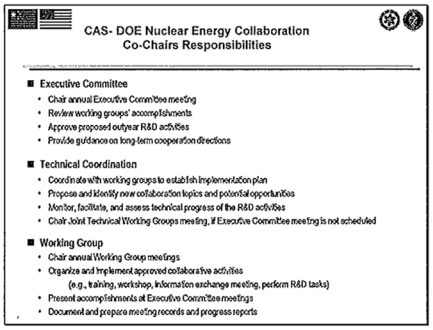

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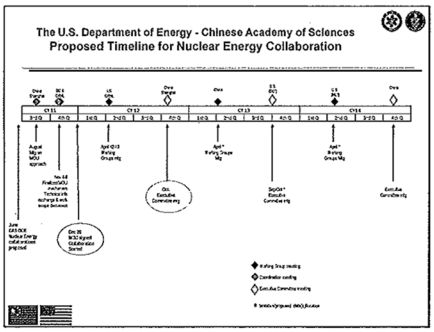

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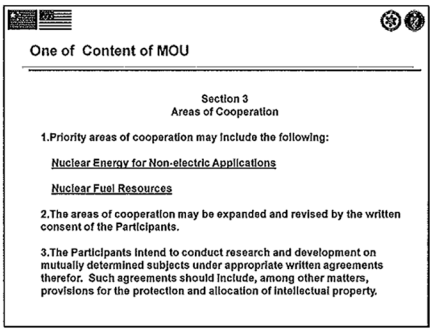

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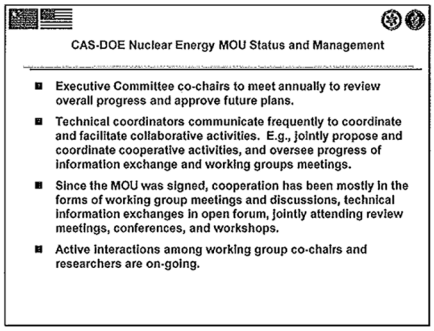

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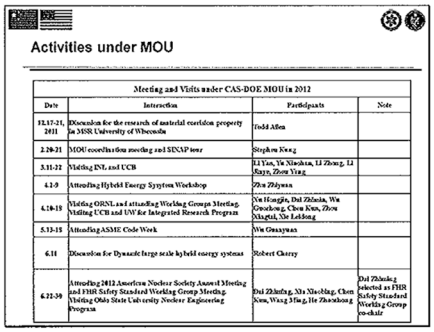

Meeting and Visits under CAS-DOE MOU in 2012

Date	Interaction	Participants	Note
12.17-21, 2011	Discussion for the research of material corrosion property in MSR University of Wisconsin	Todd Allen	
2.20-21	MOU coordination meeting and SINAP tour	Stephen Kung	
3.31-32	Visiting INL and UCB	Li Yan, Ye Nianhua, Li Zhong, Li Kuyu, Zhou Yang	
4.2-5	Attending Hybrid Energy System Workshop	Zhu Zhiyuan	
4.16-19	Visiting ORNL and attending Working Groups Meeting. Visiting UCB and UW for Integrated Research Program	Ye Hongjie, Dai Zhimin, Wu Guosheng, Chen Kun, Zhou Xiaotai, Xie Leidong	
5.13-15	Attending ASME Code Week	Wu Guoyuan	
6.11	Discussion for Dynamic large scale hybrid energy systems	Robert Cherry	
6.22-30	Attending 2012 American Nuclear Society Annual Meeting and FHR Safety Standard Working Group Meeting. Visiting Ohio State University Nuclear Engineering Program	Dai Zhimin, Xia Nianhua, Chen Kun, Wang Jifang, He Zhaozhong	Dai Zhimin is selected as FHR Safety Standard Working Group co-chair

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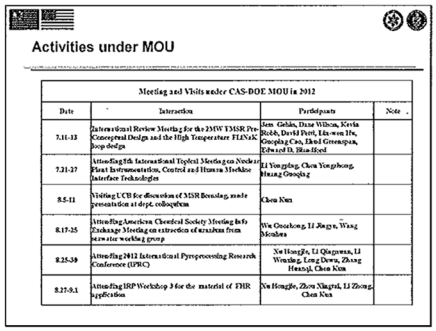

Activities under MOU

Meeting and Visits under CAS-DOE MOU in 2012			
Date	Interaction	Participants	Note
7.11-13	International Review Meeting for the 2MW TMSR Pre-Conceptual Design and the High Temperature FLiNaK loop design	Ian Gehin, Dane Wilson, Kevin Robb, David Petti, Hu-wen Hu, Guojing Cao, Brad Greenspan, Edward D. Blandford	
7.21-27	Attending 8th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies	Li Yongding, Chen Yongzhong, Huang Guoqing	
8.5-11	Visiting UCB for discussion of MSR Benning, made presentation at dept. colloquium	Chen Xun	
8.17-25	Attending American Chemical Society Meeting Info Exchange Meeting on extraction of uranium from sea-water working group	Wu Guozhong, Li Jingyu, Wang Member	
8.25-30	Attending 2012 International Pyroprocessing Research Conference (IPRC)	Xu HongJie, Li Qingnuan, Li Wenxing, Long Dewu, Zhang Huanqi, Chen Xun	
8.27-9.1	Attending IRP Workshop 3 for the material of FHR application	Xu Hongjie, Zhou Xiaqrui, Li Zhong, Chen Xun	

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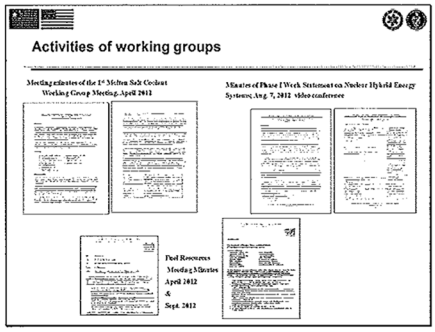


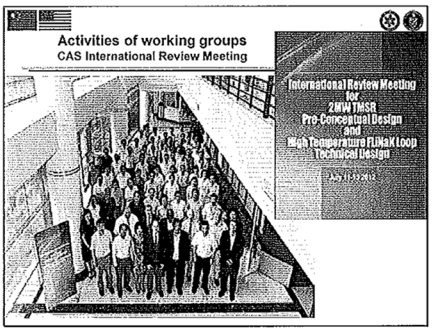
Activities of working groups

Meeting minutes of the 1st Molten Salt Coolant Working Group Meeting April 2012

Minutes of Phase I Work Statement on Nuclear Hybrid Energy Systems Aug 7, 2012 video conference

Fuel Resources Meeting Minutes April 2012 & Sept. 2012

Slide 17



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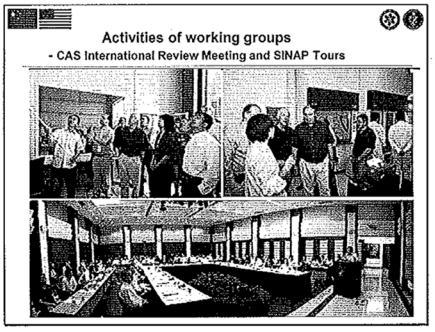

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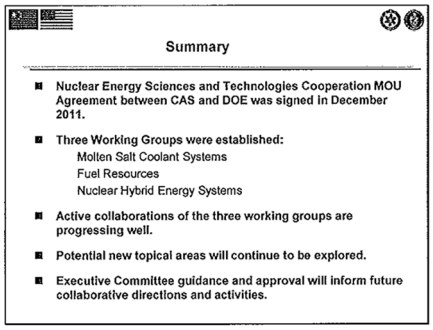

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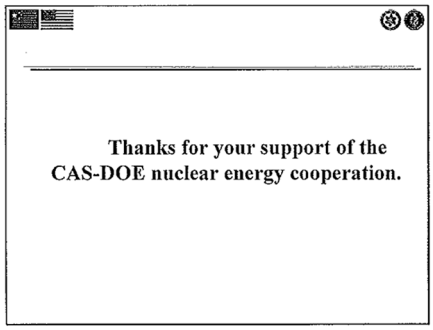

Attachment F:

Molten Salt Coolant System Working Groups Meeting Presentation and Planned Future Activities

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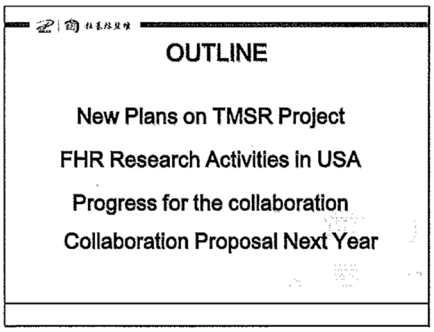

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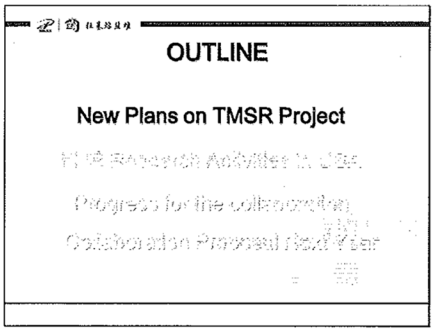

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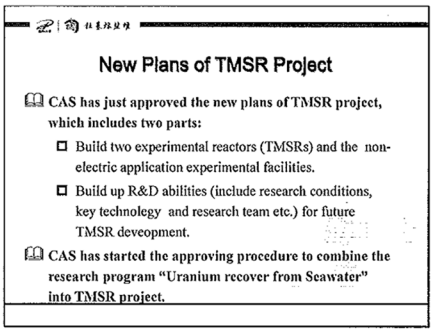

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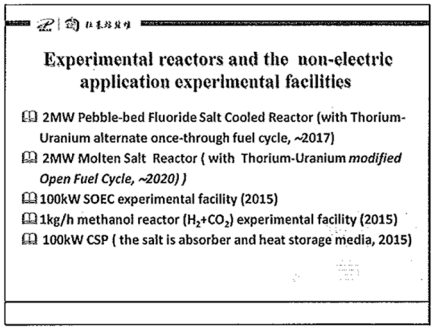
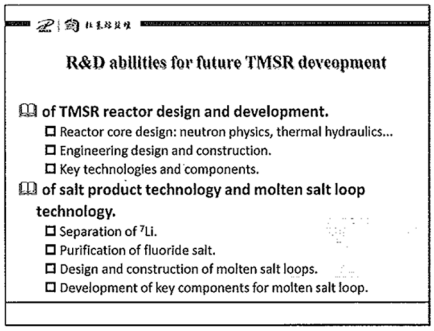


Experimental reactors and the non-electric application experimental facilities

- 2MW Pebble-bed Fluoride Salt Cooled Reactor (with Thorium-Uranium alternate once-through fuel cycle, ~2017)
- 2MW Molten Salt Reactor (with Thorium-Uranium *modified Open Fuel Cycle, ~2020)*)
- 100kW SOEC experimental facility (2015)
- 1kg/h methanol reactor (H_2+CO_2) experimental facility (2015)
- 100kW CSP (the salt is absorber and heat storage media, 2015)

Slide 6



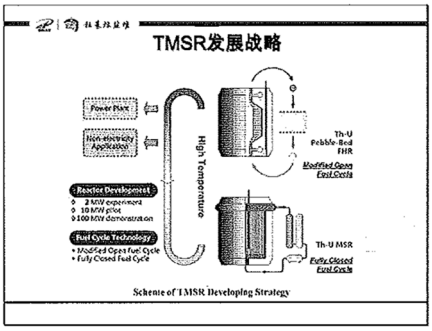
R&D abilities for future TMSR deveopment

- **of TMSR reactor design and development.**
  - Reactor core design: neutron physics, thermal hydraulics...
  - Engineering design and construction.
  - Key technologies and components.
- **of salt product technology and molten salt loop technology.**
  - Separation of ^{7}Li.
  - Purification of fluoride salt.
  - Design and construction of molten salt loops.
  - Development of key components for molten salt loop.

Slide 7

- **of Th/U fuel techonology**
  - Production of nuclear-grade Thorium fuel (both fluoride and oxide).
  - Online (or in-site) chemical separation of actinides and fission product for Th/U fuel cycle).
- **of materials for TMSRs**
  - Production, processing and testing of structure materials TMSR (Hastalloy-N, Graphite etc.).
  - carbon-based structure materials and components for TMSR
  - Effect and mechanism of material degrading under service condition.
- **of developing safety codes and licensing**

Slide 8



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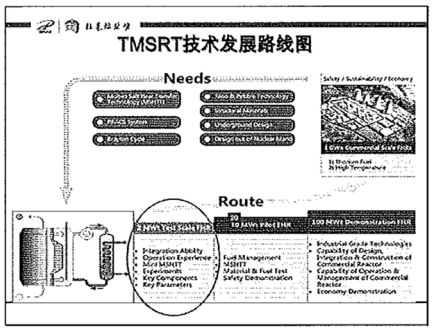

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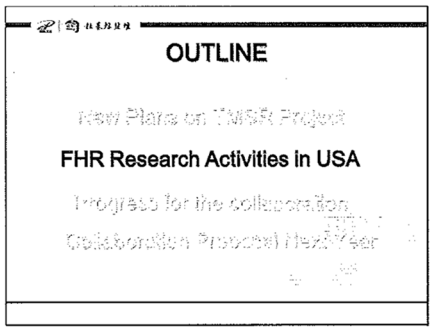

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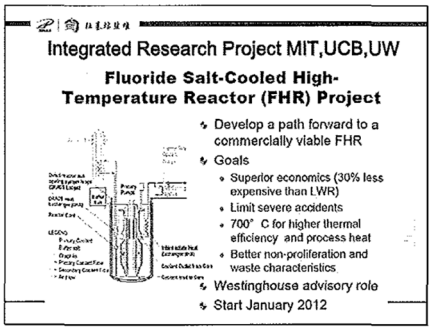

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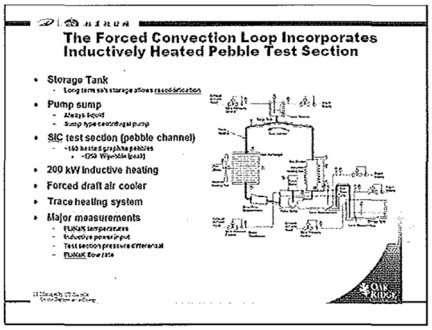

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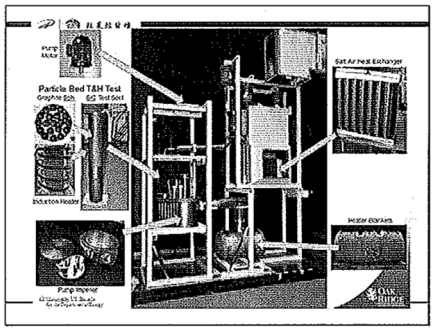

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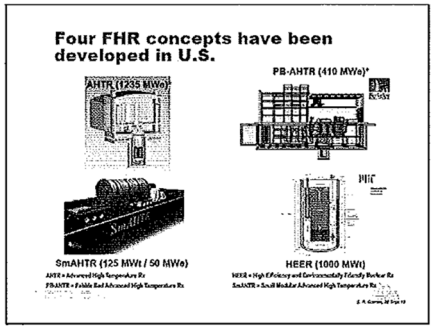

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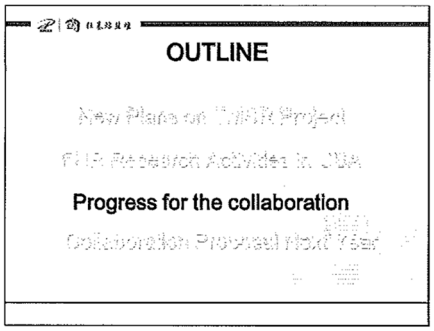

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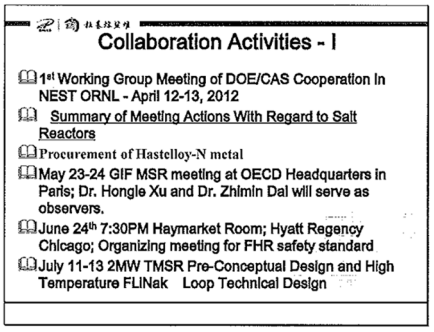

Slide 17

Collaboration Activities - II

- August 26—29 , International Pyroprocessing Research Conference (IPRC) ,Fontana, Wisconsin. (6 attended)
- August 29-30; University IRP FHR Materials Workshop; Dr. Todd Allen (allen@engr.wisc.edu) host (4 chinese scientist attended)
- October 22-26 DOE-NE Executive committee meeting, visit to SINAP and Sanmen.
- October 31st - November 1st FHR test reactor planning meeting MIT; Dr. Lin-wen Hu (lwhu@mit.edu) host.(5 will attend).
- Nov.5-6日 , Symposium on the MS Hydronics will be held in UCB (about 10 will attend)

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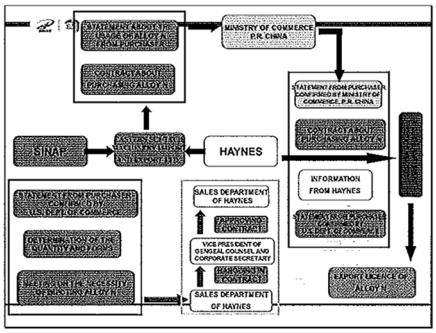

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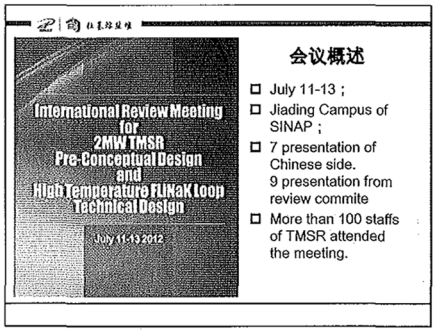

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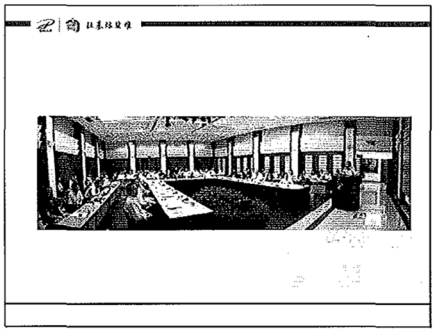

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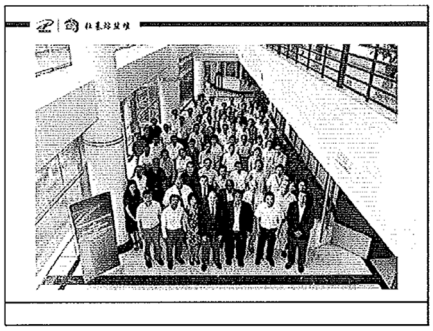

Slide 22

2MW TMSR Pre-Conceptual Design and The High Temperature FLiNaK Loop Technical Design Review Committee Report

International Review Committee:
Dr. Edward Blandford, University of California, Berkeley
Dr. Guoping Cao, University of Wisconsin – Madison
Dr. Jess Gehin, Oak Ridge National Laboratory
Dr. Ehud Greenspan, University of California, Berkeley
Dr. Un-won Ha, Massachusetts Institute of Technology
Dr. Victor Ignatiev, Russian Research Center "Kurchatov Institute"
Dr. David Petti, Idaho National Laboratory
Dr. Kevin Robb, Oak Ridge National Laboratory
Dr. Dane Wilson, Oak Ridge National Laboratory

October 2012

22

Slide 23

FHR Materials and components Workshop

FHR Workshop - 3 (29-30 Aug. 2012)

- University of Wisconsin-Madison
- Topics focus on the material (Fuel Fabrication and performance, Ceramic and Ceramic Composite Components, Metallic Components, Salt Corrosion and Chemistry Control, Preliminary FHR Fuel and Materials Test Program)
- Per Peterson (UCB)、Charles Forsberg (MIT)、Todd Allen (UW-Madison)、Regis Matzie (Westinghouse)、Jess Gehin (ORNL)、Carl M. Stoots (INL)、Jim Nestell (MPR Associates)、Victor Ignatiev (Rusia) 、Zbysek Novy (Czech) ; Hongjie Xu, , Xingtai Zhou, Zhong Li, Kun Chen and others

2013-1-9 23

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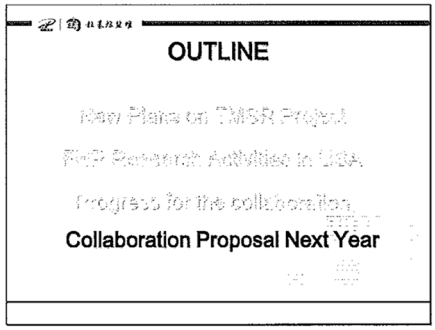


OUTLINE

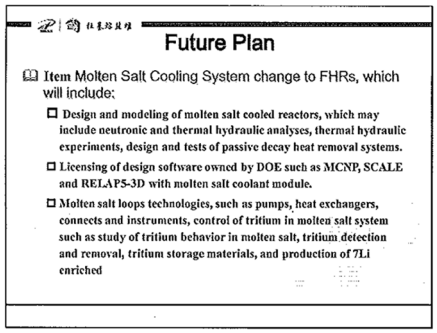
New Plans on TMSR Project

FHR Research Activities in USA

Progress for the collaboration

Collaboration Proposal Next Year

Slide 25



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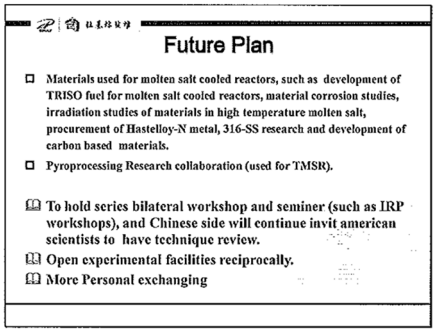

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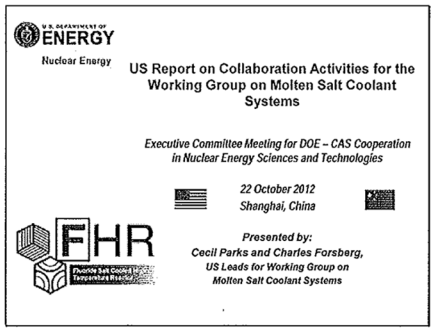

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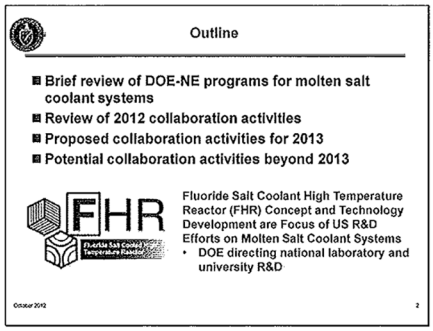

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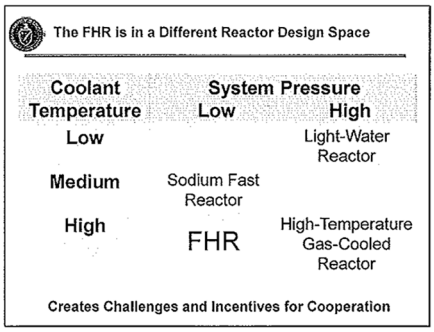

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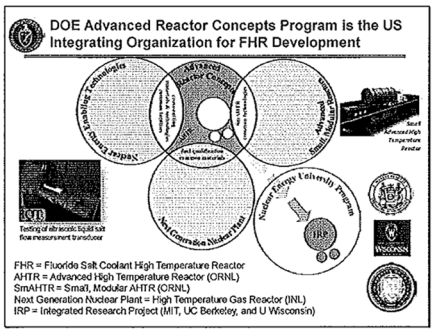

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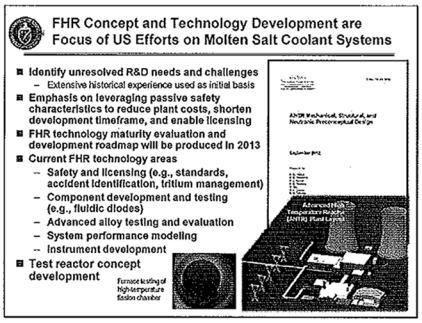

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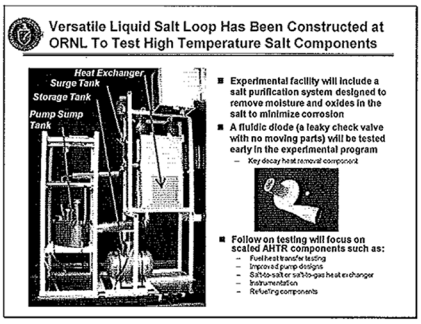

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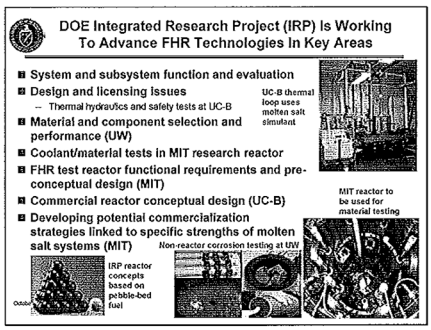

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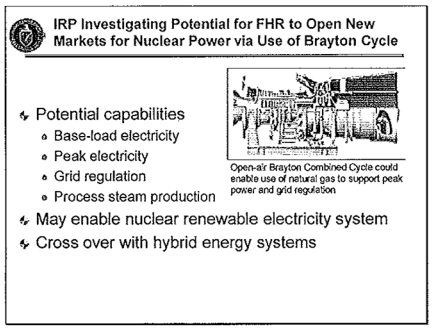


Slide 9

There are Multiple Universities Engaged in FHR Research and Development

University	Technical Areas
MIT U. of California U. of Wisconsin	Integrated Research Project
Georgia Institute of Technology	Core Design
Ohio State University	Decay Heat Removal
John Hopkins University	Carbide Coatings for Salt Systems
U. of New Mexico	Safety, Heat Transfer

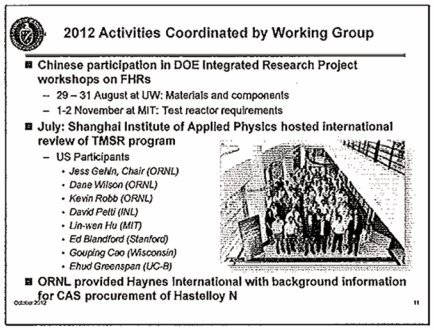
Slide 10

2012 Activities Coordinated by Working Group

- **Visit by CAS to ORNL April 12 - 13 (1st Working Group Meeting)**
  - Tours of ORNL liquid salt test loop and materials R&D facilities
  - Update provided on status and progress of CAS Thorium Molten Salt Reactor (TMSR) program
  - Discuss potential collaboration activities and process
  - Plan short-term collaboration activities
- **Initiation of American Nuclear Society Safety Standard on FHRs**
  - Organizing meeting held in June
    - *Co-chaired by US (Ed Blandford and Matt Denman) and China (Zhimin Dai)*
    - *Representatives from US and Chinese nuclear safety authorities participating*
  - First writing meeting scheduled for November preceding ANS meeting
- **DOE & CAS participating in GIF MSR system steering committee**
  - May meeting: OECD in Paris (David Holcomb, Hongjie Xu, and Zhimin Dai)
  - National programs described to international audience
  - Potential for GIF bilateral reactor technology collaboration discussed
  - November meeting at ITU in Karlsruhe Germany

October 2012 13

Slide 11



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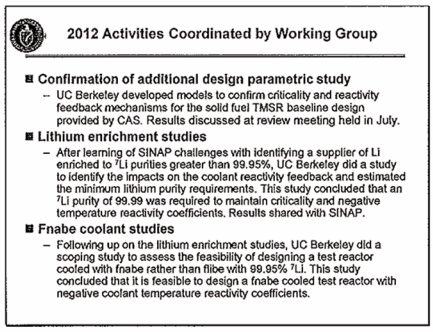

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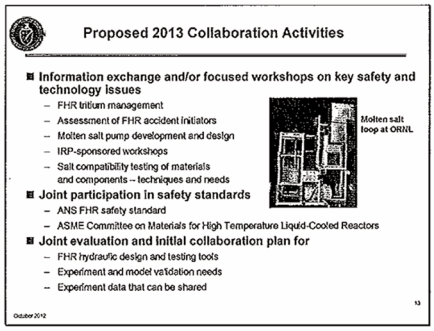

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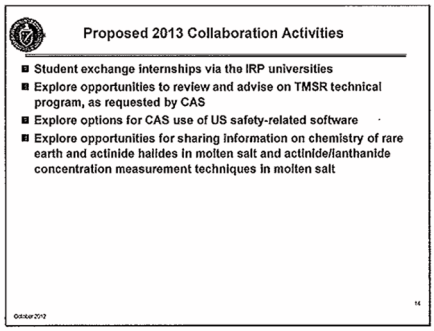

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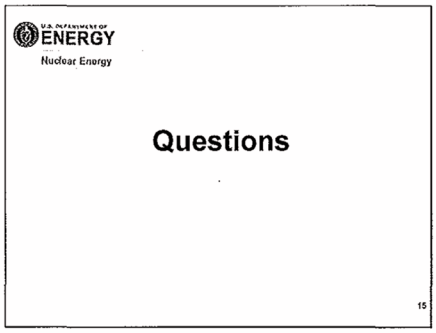
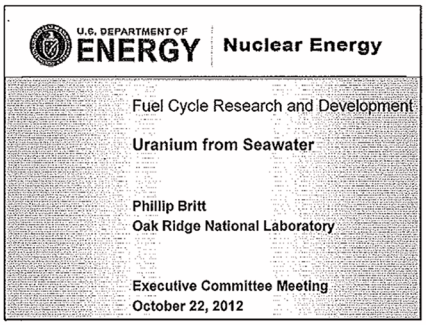


Attachment G:

Fuel Resources Working Group Meeting Presentation and Planned Future Activities

Slide 1



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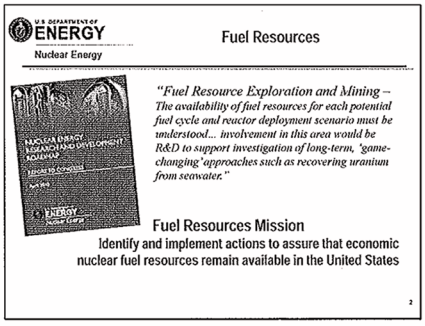

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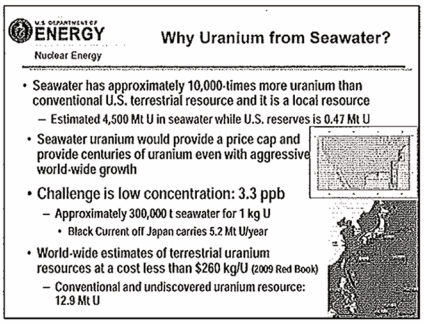

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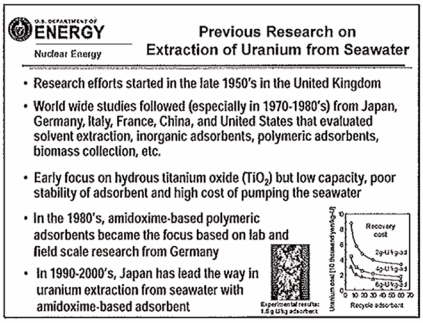

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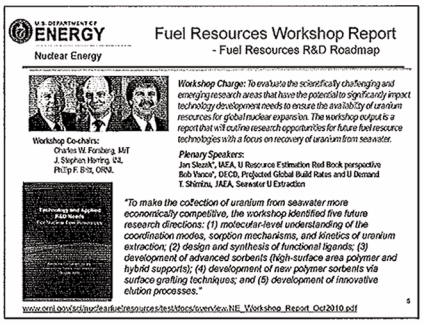

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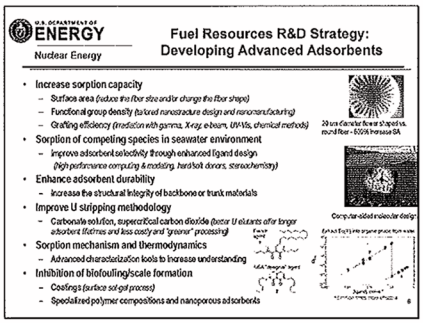

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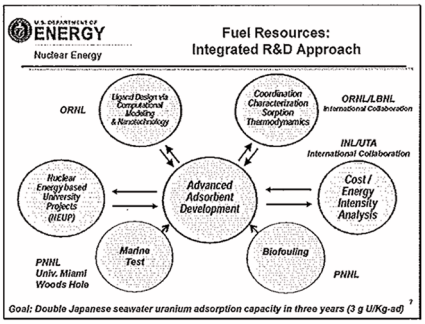

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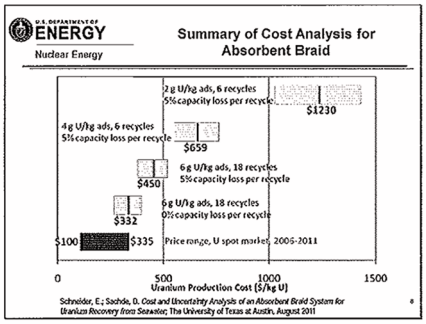

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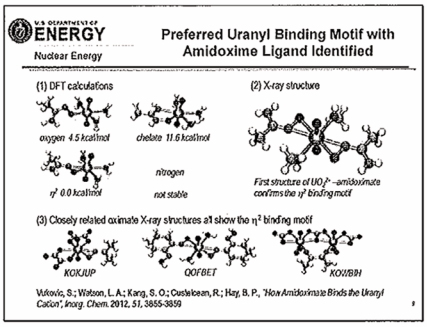

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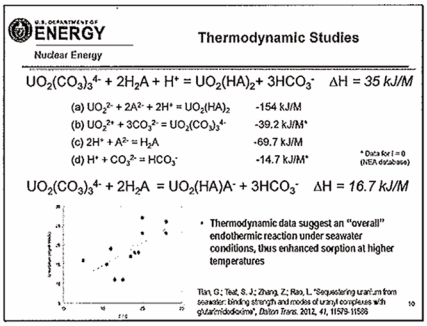

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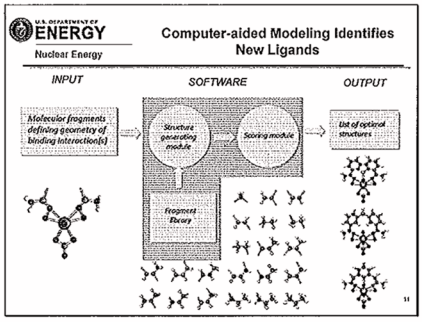

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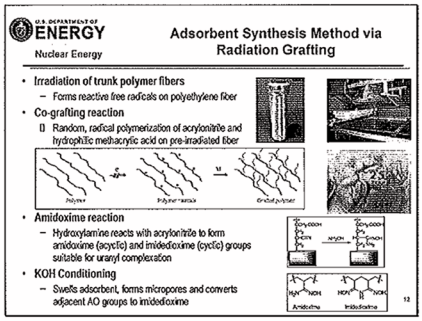

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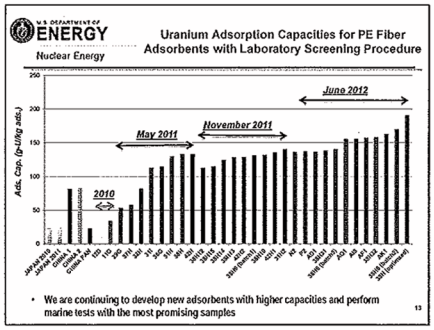

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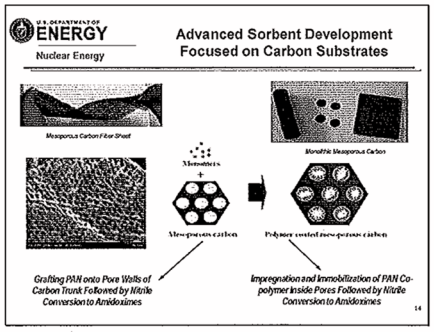

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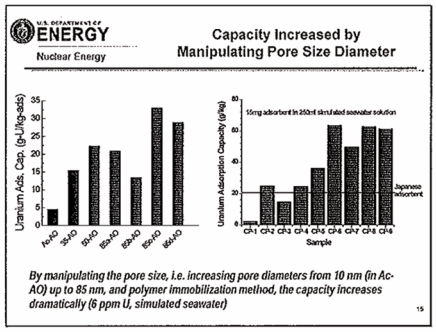

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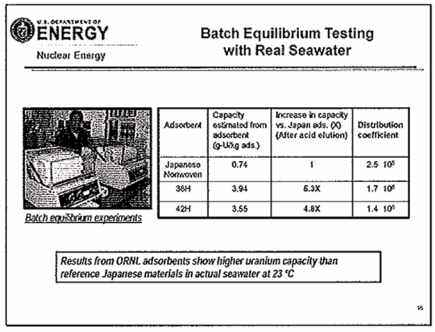

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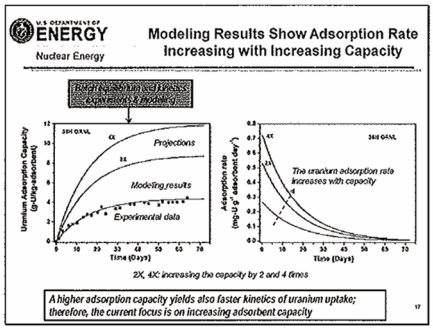

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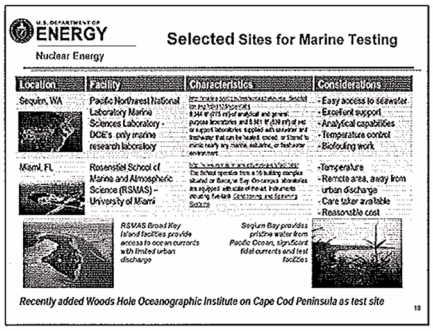

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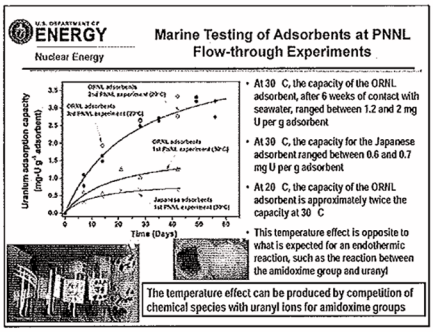

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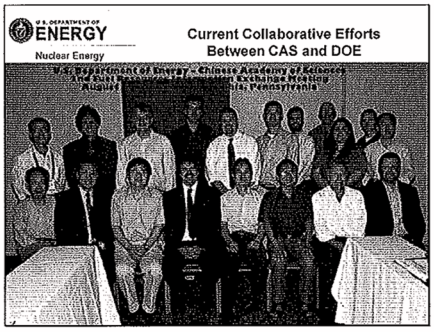

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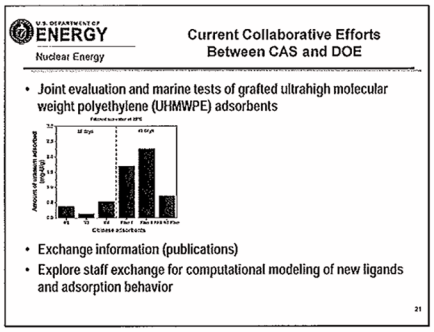

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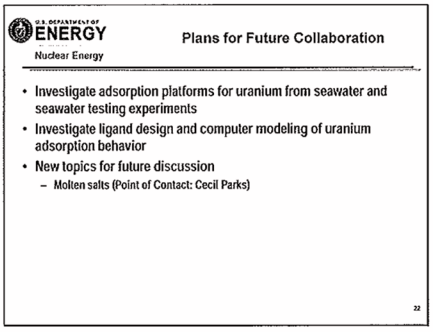

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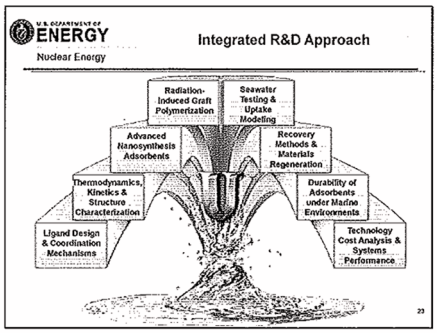
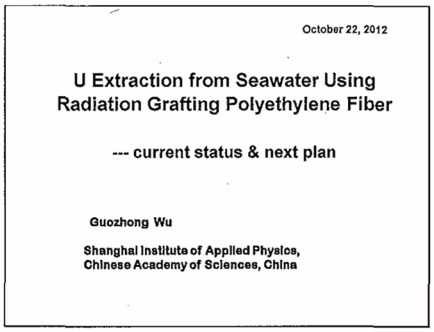

U.S. DEPARTMENT OF ENERGY
Nuclear Energy
Integrated R&D Approach
Radiation-Induced Graft Polymerization
Seawater Testing & Uptake Modeling
Advanced Nanosynthesis Adsorbents
Recovery Methods & Materials Regeneration
Thermodynamics, Kinetics & Structure Characterization
Durability of Adsorbents under Marine Environments
Ligand Design & Coordination Mechanisms
Technology Cost Analysis & Systems Performance
23

Slide 1



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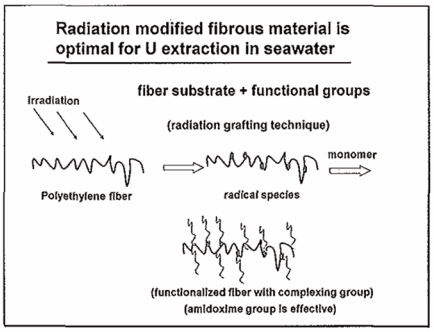


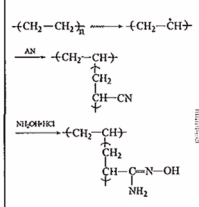
Slide 3

Current activity in SINAP

1) Radiation grafting of acrylonitrile to non-woven fiber;
2) Radiation grafting of acrylonitrile to UHMWPE (ultra high molecular weight) fiber;
3) Scale-up of radiation grafting processing

Slide 4

Preparation of uranium adsorbent from PE nonwoven fabric by radiation induced emulsion grafting



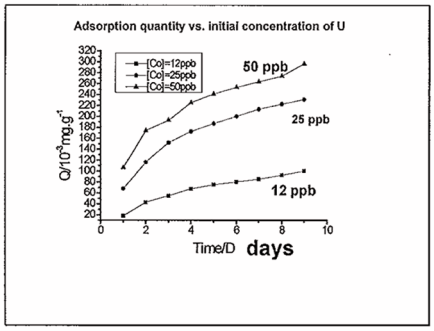
Advantages of emulsion graft polymerization :
Without organic solvents
High reaction rate
High monomer utilization ratio

Pre-irradiation : 30 kGy, 10 % AN, emulsifier, 60 °C, 6 hrs

Uranium uptake is 1.4 mg-U/g-ad

Flowing water, U conc. 2.5-3.3ppb, T: 15-25°C, 70 days;
Elution: 1M $NaHCO_3$

Slide 5



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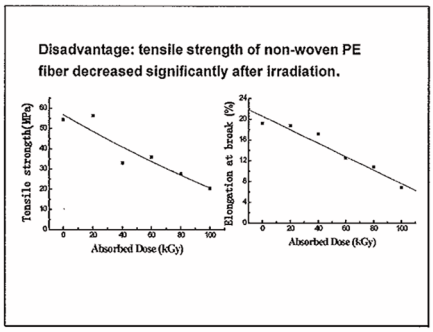


Slide 7

Our choice: UHMWPE fiber as the base material

Ultra-High Molecular Weight Polyethylene Fiber:

Advantage:

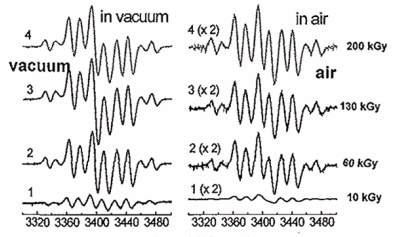
- **High strength and corrosion resistance**
- **Stable radical formation in UHMWPE fiber.**

Radiation Grafting of Acrylonitrile (AN) & Acrylic Acid to UHMWPE fiber

irradiation of Fiber in air ⟶ **Grafting of AN + AA**

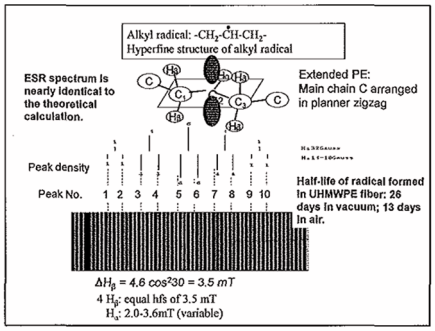
Slide 8

Stable radical formation in UHMWPE fiber after irradiation



ESR spectra of the UHMWPE fiber irradiated in vacuum and in air at room temperature with a dose rate of 0.73 Gy/s. 1: 10 kGy, 2: 60 kGy, 3: 130 kGy, 4: 200 kGy. (×2) indicates the magnification of spectrum by a factor of two.

Slide 9



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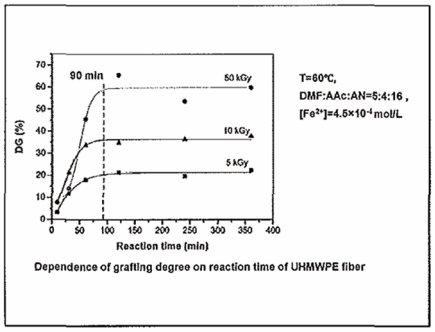

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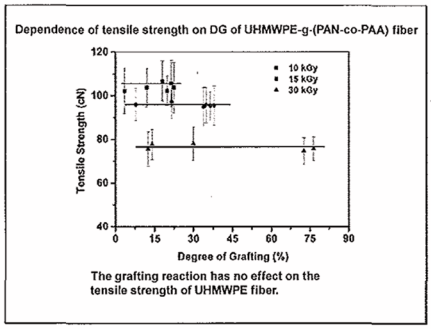

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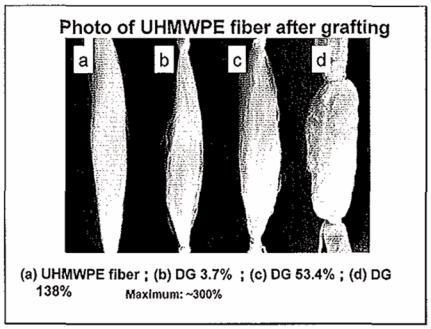

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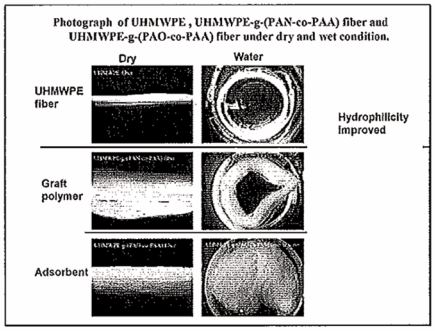

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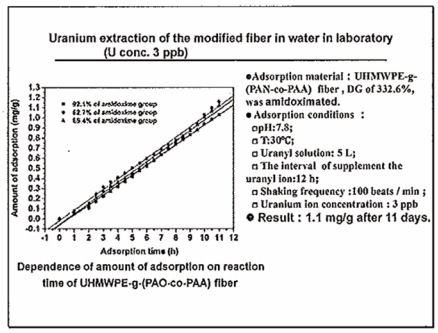
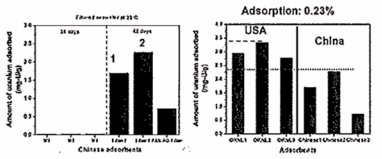


Slide 15

Marine test of the modified UHMWPE fiber in ORNL



Selectivity remains to be measured!

SINAP sample's adsorption quantity is lower than that of the US, but it should has much stronger tensile strength.

Slide 16

Future Plan in 2013-2014

1) Preparation of 1 kg grafted UHMWPE fiber in a batch;

2) Marine test of adsorption capacity and selectivity;

3) Scale-up of the adsorption material fabrication

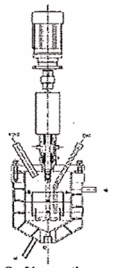
Slide 17

A reaction vessel for gamma irradiated UHMWPE fiber: design finished

Target: 1 kg/batch

The vessel put in glove box

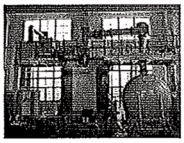
This is essential for the design of our future pilot plant.



Grafting reaction vessel

Slide 18

Construction of a continuous pilot production line using low energy electron beam for adsorbent fabrication



(300-500 KeV accelerator)

(Image) radiation grafting on non-wove fiber

Under Design, installation hopefully in summer of 2013

Slide 19

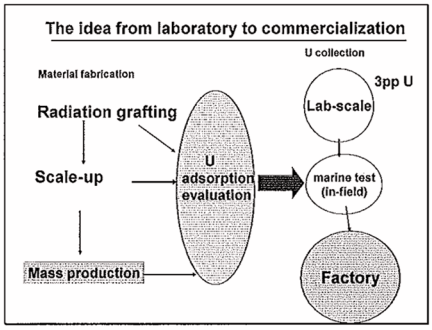
Adsorbent Evaluation

Uranium adsorption test in laboratory ;

Two marine test locations to be constructed in 2013.

(one in south, the other in east; the location not decided yet)

Slide 20



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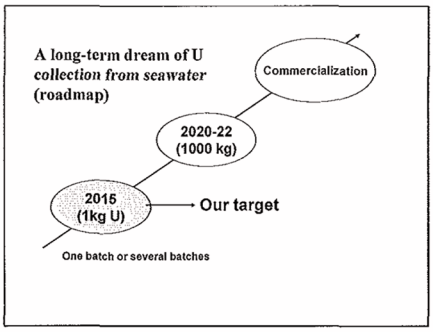

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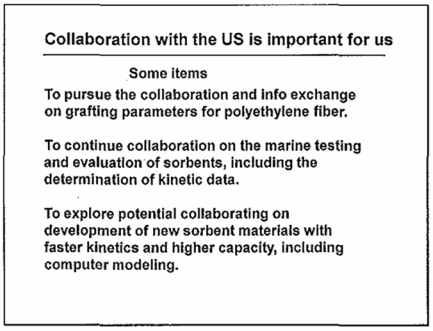


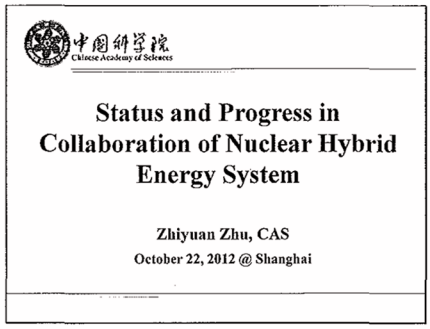
Slide 23

Thanks for your attention!

Attachment H:

Hybrid energy Nuclear Energy Systems Working Group Meeting Presentation and Planned Future Activities

Slide 1



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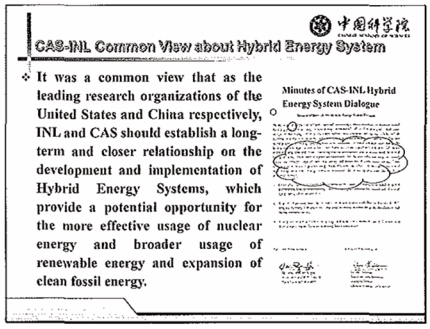

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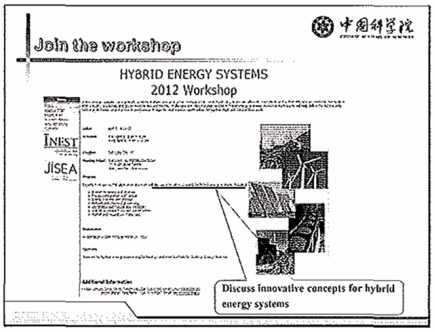

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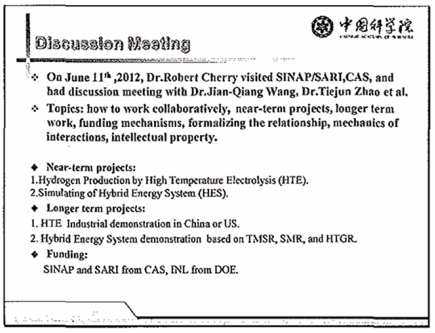

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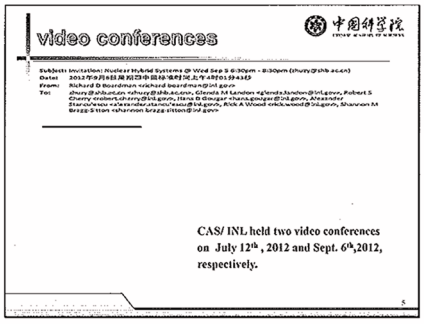

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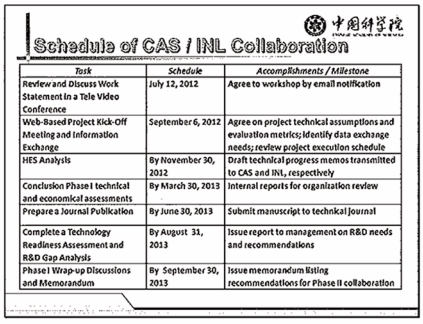

Schedule of CAS / INL Collaboration

Task	*Schedule*	*Accomplishments / Milestone*
Review and Discuss Work Statement in a Tele Video Conference	July 12, 2012	Agree to workshop by email notification
Web-Based Project Kick-Off Meeting and Information Exchange	September 6, 2012	Agree on project technical assumptions and evaluation metrics; identify data exchange needs; review project execution schedule
HES Analysis	By November 30, 2012	Draft technical progress memos transmitted to CAS and INL, respectively
Conclusion Phase I technical and economical assessments	By March 30, 2013	Internal reports for organization review
Prepare a Journal Publication	By June 30, 2013	Submit manuscript to technical journal
Complete a Technology Readiness Assessment and R&D Gap Analysis	By August 31, 2013	Issue report to management on R&D needs and recommendations
Phase I Wrap-up Discussions and Memorandum	By September 30, 2013	Issue memorandum listing recommendations for Phase II collaboration

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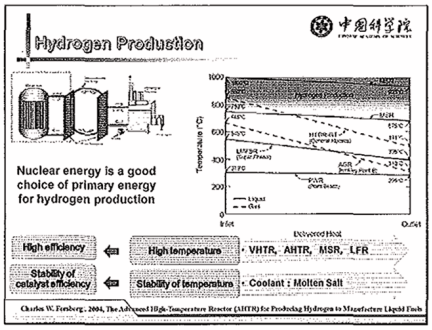

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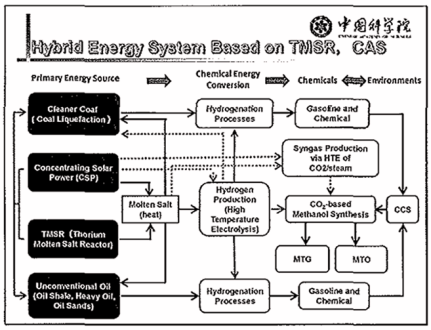

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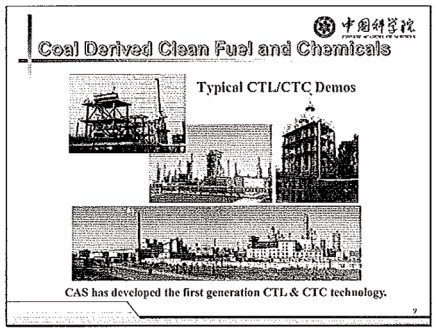

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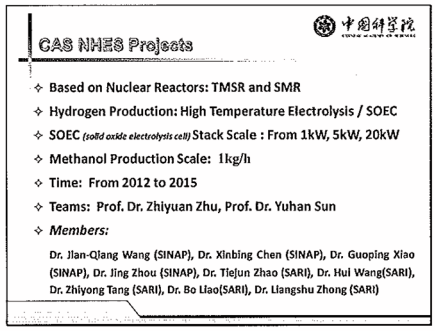

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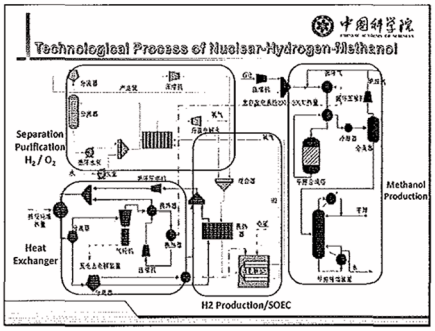

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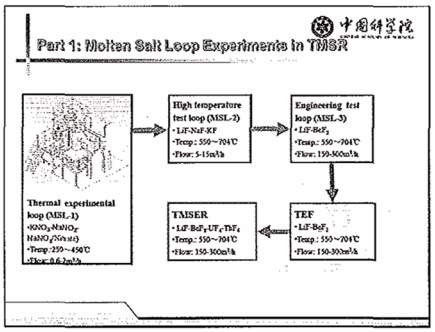

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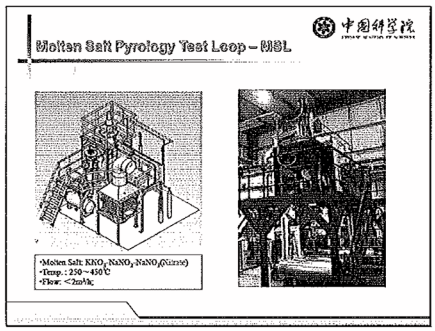

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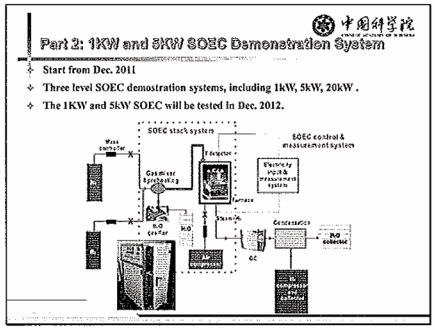

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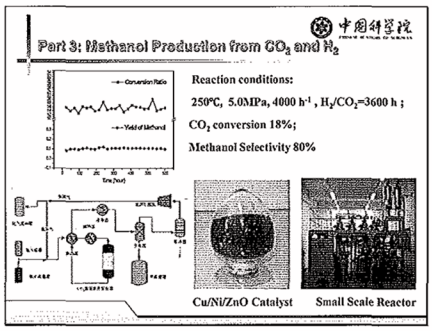

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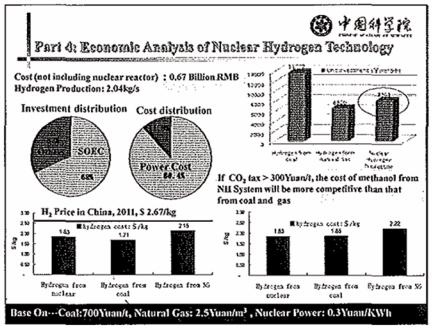

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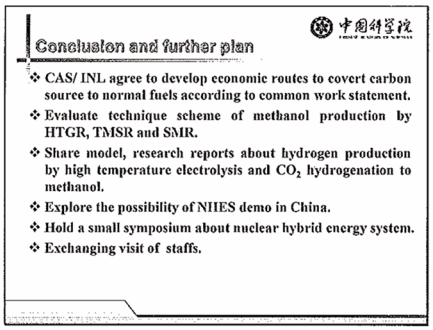

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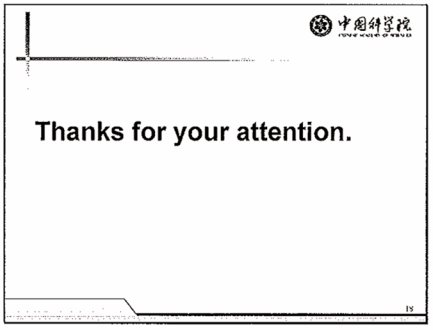

MEMORANDUM OF UNDERSTANDING

BETWEEN

THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA

AND

THE CHINESE ACADEMY OF SCIENCES

ON COOPERATION IN NUCLEAR ENERGY SCIENCES AND TECHNOLOGIES

The Department of Energy (DOE) of the United States of America, and the Chinese Academy of Sciences (CAS) of the People's Republic of China, hereinafter referred to as the "Participants":

NOTING their desire to enhance communication and cooperation on nuclear energy-related matters of common interest and to foster collaboration among scientists, laboratories, research institutes and universities of the Participants' countries and to facilitate and promote cooperation in research and development in a broad range of nuclear energy sciences and technologies; and

NOTING the Agreement for Cooperation between the Government of the United States of America and the Government of the People's Republic of China Concerning Peaceful Uses of Nuclear Energy, signed at Washington on July 23, 1985,

Have reached the following understanding:

Section 1
Objective

1. The objective of this Memorandum of Understanding (Memorandum) is to promote and facilitate cooperation on the scientific and technical aspects of nuclear energy technologies.

2. By their joint determination, the Participants may invite other entities to participate in the cooperative activities carried out in the framework of this Memorandum: governmental agencies, universities, science and research centers, institutes and institutions, private sector firms, and other entities of the Participants' respective governments. The costs of such participation are the responsibility of the entities that incur them.

3. The Participants' cooperation under this Memorandum is intended for peaceful purposes only.

Section 2
Forms of Cooperation

1. Forms of cooperation under this Memorandum may include: exchange of publicly available technical information, data and experience; exchange of technical and managerial personnel for visits and short-term assignments; exchange of equipment, materials and instrumentation; joint conferences, seminars or workshops; and such other forms of cooperation as the Participants may jointly decide in writing.

2. The terms of visits and assignments, and the exchange of equipment, materials, and instrumentation should be the subjects of appropriate written agreements between the sending and receiving entities.

Section 3
Areas of Cooperation

1. Priority areas of cooperation may include the following:

   Nuclear Energy for Non-electric Applications
   Nuclear power could be used to displace greenhouse gas emitting fuels in the industrial sector. Petroleum refining, for example, requires temperatures in the range of 250-500°C while steam reforming of natural gas requires process heat in the 500-900°C range. Achieving higher output temperatures requires switching to a new coolant technology such as molten salt. With advanced coolants, it is possible to achieve outlet temperatures ranging from 500°C to over 900°C.

Potential subjects of collaborative activities may include materials and chemistry of fluoride salt coolant systems.

Nuclear Fuel Resources
Nuclear energy can help alleviate the concern over greenhouse gases and global warming, energy supply security, and high and volatile fossil fuel prices. For nuclear energy to remain a viable and sustainable energy source, there must be assurance that economical sources of nuclear fuels are available. The focus of this cooperation is direct extraction of dissolved uranium from seawater. Although uranium is present in very low concentrations in seawater, 3.3 parts per billion, the oceans contain over 4500 million tonnes of uranium, which would provide essentially unlimited supply of nuclear fuel. Potential subjects of collaborative activities may include: (a) molecular-level understanding of the coordination modes, sorption mechanisms, and kinetics of uranium extraction; (b) new functional ligands; and (c) advanced sorbent materials.

2. The areas of cooperation may be expanded and revised by the written consent of the Participants.

3. The Participants intend to conduct research and development on mutually determined subjects under appropriate written agreements therefor. Such agreements should include, among other matters, provisions for the protection and allocation of intellectual property.

Section 4
Management

1. Execution of this Memorandum is to be guided by an Executive Committee (EC) consisting of one co-chair from each Participant: DOE Assistant Secretary for Nuclear Energy and Vice President of CAS.

2. The EC co-chairs should designate one technical coordinator from each Participant to organize technical activities under this Memorandum. The technical coordinators should jointly plan, identify, and coordinate cooperative activities. Specific working groups may be established to collaborate on mutually determined topics.

3. Working groups and/or EC meetings should take place on an annual basis or as otherwise mutually decided, alternately in the United States and in the People's Republic of China.

4. The host Participant should choose the meeting site and bear the costs for the arrangements associated with the meeting. Representatives from each Participant attending the meetings are to be responsible for their own travel and lodging expenses.

5. The technical coordinators should jointly prepare written reports of the meetings. Each Participant may disseminate the written meeting report without prior notification to the other Participant, after the record has been approved by EC. The report should document the progress of activities and the next year's plans for continuation of cooperation.

6. The technical coordinators may invite representatives of other organizations within their countries to attend joint working groups and/or EC meetings.

Section 5
General Considerations

1. This Memorandum does not constitute a legally binding agreement.

2. Each Participant should implement this Memorandum in accordance with the laws, regulations and other requirements of its respective country and international agreements to which its government is party.

3. Any questions relating to this Memorandum arising during its term should be resolved by consultations between the Participants.

4. Each Participant is responsible for the costs of its participation in all cooperative activities carried out in the framework of this Memorandum, unless they determine otherwise in writing. Each Participant's participation in the cooperative activities is subject to the availability of funds, resources, and personnel.

Section 6
Commencement, Modification, and Discontinuation

1. The Participants' implementation of cooperative activities within the framework of this Memorandum may commence on the date of signature.

2. This Memorandum may be modified by mutual determination of the Participants in writing.

3. The Participants may discontinue this Memorandum at any time in writing. Alternatively, a Participant that wishes to discontinue its participation in the activities under this Memorandum should endeavor to provide at least six (6) months' written notice to the other Participant.

Signed, in duplicate, at Washington on the 21 day of December, 2011, and at Beijing on the 29 day of December, 2011, in the English and Chinese languages.

FOR THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA:

FOR THE CHINESE ACADEMY OF SCIENCES:

谅解备忘录

美利坚合众国 能源部

与

中国科学院

关于核能科学与技术合作

美利坚合众国能源部（能源部）和中华人民共和国科学院（中科院），以下简称"双方"：

注意到双方对在核能方面共同关注事宜加强沟通与合作，促进双方的科学家、实验室、研究机构和大学间的合作，和实现广泛的核能科学与技术领域的研发合作上的愿望；并

注意到于 1985 年 7 月 23 日在华盛顿签署的美利坚合众国政府与中华人民共和国政府关于和平利用核技术的合作协议，

达成以下谅解：

一、目标

1. 本谅解备忘录（备忘录）旨在推进和加快核能技术领域的科技方面的合作。

2. 经共同确认后，双方可以邀请其他单位参与在此备忘录框架下开展的合作活动，包括：政府机构、大学、科研中心、研究院所、私人企业和双方各自政府下的其他单位。其所需费用由参与单位自行负担。

3. 双方在此备忘录下的合作均仅限于和平目的。

二、合作形式

1． 在本备忘录下的合作形式可包括：公共技术信息、数据和经验的交换；技术与管理人员的互访和短期派驻；设备、材料与仪器的交换；共同举办学术大会、研讨会或讲习班；以及双方以书面形式共同确定的其他合作方式。

2． 人员的互访与短期派驻以及设备、材料和仪器的交换等条款应由派遣与接收单位以适当书面形式达成双方共识。

三、合作领域

1． 优先合作领域包括如下方面：

核能在非电力应用领域的合作

核能可用于替换工业领域排放温室气体的燃料，例如，石油提炼需要温度在 250-500°c，而天然气蒸汽重整是热处理的温度应在 500-900°c 间，达到更高的温度效果则需要转换到新的冷却技术，如熔盐。有了先进的冷媒，可以使产出温度达到 500°c -900°c 以上。潜在领域的合作活动可包括氟化盐冷却系统的材料与化学研究。

核燃料资源

核能可以减少对温室气体排放和全球变暖、能源安全和反复无常的化石能源的价格上的担忧。为使核能继续作为即可性又可持续的能源资源，必须确保可获得经济性的核燃料资源。此合作的重点是直接从海水中萃取铀，虽然铀在海水中的浓度很低，3.3 ppb(十亿份率)，但是海水含有超过 45 亿吨的铀原料，这将为核燃料提供无限的资源。潜在领域的合作活动可包括 (a) 配位模型分子级别的理解，吸附机制，和铀萃取的动力学；(b)新功能配体；及(c)先进的吸附剂材料。

2． 经双方一致书面同意，可将合作领域扩展和修改。

3． 双方将在以书面协议形式共同确定的领域进行研究和开发工作。此类协议其中，涵盖的其他事宜当中，应包括保护和分配知识产权的条款。

四、管理

1. 对本备忘录的执行将受执行委员会的监督，执行委员会包括双方各一名主席，即能源部核能助理部长和中科院副院长。

2. 执行委员会主席应从本方各自指派一名技术协调员执行本备忘录下的相关技术活动。双方技术协调员应共同计划、确定和协调合作活动，并可针对双方共同确立的课题成立相关工作组。

3. 工作组和/或执行委员会会议每年举办一次或按双方商定择期举办，会议轮流在美国和中国举行。

4. 主办方应负责选择会议的地点并承担会议相关的费用。参与会议的双方代表应承担各自的旅费和住宿费用。

5. 双方的技术协调员应共同撰写会议报告，经执行委员会批准后，双方均有权发布会议书面报告，无需事先通知对方。会议报告应包含双方合作活动的进展情况，以及下一年延续合作的实施计划。

6. 技术协调员可以邀请其本国其他机构的代表参加工作组和/或执行委员会会议。

五、总体考虑

1. 本备忘录将不受法律约束。

2. 任何一方在本备忘录下所开展的活动均须遵守其相关法律、规定和要求，以及本国所加入的国际协议。

3. 在备忘录有效期内，任何关于本备忘录的问题均由双方通过协商解决。

4. 除非另行书面约定，本备忘录下合作所产生的费用均由发生费用的一方承担。本备忘录下所开展的活动取决于人力、已拨经费和其他资源是否到位。

六、生效、修改和终止

1． 双方在本备忘录框架下的合作在本备忘录签署之日开始实施。

2． 本备忘录经双方书面同意可予以修订。

3． 本备忘录可在任何时候由双方以书面形式终止；如一方希望终止本谅解备忘录，应提前六个月书面通知另一方。

本谅解备忘录于 2011 年12月29日在北京签署，于 2011 年12月21日在华盛顿签署，英中文版本各一式两份。

美国能源部：

中国科学院:

DEPARTMENT OF DEFENSE AUTHORIZATION REQUEST FOR APPROPRIATIONS FOR FISCAL YEAR 2023 AND THE FUTURE YEARS DEFENSE PROGRAM

WEDNESDAY, MAY 11, 2022

UNITED STATES SENATE,
SUBCOMMITTEE ON STRATEGIC FORCES,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

UNITED STATES SPACE FORCE PROGRAMS

The Subcommittee met, pursuant to notice, at 4:37 p.m. in room SR–232A, Russell Senate Office Building, Senator Angus King (Chairman of the Subcommittee) presiding.

Committee Members present: Senators King, Kelly, Fischer, Cotton, Rounds, Cramer, and Tuberville.

OPENING STATEMENT OF SENATOR ANGUS KING

Senator KING. I call this hearing of the Strategic Forces Subcommittee of the Senate Committee on Armed Services to order.

I want to thank our witnesses for joining us today before this Subcommittee and thank you for your service.

The purpose of today's hearing is to examine the fiscal year 2023 budget of the Space Force, a separate title 10 service, which was recently authorized in the fiscal year 2020 National Defense Authorization Act (NDAA). For fiscal year 2023, the Space Force budget is $24.5 billion, a $7.1 billion or 40 percent increase over fiscal year 2022. Of the $7.1 billion, however, $3 billion is for interservice transfers, as the Space Force assumes satellites and people from the Army and Navy, and the remaining $4.1 billion is for programmatic growth, still a 20 percent increase over fiscal year 2022.

I will be looking to hear what is and transferred into the Space Force, especially with the transfer of uniformed Army and Navy personnel.

The administration has submitted a proposal for a new personnel system that would treat the Space Force guardians as either full- or part-time components. The Reserves would fall into the part-time component, and I want to know more about this, given competing proposals for a Space National Guard.

Finally, since the Space Force is a title 10 service, its purpose is to train and equip guardians to defend our assets in space, which is now a warfighting domain, given the action of Russia and China against our satellites. I want to know how our policy is developing

to defend our space assets and, if necessary, ensure a near-peer adversary space system cannot be used to help a system attack on our forces on the ground or at sea during a conflict.

Again, let me thank our witnesses for agreeing to appear today, and after opening statements, we will have a 5-minute round of questions to the witnesses.

Senator Fischer?

STATEMENT OF SENATOR DEB FISCHER

Senator FISCHER. Thank you, Senator King.

I join you in welcoming our witnesses. Thank you all for being here with us today and for the work that you do on behalf of this Nation.

Dr. Plumb, it is good to see you again. I understand you will be testifying before this panel again next week. Three times in a row, that has to be some kind of record. We appreciate your service, sir, and we look forward to hearing from you and the other witnesses today about the continued evolution of the Department's national security space enterprise.

It has been 2½ years since the founding of the Space Force. We welcome the panel's views on what progress has been made, particularly toward developing an acquisition system that delivers capabilities on a timeline that is responsive to the needs of our warfighters and paces the actions of our adversaries. Thank you.

Thank you, Mr. Chairman.

Senator KING. Thank you.

Our witnesses today are Mr. Frank Calvelli, Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics; Dr. John Plumb, welcome back, Assistant Secretary of Defense for Space Policy; and General David D. Thompson, Vice Chief of Space Operations, United States Space Force.

So, Mr. Frank Calvelli?

STATEMENT OF FRANK CALVELLI, ASSISTANT SECRETARY OF THE AIR FORCE FOR SPACE ACQUISITION AND INTEGRATION

Mr. CALVELLI. Chairman King, Ranking Member Fischer, and distinguished Members of the Subcommittee, it is an honor to appear before you to discuss the future of Space Acquisition. Thank you for asking me to testify. I am excited to join the Department and for this important work to come as we optimize Space Acquisition.

As you know, we must do more, and quickly, to accelerate and improve Space Acquisition. Our adversaries are catching up, or in some cases, exceeding our capabilities. Strong partnerships between the Department, Congress, and the commercial industry are critical to outpace China and other adversaries.

As I step into this new role, I would like to share with you my initial goals and priorities. These include: one, driving speed into our acquisitions in order to deliver new capabilities faster, to outpace our adversaries, and maintain the technological advantage we get as a Nation from space; two, making our space architectures are resilient so that it can be counted on during times of crisis and conflict; three, integrating our space architecture with other warfighting domains to give our warfighters a strategic edge; four,

driving program management discipline across our acquisitions in order to ensure that we deliver new capabilities on schedule, on cost, and meeting requirements; and five, ensuring that our space and ground systems come together as a system and that our ground systems are more readily available before launch to take advantage of the new capabilities that we just put into space.

I look forward to working with you over the coming months to continue the strong partnership between the Department and the Congress to optimize and strengthen Space Acquisition processes and outcomes. I look forward to your questions. Thank you.

Senator KING. Dr. Plumb?

STATEMENT OF THE HONORABLE JOHN F. PLUMB, ASSISTANT SECRETARY OF DEFENSE FOR SPACE POLICY

Mr. PLUMB. Thank you, Chairman King, Ranking Member Fischer, Members of the Subcommittee.

I appreciate the opportunity to testify today and get my frequent-flyer miles.

As the first-ever Assistant Secretary of Defense for Space Policy, I am committed to continuing DOD'S close partnership with Congress on advancing national security space interests. Space plays a critical role in American security, prosperity, and way of life. It enables and supports the entire Joint Force. It helps protect servicemembers in harm's way and it enables them to execute their mission and defend the Nation.

Space provides indication and warning of emerging threats and attacks. It delivers the GPS [Global Positioning System] signals supporting rapid and precise global power projection. It generates intelligence to allow national decision-makers to anticipate risks and de-escalate crisis, and it enables those same decision-makers to command-and-control forces globally.

In the tremendous growth of commercial space, largely due to U.S. business innovation, it is fueling an increasing important part of the U.S. economy. The growth of the U.S. Space Industrial Base affords DOD new opportunities to leverage commercial advancements to support national security.

Space has, once again, captured the imagination of a new generation of Americans. This will inspire more students to pursue careers in the STEM disciplines and that will pay dividends to our national economy and national security in the future.

Looking at the threat environment, China and Russia both seek to increase their military use of space and to exploit the perceived United States overreliance on space-based systems.

China remains our pacing challenge, as Secretary Austin has said. They are developing and fielding a wartime space architecture. China has dramatically increased their quantity and quality of space and counterspace systems, increasing ground- and space-based antisatellite weapons to target United States and allied satellites.

Russia maintains a large network of reconnaissance, communication, and navigation satellites, and they are also developing, testing, and fielding counterspace weapons, including ground-based and on-orbit capabilities to target United States and allied satellites. These threats require the U.S. to consider new approaches

to ensuring our use of space, including developing more proliferated and, therefore, more resilient constellations.

To that end, the President's fiscal year 2023 budget request seeks $27.6 billion for DOD space capabilities, including $4.7 billion to fund the transition to a new resilient missile-warning and missile-track architecture; $1.8 billion to procure two GPS III follow-on satellites and to continue testing and integration of military GPS-user equipment; $1.6 billion for secure, survivable, and jam-resistant SATCOM; and $1.6 billion to procure six National Security Space Launch vehicles.

In November, Russia conducted an irresponsible, destructive test of a direct-ascent ASAT [antisatellite weapon] missile, creating more than 1,500 pieces of trackable debris, hundreds of thousands of smaller pieces that threaten safe space operations in low-earth orbit.

In contrast, the Department is committed to promoting norms of responsible behavior in space to ensure the space domain remains secure, stable, and accessible. The Deputy Secretary of Defense stated in December at the National Space Council meeting, the Department would like to see all nations agree to refrain from anti-satellite weapons testing that create debris.

At Vandenberg last month, Vice President Harris announced a U.S. commitment that the U.S. will not conduct destructive, direct-ascent ASAT missile testing. These types of tests jeopardize the long-term sustainability and safety of space for all. This includes human spaceflight programs and all commercial satellite operators. Ending destructive, direct-ascent ASAT missile tests is, therefore, in our national security interests and in our national economic interest. The U.S. has demonstrated a leadership with this commitment and encourages all nations to support responsible space behaviors.

In conclusion, the threats facing the U.S. in space, and from space, continue to grow in both, quantity and quality. Countering those threats requires that we continue this longstanding bipartisan cooperation between DOD and the Congress. I am committed to sustaining those efforts and I am honored to work with this Committee to do so.

Thank you, and I look forward to your questions.

[The statement of Mr. Plumb follows:]

PREPARED STATEMENT BY DR. JOHN F. PLUMB

INTRODUCTION

Chairman King, Ranking Member Fischer, Members of the Subcommittee, thank you for the opportunity to testify today on the United States Space Force and associated programs.

As the Assistant Secretary of Defense for Space Policy, I am responsible for the overall supervision of the policy of the Department of Defense (DOD) for space warfighting, as well as interagency coordination and international engagement on space policy and strategy. In addition to space, my policy portfolio includes those other strategic capabilities essential to integrated deterrence: cyberspace operations, nuclear weapons, missile defense, and countering weapons of mass destruction. I am grateful for the opportunity to appear before you as the first person confirmed to this new position, and I welcome the opportunity to address space policy, space security, and the role of space in DOD's approach to integrated deterrence. I am committed to continuing the close partnership between DOD and Congress on advancing our national security space interests.

IMPORTANCE OF SPACE

Space plays a critical role in American security, prosperity, and way of life.

Space contributes to our national security by enabling and supporting the entire Joint Force: our servicemembers on land, at sea, and in the air rely on space every single day to defend the Nation. Space capabilities provide indications and warning of emerging threats and attacks. Space systems deliver the positioning, navigation, and timing (PNT) signals that support rapid and precise global power projection. Space systems generate intelligence on operationally relevant timelines and allow national decision makers to anticipate risks and de-escalate crises, and space also enables those same decision makers to command and control forces in multiple theaters around the globe.

Russia's unprovoked further invasion of Ukraine provides a timely example of the role of space in shaping the information environment. United States Government, allied, and commercial satellites tracked Russian military movements in the lead-up to the invasion, aiding senior decision makers and helping facilitate our early coordination with allies and partners. Satellites have continued to track the activities of Russian forces during the conflict and are contributing to the international effort to hold Russia accountable for its unprovoked invasion, while supporting the Ukrainian people in their fight against brutal Russian aggression.

DOD's space capabilities provide value well beyond national security. The Department's Global Positioning System (GPS) constellation provides precise PNT signals that are used in an untold number of ways in both the civil and private sector. Examples include: routing cell phone data; synchronizing weather radars; timestamping financial transactions; geographical information systems (GIS); and driving from point A to point B in your car without getting lost. U.S. military satellites help support space-based environmental monitoring, including weather forecasting and climate change modeling. Our Overhead Persistent Infrared (OPIR) constellations are designed to provide missile warning and tracking capabilities, but also support crews on the ground fighting wildfires and help scientists track the impacts of climate change. DOD's space surveillance network supports the Department's space domain awareness mission but also provides foundational data that enables the safety of space operations and supports the global space situational awareness needs of all space operators.

The explosive growth of commercial space, which has been successful due in large part to the remarkable innovation of U.S. businesses, is fueling an increasingly important part of the U.S. economy. That same growth presents DOD with new opportunities to leverage commercial technological advancements to support national security needs. Moreover, space is once again capturing the imagination of a new generation of Americans. This can inspire more students to pursue careers in STEM (science, technology, engineering, and mathematics) disciplines, paying dividends to our national economy and national security in the future.

A striking way to highlight the importance of space to U.S. national security can be found by reviewing the four Defense priorities of the 2022 National Defense Strategy. All four priorities require and rely on the ability of the United States to operate in space, both in peacetime and during conflict:

1. Defending the Homeland, paced to the growing multi-domain threat posed by the People's Republic of China (PRC).
2. Deterring strategic attacks against the United States, our Allies, and our partners.
3. Deterring aggression—while being prepared to prevail in conflict when necessary—prioritizing the PRC challenge in the Indo-Pacific, then the Russia challenge in Europe.
4. Building a resilient Joint Force and defense ecosystem.

THE THREAT ENVIRONMENT

In recent years, as the PRC and Russia have integrated space into their respective national and warfighting strategies. The threats facing the United States in space and from space have changed fundamentally and continue to grow in both quantity and capability.

As Secretary Austin has made clear, China is the Department's pacing challenge. This holds true in space as it does in other domains. The United States developed most of our current space architecture in an era when space was perceived more or less as a sanctuary. In contrast, over the past decade China has dramatically increased the quantity and quality of its space and counterspace systems in order to develop and field a wartime space architecture. China is working to match or exceed United States capabilities in space to gain military, economic, and reputational benefits: it is integrating space services and satellite communications into its weapons

and command-and-control systems; its counterspace capabilities pose a growing threat to United States and allied space systems and would be integral to potential military campaigns by the People's Liberation Army (PLA). China's wartime space architecture requires the United States to consider new approaches to ensuring our own use of space, including developing more proliferated—and therefore more resilient—constellations of our own.

Russia also remains a key space competitor, maintaining a large network of reconnaissance, communications, and navigation satellites. Russia will continue to integrate space services into weapons and command-and-control systems, allowing quicker identification, tracking, and targeting of United States forces during a conflict. In recent years, Russia has focused on developing its civil and commercial space capabilities, and it is able to employ its civil and commercial remote sensing satellites to supplement its military-dedicated capabilities. Russia continues to train its military space elements and is developing, testing, and fielding counterspace weapons to target

U.S. AND ALLIED SATELLITES.

PRC and Russian military doctrines indicate that both countries view space as critical to modern warfare. They both consider the use of counterspace weapons as a means of reducing U.S. military effectiveness and a means for winning future wars. They both seek to leverage the space domain to gain informational, operational, and logistical advantages. And they both increasingly seek ways to expand their capabilities in space and to exploit the perceived U.S over-reliance on vulnerable space-based systems.

As China and Russia improve their respective space and counterspace capabilities, both nations are integrating space scenarios into their military exercises. They continue to develop the means to deny others the use of space through employment of malicious cyberspace activities, including cyber attacks, against ground sites supporting space operations; both have developed sensor networks for tracking and targeting others' satellites; and both have extensive inventories of jamming capabilities to disrupt satellite communications. Russia and China have developed directed energy weapons to blind intelligence, surveillance, and reconnaissance (ISR) satellites, and they continue the development, testing, and proliferation of direct-ascent and on-orbit antisatellite weapons to hold at risk United States and allied space assets.

Space, Integrated Deterrence, and the President's Budget Request Deterrence requires actions to reduce a competitor's perception of the benefits of aggression relative to restraint. Deterrence also requires credible capability and will to impose costs that would outweigh the benefits of aggression. Ultimately, deterrence is premised on altering a competitor's perceptions of the net benefits and costs of aggression.

Assured space capabilities, and the ability to prevent hostile uses of space, are vital components of integrated deterrence across all domains and through all levels of competition, crisis, and conflict that the Department will leverage and continue to strengthen. In this regard, our fiscal year 2023 budget request would:

- Strengthen mission assurance and reduce the benefits of attacks in space by accelerating the transition to diverse, proliferated, and protected space architectures that will demonstrate our growing ability to maintain mission capable status in a degraded state and under sustained attack.
- Bolster our ability to fight through disruption by improving defensive capabilities and increasing options for reconstitution, thereby reducing the benefits of aggression in space.
- Expand and modernize our ability to deliver advanced capabilities to enable joint and combined operations across domains, and support national leadership decisions with assured missile warning, missile tracking, and secure nuclear command and control.
- Sustain our information advantages by improving our ability to integrate, defend, and reconstitute our ISR and decision systems on operationally relevant timelines to achieve our objectives, notwithstanding aggressive interference and deception.
- Advance and expand our architectures of: space-based sensors that provide indications and warning of threats to space systems; ISR capabilities that provide persistent, global information; and multi-function terrestrial sensors that provide additional opportunities to strengthen space domain awareness.

More specifically, DOD's fiscal year 2023 national security space budget request seeks $27.6 billion in vital space capabilities, resilient architectures, and enhanced

space command and control to support our terrestrial forces and keep space safe for military, civilian, and commercial operations. These investments include:

- Missile Warning: $4.7 billion would fund transition to new, resilient missile warning and missile tracking architectures, completion of the Next Generation OPIR Polar capability, and development of the associated enterprise ground portfolio that will track an increased range of threats, including hypersonic and maneuverable weapons.
- GPS Enterprise: $1.8 billion for PNT would fund procurement of two GPS III follow-on satellites and continues testing and lead platform integration of Military GPS User Equipment (MGUE) Increment 1 receivers capable of using our most protected, jamming-resistant GPS M–Code signals.
- Satellite Communications (SATCOM): $1.6 billion would fund development of secure, survivable, and jamming-resistant SATCOM capabilities.
- Launch Enterprise: $1.6 billion would fund six national security space launch vehicles for assured access to space across all of the orbits that we use.

NORMS AND TENETS OF RESPONSIBLE BEHAVIOR

In previous hearings, this Subcommittee has helped increase visibility of the importance of norms and responsible behavior in space as an element of ensuring a safe operating environment and reducing the risks of misunderstandings and miscalculations that could lead to conflict and escalation. In collaboration with the Department of State, the Department is committed to promoting standards and norms of responsible behavior in space to shape the operating environment and ensure that the space domain remains secure, stable, and accessible.

As a defense organization and one of the single largest space operators in the world, the Department has taken an important step toward these objectives by sharing tenets that describe our longstanding operational practices in space. We hope this step will set an example and help develop a shared understanding among nations of what constitutes safe and responsible behaviors for all military space operators, and help reduce the risks of misunderstanding and inadvertent escalation.

In July 2021, Secretary of Defense Lloyd Austin signed a memorandum to DOD leadership that outlines guidance for DOD space operations in the form of five key "Tenets of Responsible Behavior in Space." That guidance provides a clear and transparent statement of how Department of Defense Components will operate in space under normal circumstances. These Tenets of Responsible Behavior provide that our space operators, unless otherwise directed, will:

- Operate in, from, to, and through space with due regard to others and in a professional manner;
- Limit the generation of long-lived debris;
- Avoid the creation of harmful interference;
- Maintain safe separation and safe trajectory; and
- Communicate and make notifications to enhance the safety and stability of the domain.

U.S. Space Force guardians, and military servicemembers from across the Joint Force who use space or deliver effects in space, operate consistent with these tenets. Furthermore, at the Secretary's direction, the U.S. Space Command continues to develop guidance regarding specific behaviors for DOD operations in the space area of responsibility that will continue to advance these tenets.

On November 15, 2021, when Russia conducted a destructive test of a direct-ascent anti-satellite (ASAT) missile against an orbital target, the world saw clearly that not all nations adhere to the same sense of responsibility for their actions in space. That test created more than 1,500 pieces of trackable debris (greater than 10 cm) and hundreds of thousands of smaller pieces that pose a threat to the safe operation of satellites in low Earth orbit, including to astronauts on the International Space Station and on a growing number of other platforms. The threats that such irresponsible behavior present for the interests of all space operators are one reason why the Deputy Secretary of Defense stated at the December 1, 2021, National Space Council meeting that the Department "would like to see all nations agree to refrain from anti-satellite weapons testing that creates debris."

The United States Government took an important step toward that broad goal on April 18, 2022, at Vandenberg Space Force Base, when Vice President Harris announced a U.S. commitment to not conduct destructive direct-ascent ASAT missile testing. This non-legally binding commitment is focused on stopping the single most impactful and threatening behavior to the space domain at the present time: the destructive testing of direct-ascent ASAT missiles, which degrades the space operating environment. Destructive direct-ascent ASAT missile testing jeopardizes the long-

term sustainability of space and imperils the exploration and use of space by all nations. Destructive direct-ascent ASAT missile tests place not just U.S. Government satellites at risk—civil and national security programs alike—but place commercial satellites at risk as well. At the dawn of this new era of rapidly increasing commercial access to and use of space, in order to protect the economic benefits the United States derives from space now and in the future, ending destructive direct-ascent ASAT missile tests is more important than ever.

This commitment, a unilateral statement of restraint in the space domain that is in our national interest as well as in the interest of all spacefaring nations, demonstrates that we are renewing U.S. leadership on the world stage. We are going to lead by example, but we will be working in partnership with the Department of State to encourage other nations to consider making similar commitments over the coming weeks and months.

ALLIES AND PARTNERS IN COMBINED SPACE OPERATIONS

U.S. allies and partners provide an asymmetric strategic advantage that our adversaries cannot hope to match. The United States and its partners in the Combined Space Operations (CSpO) initiative—Australia, Canada, France, Germany, New Zealand, and the United Kingdom—are increasingly focused on ensuring freedom of access in space, and recognize the role that space plays in our security and in our ability to deter aggression. On February 22, 2022, the CSpO partners published the "Combined Space Operations Vision 2031," which addresses the overarching need to encourage responsible use of space, recognizing the challenges to space sustainability, the threats presented by technological advances, and the increasingly comprehensive and aggressive counterspace programs of other nation states.

The CSpO Vision 2031 describes a common mission to generate and improve cooperation, coordination, and interoperability to sustain freedom of action in space, optimize resources, enhance mission assurance and resilience, and prevent conflict. It sets forth common objectives focused on:

- Preventing conflict extending to or originating in space while promoting security and stability in all domains;
- Achieving unity of effort through information sharing across multiple classification levels and real-time synchronized networked operations centers operated by a workforce with common training;
- Establishing and maintaining a robust, responsive, and interoperable space infrastructure enabling continued space effects in the face of adverse action or changes to the space domain; and
- Defending and protecting our national interests and the space domain.

As our competitors continue to advance their capabilities and capacity to use space and hold U.S. space systems at risk, space partnerships like those we are developing through CSpO will fundamentally strengthen deterrence.

CONCLUSION

The security environment in the space domain is undergoing significant changes. Those changes can increase opacity and risk of miscalculation during a crisis or conflict. The risk of inadvertent escalation is high in the space domain due to the lack of clear norms of behavior, unclear escalation thresholds, complex domain interactions, and the rapid introduction of new capabilities, including adversarial counterspace capabilities. The Department remains committed to strengthening our space mission assurance, denying hostile uses of space, advancing international norms for responsible behavior in space, and maintaining our strategic advantages in space, including through our increasingly robust international space partnerships with our longstanding allies and partners. The Vice President's announcement of a non-legally binding U.S. commitment to not conduct destructive direct-ascent ASAT missile testing, and our investments to accelerate resilience in our space architectures as facilitated by DOD's fiscal year 2023 national security space budget request, provide clear examples of this overarching commitment.

The United States and our allies and partners are ready for the challenge. Here at home, U.S. advances in our approach to space security over the past decade are a result of persistent, bipartisan effort and close cooperation between the Executive and Legislative branches of our government. I am committed to sustaining those efforts and honored to work with the Congress, our DOD civilians and Military servicemembers, my interagency colleagues, U.S. industry, and our international allies and partners in a common cause to secure the advantages of space for our national interests.

Senator KING. General Thompson?

STATEMENT OF GENERAL DAVID D. THOMPSON, USSF, VICE CHIEF OF SPACE OPERATIONS

General THOMPSON. Chairman King, Ranking Member Fischer, and distinguished Members of the Subcommittee, thank you for the opportunity to testify today.

It is an honor to appear before you on behalf of the Secretary of the Air Force, the Honorable Frank Kendall, the Chief of Space Operations, General Jay Raymond, and the 14,000 guardians around the world executing our space missions today.

U.S. military success and great power competition depends on access to and freedom to operate in space, while denying the same to our adversaries. In 2019, Congress established the Space Force to organize, train, equip, and present forces to deter hostile action and protect U.S. interests in space and to secure the domain for stable, peaceful use.

Space capabilities are a cornerstone of integrated deterrence, not just in space, but in every domain and those space capabilities that we operate underpin every aspect of our national security. At the same time, our space systems and use of the domain remain under threat by competitor nations.

China remains our pacing challenge. In 2021, the PRC continued to accelerate the integration of space capabilities into its military operations, especially space-based surveillance, intelligence, and reconnaissance, which puts the soldiers, sailors, airmen, and marines, we protect and support at great risk. Additionally, Russia's overarching strategy remains to challenge the United States in space; that is unchanged for decades. It is continuing to improve its military space capabilities as well. Both nations are also developing and deploying an array of kinetic and non-kinetic counterspace weapons that threaten U.S. systems in every orbital regime, on the ground, and in cyberspace.

In response to these challenges, and in keeping with the reasons the Space Force was established, we continue to make substantial progress in the design, development, and fielding of space capabilities that maintain our freedom to operate in space. We advance recruiting, training, and educating the workforce that is demanded to operate in such a highly technical domain, and in putting in place the intelligence, analytic, and test foundations that ensure success of our forces in future conflict.

The President's fiscal year 2023 budget request for the Space Force does this in several ways. As examples, it initiates the first major transformation to a resilient force structure with a proliferated missile-warning, missile-tracking architecture, which is also capable of tracking hypersonic and maneuvering vehicles. It enhances our awareness of all activities in space and the ability to command and control forces in this increasingly dynamic domain. It begins the build-out of an operational test and training infrastructure that will generate the military readiness appropriate to the challenges we face, and it allows us to assume full authority for the preparation, training, and management of the 14,000 guardians, who are Space Force's greatest asset and its primary instrument.

I look forward to discussing these and many other aspects of our request in more detail with you in today's hearing and as we partner in the coming months. Your support and enactment of the fiscal year 2023 defense authorization bill will enable the Space Force to remain the world's leader in space and to continue to preserve freedom of action for the Nation.

Thank you for your continued advocacy and support. We are eager to work with your committee to build a strategy and make the investments needed to secure our Nation's vital interests.

[The joint prepared statement by The Honorable Frank Calvelli and General David D. Thompson follows:]

JOINT PREPARED STATEMENT BY THE HONORABLE FRANK CALVELLI AND GENERAL DAVID D. THOMPSON

INTRODUCTION

Chairman King, Ranking Member Fischer, Distinguished Members of the Subcommittee, thank you for the opportunity to testify on behalf of the Secretary of the Air Force, the Honorable Frank J. Kendall III, the Chief of Space Operations, General John W. "Jay" Raymond, and the airmen and guardians tasked with organizing, training and equipping forces to advance American interests in space. In its third year of existence, the Space Force continues to make tremendous progress in addressing national security challenges and threats of the space domain, and in building out the blueprint of a 21st century, mission-focused military service.

Space remains vital to our security and our way of life. U.S. military success in great power competition depends on access and freedom to operate in space. Over the past two decades, the space domain has shifted from a benign to a contested environment. Our adversaries are increasingly disruptive and hostile. To better protect our national interests, in December 2019 the Space Force was established with an explicit mandate to: (1) provide the United States freedom of operation in, from, and to space, and (2) conduct prompt and sustained space operations. Today, and every day, our guardians accomplish these tasks for the Nation ensuring unprecedented space capabilities for warfighters, allies, and civilians.

The Space Force provides the joint force and our allies and partners essential services vital to effective military operations. Unique services such as missile warning; positioning, navigation and timing; communications; and space-enabled tracking and targeting, make our Armed Forces the most flexible and lethal on the planet. These services, also make the United States a valued security partner. The Space Force delivers unmatched capability in these missions today and is developing the next generation of capabilities to meet requirements in the future.

Space Force capabilities and readiness contribute to integrated deterrence, strategic campaigning, and building an enduring advantage. We believe integrated deterrence starts in space. The Space Force must deliver resilient space capabilities and contribute to protecting terrestrial forces from adversary space capabilities that are an increasingly effective element of their combat operations.

Given growing strategic competition, it is imperative that the Space Force has the resources to modernize our forces to ensure freedom of action in, from, and to space. The President's Fiscal Year 2023 Budget Request for the Space Force initiates a necessary transformation, beginning with fielding a resilient missile warning and tracking architecture to detect and maintain custody of emergent hypersonic and maneuverable missile technologies, while making survivability under attack a key attribute of the design.

THE SPACE ENVIRONMENT

Foreign Space Threats

Space capabilities underpinning our national security remain threatened by adversary nations. Our competitors enjoy growing access to increasingly affordable space services and technology, multiplying threats beyond traditional space powers. Expanded intelligence for space will be vital to staying abreast of current and future threats.

The People's Republic of China (PRC) and Russia continue to improve their military space and counterspace capabilities. Correspondingly, their overarching strategy remains to challenge the U.S. in space. These countries are developing and deploying an array of kinetic and non-kinetic counterspace weapons that threaten U.S.

space systems in all orbital regimes and their associated ground systems. They are also developing and deploying space-based Intelligence, Surveillance and Reconnaissance (ISR) systems that will be able to observe U.S. and Allied forces in all domains and all regions of the globe.

The PRC is the pacing challenge in the space domain, possessing on-orbit military capabilities rivaling those of the United States, and is pursuing a diverse counterspace weapons development program. The PRC calls space a critical domain in strategic competition, and they are now a spacefaring superpower who has launched more satellites into orbit than any country other than the United States. The PRC's growing commercial space sector enhances their industrial base and drives foreign dependency on Chinese technology. The People's Liberation Army (PLA) has developed robust and capable space services—ISR, communications, weather, and navigation constellations—that give PLA forces the integrated information needed to threaten U.S. joint operations in all domains. An example of the type of threat we must be able to defeat occurred in the summer of 2021 when the PRC launched a missile that deployed a hypersonic glide vehicle that circled the globe and flew back to hit a target in China. This test effectively demonstrates possession of the technologies needed for an unwarned, maneuvering fractional orbital bombardment system. We are actively working on systems to combat threats like this.

Russia remains dangerous with substantial space capacity, advanced technical and scientific capabilities, and a commitment to develop a broad array of counterspace weaponry. For example, Russia has seven prototypes in orbit that are capable of destroying other satellites. As demonstrated this past November, Russia's ground-based "Nudol" missile is designed to destroy Low Earth Orbit (LEO) satellites. That Nudol test destroyed a defunct Russian satellite, creating more than 1,500 pieces of debris, and threatening the International Space Station and other satellites in LEO.

Standards of Responsible Behavior

All nations share in the benefits, and costs, of human activity in space. Longstanding U.S. space policy promotes the long-term safety, security, stability, and sustainability of the space domain. The United States continues to partner with like-minded spacefaring nations in championing Norms of Responsible Behavior under the leadership of the National Space Council. Recently, Vice President Kamala Harris, who chairs the National Space Council, set a new international standard when she stated the U.S. commits not to conduct destructive direct-ascent anti-satellite missile testing. Likewise, we must continue to lead and advocate for responsible space behavior while developing systems that protect and counter our adversary's capabilities. The Space Force supports the Assistant Secretary of Defense for Space Policy, U.S. Space Command, and other Department of Defense (DOD) components as they develop guidance regarding the Tenets of Responsible Behavior in Space for DOD operations. The Space Force is also engaging allies and partners on the importance of responsible behavior via initiatives like the Combined Space Operations forum and conducting international space wargames.

SPACE FORCE YEAR THREE

Following the first two years of our existence, where the Space Force first blueprinted the design for a 21st century military service and aggressively built out the multi-year plan in detail, we are delivering on the expectations set by our Nation's leaders.

Force Design

The Space Force utilizes the Space Warfighting Analysis Center (SWAC) to develop force design processes to assess the fielding of space systems through the lens of operational need and requirements satisfaction, vulnerability and performance under attack, and cost. This process postures us for the first time to make architecture and programmatic decisions based on a clear understanding of warfighter needs, enabling concepts, budget, threat projections, while accounting for technology constraints and opportunities.

The missile warning/missile tracking mission trailblazed this process and successfully informed our fiscal year 2023 budget submission. On-going force design efforts include Space Data Transport, Tactical ISR and space-based support to active missile defense, with Positioning, Navigation, and Timing (PNT) and Space Domain Awareness to follow. These activities also serve to build out the analytic base required to support additional force design, and modeling and simulation in support of testing and training.

The SWAC's ability to use a "clean-slate" approach—without pre-conceived ties to previous acquisition strategies or programs and without any preference to a particular mission set or function within the Space Force, allows the SWAC to act objectively on behalf of the Service, joint warfighters, and the entire national security space enterprise.

Integrator for Joint Space Requirements

Through the SWAC's leadership in the new force design process, the Space Force has laid the foundation to succeed in their role as the DOD lead for integrating joint space requirements. In this role the Space Force engages Combatant Commands (CCMDs), the other Services, Intelligence Community (IC), U.S. Government (USG) agencies, industry, and Allies to understand, document and inform requirements satisfaction (validated through Joint Requirements Oversight Council), programming and budgeting, and acquisition strategies. The Space Force is working with the Joint Staff to fully codify this role and is currently exploring development of an implementation plan to execute this role that will facilitate consolidation of space requirements from across the Joint Force, identify capability gaps, advocate for DOD space requirements at joint forums and inform budget decisions.

Guardian Training and Education

In August 2021, General Raymond activated the Space Training and Readiness Command (STARCOM) to focus on service responsibilities to recruit, train, educate, and develop ALL Guardians, military and civilian. Space-centered training has been incorporated into all Space Force military accessions training programs and we have created space-focused programs at Air University (AU). These initial steps strive to create independent, space-focused education programs for all Guardians and the Joint Force. In September 2021, the Space Force published the Guardian Ideal, Space Force Values, and the Guardian Commitment. All three are foundational to the new Space Force team-centric culture and will guide how we recruit, train, develop, and employ Guardians as a part of our interconnected high-performing teams.

The Space Force is developing Science, Technology, Engineering, and Mathematics (STEM) focused officer-candidate development and Advanced Academic Degree (AAD) opportunities for all Guardians via the University Partnership Program (UPP). USSF partnerships with select STEM focused universities facilitates Guardian acquisition of technical degrees most needed by the USSF. Guardians pursuing AADs at these schools have the opportunity to conduct research projects mutually beneficial to the school and USSF. In fiscal year 2021, UPP began with 11 universities that are top suppliers of talent to U.S. aerospace and defense industries. The program will expand to at least 13 schools in fiscal year 2022. UPP universities have Reserve Officers' Training Corps (ROTC) Detachments that consistently commission the most cadets, and are amongst the top engineering schools in the country.

Space Operational Testing and Training Infrastructure

The National Space Test and Training Complex (NSTTC), a core element of the Space Force's Operational Test and Training Infrastructure (OTTI), is foundational to testing and evaluating space warfighting systems, as well as providing Guardians with a threat-representative training platform.

Currently, there is no national capability for enterprise-level testing and training of our space assets and infrastructure. Consequently, our ability to establish, assess, and maintain readiness in an increasingly contested intellectual and increasingly congested physical space environment is minimal. NSTTC will provide a multi-venue, operationally-relevant environment for the testing, training, and evaluation of both material investments and non-material processes to inform current and emerging warfighting requirements and capabilities.

Space as a Digital Service

For most in the joint force, the space domain is experienced digitally via the data and services provided by space systems. Because of the highly technical nature, the Space Force requires a workforce that has the digital fluency to rapidly turn data into useful insights to accelerate innovation of operational and business activities. Digital aptitude remains essential to help lead the transformation to becoming an interconnected, innovative, digitally-dominant force in order to deter and defeat threats to space operations. To achieve this goal, the Space Force has provided Digital University access to all Guardians, which incorporates curated digital content designed to establish a foundational level of fluency on modern digital topics.

The Space Force remains on the forefront of digital transformation to meet demand for existing and emerging needs. The President's fiscal year 2023 budget request reflects this commitment. For example, the Space Force intends to continue

building a cadre of organic software coders ("Supracoders") to streamline software development and promote the adoption of software technology that will prove instrumental to Space Force operations, testing, and training. We plan to train 90 in fiscal year 2023, bringing the total number in the force to more than 200.

Unit/Mission Transfers

In accordance with existing statute and congressional intent, the DOD intends to transfer fully mission-capable space operational units, support equipment, property, and related resources to the Space Force with no mission degradation or adverse personnel actions. Across the FYDP, the Space Force will accept the transfer of 15 global units, 319 military billets, 259 civilian billets, and $2.5 billion in budgetary resources.

Specific to 2022, the Space Force intends to incorporate the Navy Narrowband Satellite System and Army Wideband Payload Operations, upon certification to the defense appropriation committees. To ensure mission continuity, the DOD is offering civilians and military personnel assigned to such units the opportunity to volunteer to transfer with the unit to the Space Force. The Space Force has established a selection board, including service liaisons, to oversee individual personnel transfers.

Looking forward, and in accordance with Title 10, United States Code, Section 9086, the DOD will transfer the Space Development Agency (SDA) no later than October 01 2022. In the coming months, the SDA plans to transfer offices and operations centers in the National Capital Region and other areas around the country, along with 36 military and 67 civilian personnel billets and associated budgetary resources.

Space Force End Strength

Sufficient end strength is critical to implementing the long-term vision of the DOD and consolidating all of the Armed Forces space missions and forces into the Space Force. The fiscal year 2022 National Defense Authorization Act (NDAA)—authorized military end strength for the Space Force is 8,400 and includes 319 servicemembers projected to be realigned from the Army and Navy units. Prior to fiscal year 2023, Space Force end strength was included in U.S. Air Force military personnel appropriations. The Space Force will have a separate end strength appropriation starting with the fiscal year 2023 President's Budget.

SPACE ACQUISITION

The Department of the Air Force, in partnership with the United States Space Force, is forging a new paradigm for how we acquire national security space systems. To realize our vision for space acquisition, we are implementing changes in all aspects of how we conduct business. The Department of the Air Force pursued a unity of effort approach to acquisition with the Secretary of the Air Force instituting the office of Space Acquisition and Integration and the activation of Space Systems Command. These changes realign our structure to lead and advance integrated acquisition efforts. Through that integration role, the Department and the Space Force are pursuing a flexible approach to Space Acquisition. This strategy will enable us to not only meet warfighter requirements, but also meet the pacing challenges required to project global power, and incentivize the civilian space industry. We are utilizing forums such as the Program Integration Council (PIC) and the Space Acquisition Council (SAC), to achieve synergistic efforts, while tapping into emerging technical advancements necessary for us to remain technology leaders and more importantly, maintain U.S. space superiority.

By leveraging the PIC to unite senior leaders from the Space Systems Command (SSC), Space Rapid Capabilities Office, Department of the Air Force Rapid Capabilities Office, Space Development Agency, National Reconnaissance Office, Missile Defense Agency, United States Space Command, Space Operations Center, and the Air Force Research Laboratory, we have improved communication and coordination necessary to align efforts and achieve synergy across the National Security Space enterprise.

The Space Force, in partnership with the Missile Warning/Missile Tracking/Missile Defense Enterprise community, built upon the Overhead Persistent Infrared (OPIR) Enterprise Architecture Strategy delivered to Congress in October 2020 to formalize Missile Warning and Missile Tracking force design and acquisition strategies. This ensures OPIR capabilities meet warfighter needs. New resilient Missile Warning/Missile Tracking space and ground architectures will transform the DOD's legacy missile warning force design. This distributed multi-orbit architecture will address emerging missile threats, and be protected, survivable, and reconstituted. The Department is heavily investing in fiscal year 2023, requesting $1.029 billion for this mission area.

On January 27 2022, the SAC reviewed the Space Force Chief Strategy and Resourcing Officer's Missile Warning, Tracking, and Defense requirements allocation and associated recommendations for an Integration Plan proposed by Space Systems Command, the Space Development Agency, and Missile Defense Agency. The Integration Plan includes a governance concept with a combined program office that will enable coordinated capability development across the mission areas. In addition, Space Systems Command has the charge to execute system of systems integration to deliver an end-to-end, sensor-to-shooter capability.

The Department is also heavily investing in mission areas such as strategic communications and space domain awareness. For Enhanced Strategic SATCOM, the Space Force is pursuing a competitive acquisition strategy for the space segment through rapid prototyping, which is maturing the industrial base, driving innovationand controlling costs. The Deep Space Advanced Radar Capability provides all-weather, ground-based radars to detect, track, and maintain custody of deep space objects around the clock, and recently was authorized to proceed on Middle Tier Acquisition (MTA) Rapid Prototyping pathway for its first site. Fiscal year 2023 is an important investment year for the design and development for Operational Leave-behind Capability by fiscal year 2025.

National Security Space Launch (NSSL) has an unprecedented record of mission success, maintaining a 100% mission success track record while continuing to lower the cost of mission assurance. Since 2013, the Department has saved over seven billion dollars in NSSL procurements due to block buys and competitive acquisition strategies, which has allowed reallocation to other capabilities for the warfighter. The fiscal year 2023 priority is to complete certification of the Vulcan and Falcon Heavy launch systems to ensure we can meet all reference orbits and maintain assured access to space. Additionally, we are meeting Congressional intent to stop using the Russian RD–180. The USSF has four remaining Atlas V launch services that use the RD–180 engines, which are all launching over the next 18 months. That will end our dependency on foreign made engines.

At the same time, we have remained focused on acquisition advances. Space Systems Command continued to improve GPS for the warfighter by awarding contracts for three more GPS IIIF satellites. This new generation provides regional military protection capability, an M-code signal that can be concentrated on a particular region, and provides over 140x times greater anti-jamming measures over legacy signals. These advancements ensure our military personnel can access critical PNT data in contested environments.

We appreciate Congress' support in providing authorities needed to deliver capabilities at the speed of relevance for the warfighter. Using MTA authorities, we are rapidly identifying, prototyping, and fielding innovative solutions for some of the most pressing challenges we face. Nine programs currently utilize MTAs, but we are also increasing flexibility through non-traditional approaches, such as the Space Enterprise Consortium (SpEC) Other Transaction Authority (OTA) agreements. Authorities like these are paramount to improving engagement with our commercial partners. A thriving commercial sector presents increased opportunity for the Department to leverage commercial space services, for DOD to provide a demand signal to stimulate commercial sector innovation, and to further build and diversify the industrial base and incubates capabilties that may meet future requirements.

In order to rapidly increase the resiliency and move at the speed of relevance, we are leveraging our partnerships with industry, academia, allies, and our international partners around the globe. These partnerships are essential for ensuring we are harnessing emergent technologies into the space enterprise. SSC's Front Door is designed to be a single focal point for strategic commercial partnerships and to establish a diversified and enduring marketplace for the Joint Force to purchase and receive essential services. Through activities such as Pitch Days, similar to commercial investment pitch competitions, it is now easier for start-ups and other nontraditional companies to bring their commercial solutions to the Department. This is just one innovative example of how the Department of the Air Force will exceed the pace of demand and become increasingly more agile than our Nation's adversaries.

We will also be leveraging lessons learned from the Space Development Agency as we begin the formal transfer of that organization into the Space Force at the beginning of Fiscal Year 2023. This transition will enhance the Department's ability to integrate innovative acquisition approaches and deliver new satellites and ground system prototypes into the operational baseline for the Space Force.

Technology and pacing threats are evolving at an ever-increasing rate. Achieving enduring advantages means the Space Force must undergo a transformation from current legacy systems to the architectures needed to be competitive. The Space Force is leveraging technology to deliver game-changing space capabilities.and solid-

ify an ecosystem through our University Research Consortium. Quantum technologies, counter-hypersonics, and artificial intelligence/machine learning are several of the emerging technologies that are necessary to integrate into the Space Force architectures to stay ahead of potential adversaries.

CONCLUSION

In conclusion, the Department of the Air Force and United States Space Force stand ready to provide forces and capabilities that protect and defend U.S. interests in space. As General Raymond has stated: "America's Space Force will be Semper Supra, always above. We are moving swiftly to establish a lean, innovative Service and a rapid, agile acquisition process ready to meet the challenges of today and the future. We stand ready to protect and deter, and to fight and win in freedom's high frontier."[1] We would like to thank the Congress for your leadership and support.

Senator KING. Thank you.

The first point I want to make is that we are in the process now of putting together the National Defense Authorization Act for this year, literally in a matter of—the paperwork is moving, so we are talking about in a matter of weeks.

To the extent any of you, or the Secretary, has, or the Commanding General have suggestions or needs or thoughts about authorities or modifications to current statute, as it, as you have grown into this new force, please let us know as soon as possible so that we might consider those as amendments or as proposals in this year's National Defense Act. So, I hope you will consider that an open invitation. The other way to put it is: Don't complain next summer when you didn't get what you want if you don't tell us what you need.

Dr. Plumb, Section 1602 of the 2022 Act requires the Secretary of Defense to designate the Chief of Space Operations as the force design architect for the space systems by March of this year, 2022. This is important. We give the same designation to the Chief of Naval Operations for the fleet at sea and the Chief of the Air Force for planes in the air. During our Air Force posture hearing, Senator Reed asked the Chief of Space Operations whether this designation had occurred, and he said it was still residing in the Office of Secretary of Defense Space Policy.

Why has this not occurred and when will it occur?

Mr. PLUMB. Thank you, Senator.

I have spoken with General Raymond about that, and I have spoken with your staff about this. So, I was really alerted to this just last week. I immediately took it to my office, so my office is now responsible for it. I have initiated conversations with OGC, Office of General Counsel, on getting this right. I will get that done. It is a little bit new because it has all space in it, but we will get that designation done.

I will point out that, I think functionally speaking, and General Thompson may want to weigh in, but that functionally speaking, I believe the CSO [Chief of Space Operations] is the Force's architect at this point, but that is not the same as formalizing it as you have asked. So, I will do that. It will take a little bit of time to get it through the building.

Senator KING. Well, I hope a little bit of time is measured in weeks and not months.

[1] John W. "Jay" Raymond, (Gen, SPACE FORCE), Chief of Space Operations, "Chief of Space Operations Planning Guidance," November 2020.

Mr. PLUMB. Yes, sir.

Senator KING. Thank you.

This is a somewhat difficult situation because we are talking about some things that are public and a lot of things that aren't and we have to be careful in our discussion. But as your testimony indicates, we know that both, China and Russia: (A) are establishing a major presence in space; (B) are establishing a capability to hold our satellites and our space assets at risk.

Insofar as you can testify in an open session, please outline our strategy, if you will, for protecting our assets and dealing with what is now a highly contested domain, which wasn't the case until pretty recently.

General?

General THOMPSON. Senator, I will outline that, I will say, in three primary points today. The first element of the strategy is to fully and deeply understand all of the activities in the domain: what objects are out there; the things that they do; their capabilities; whether or not they pose a threat to us, our capabilities and our assets; the capabilities, techniques, tactics, doctrine that might be used in their employment; and to be able to ensure that we have indications and warnings should an attack be coming. A lot of the investment in our budget and the work we have been doing to date creates the space domain awareness infrastructure and architecture that we need to do that.

The second thing is, many of the space systems that are on orbit today and will be for years to come, were not designed to operate in a domain like this and under threat; however, there are things that we can and are doing to them to increase their ability to be defended and to contribute to their own defense, things like: ensuring that additional fuel remains onboard in case we need to maneuver; looking at ways to make them more difficult targets to track and, ultimately, to attack; and let's just say in this setting, other systems, other capabilities and other tactics that will make them more difficult to attack and destroy, should an adversary attempt to do so.

The third major component of our strategy is to create those resilient architectures going forward that are much harder, that are survivable by design and less vulnerable in terms of protection. The primary mechanism by which we do that, and we intend to do that, is rather than architectures today that consist of a relatively small number of very capable, very sophisticated satellites, building architectures with larger numbers of less capable, less expensive satellites, that in aggregate, give us the same capability. In fact, in this budget, our request for the missile-warning, missile-tracking architecture that we have proposed is the first major step for the architectures in that regard.

So, in this setting, those are the three major points of making us more defendable and more resilient in space.

Senator KING. Thank you. Excellent.

Senator Fischer?

Senator FISCHER. Thank you, Mr. Chairman.

General Thompson, I appreciate the Space Force's effort to pivot towards proliferated satellite architectures. The resilient missile-warning, missile-tracking program that I discussed with General

Raymond at the full committee hearing last week, is but one example of that.

I agree with the conceptional advantages distributed architectures provide, but how ready is the industrial base to meet production needs associated with those much larger constellations?

General THOMPSON. Madam Senator, I would say that it is probably as ready as it has been in the last several decades and for several reasons. One is, we maintain some sort of capability in terms of the production of our current satellites and some of the investments in technology and prototyping, but a great portion of the industrial base is expanding because of commercial investment.

While there are some specific aspects of military and national security space systems that don't lend themselves to commercial investment, a vast majority of the operating techniques, the subsystems used would apply both, to commercial investment and to military national security investment, as well. So, while there are some very specific niche capabilities that we have pursued and we have maintained with competition in various aspects, and I think the investment we are seeing in commercial space has served all of us well in creating a more robust and more capable industrial base to address our space needs.

Senator FISCHER. Do you see limitations or bottlenecks on certain things like refrigeration units, for example?

General THOMPSON. I would say there are a few very boutique capabilities for which we probably have a few bottlenecks. Some of the sophisticated sensors that we use, the sensor elements and those aspects of them, we do, but generally speaking, when you think about the subsystems onboard a spacecraft, whether it is power subsystems, propulsion subsystems, attitude control, generally speaking, there are not bottlenecks in that regard, but there are for some of the very specialized capabilities and specialized technologies, there are a few.

Senator FISCHER. You don't find that a limitation?

General THOMPSON. I would say it is, but I cannot point specifically today to any space system whose development is being held up due to the lack of the readiness of a capability or a provider for those capabilities.

Senator FISCHER. When the Space Force is looking at architecture or design, is there a process through which it takes industrial base limitations into account so that we don't produce plans are a technically sound, but not feasible?

General THOMPSON. Yes, ma'am, there is.

Really, what happens is, and it is part of a longstanding process, but part of our new process, one of the new processes that we created in our Space Warfighting Analysis Center was to bring in industry early and any Force-design activity that we are performing, providing them with our requirements, our design concepts, the results of our analysis as to how, in fact, we intend to accomplish missions, provide them with all of that data and ask them to provide input directly, or come back later after the fact. That is one point in time in which we can have the conversation about whether the technology is there.

But the second point is when we then take those designs and hand them over to Mr. Calvelli and the Acquisition team, that is

where they truly begin the extensive review of all the expected technologies, and as part of the system acquisition process, determine whether the technology is available, whether it is ready, whether there is risk-reduction and prototyping work that needs to be required, and assess the risks and effort required to either, deliver the system or come back and say, unfortunately, the technology is probably too risky to pursue at that point.

Senator FISCHER. Did you have anything, Mr. Secretary, you wanted to add to that?

Mr. CALVELLI. No, I think General Thompson nailed it really well.

You are right, ma'am, you don't want to start down an acquisition that you can't execute because of the supply chain or technology issues, so you have to take a really close look up front and make sure whatever you are going to decide to put out in that request proposal and then put under contract is actually something you can achieve.

Senator FISCHER. You know, we have to meet the needs of combatant commanders at STRATCOM [U.S. Strategic Command], especially, and there has been, I would say, some questions raised on the ability to meet those needs and what is needed as a resource to do that. Thank you.

Senator KING. Senator Cotton?

Senator COTTON. Thank you, Gentlemen.

Mr. Secretary, from where I sit on this committee and the Intelligence Committee, it seems like the NRO [National Reconnaissance Office] has been slightly more successful in delivering space capabilities in a timely and efficient fashion.

Can you talk to us a little bit about your experiences there and what your plans are to help replicate that success in the Department.

Mr. CALVELLI. Yes, thank you, Senator.

The NRO has a culture of programmatic discipline. It is inherent in its DNA. We expect our program managers to understand, technically, their programs, to understand their contracts, and to deliver on cost, on schedule, and meeting the requirements.

From my position where I was at as the deputy there and working with the director, we also sort of oversaw and made sure that culture continued, and we managed our programs. We managed our program element officers and our program managers to deliver. I mean, so that became just part of the culture over the last decade or so that, you know, it is really important that you hit your plan.

The other thing is, you know, we really learned some things about making sure that when we put proposals out there that we really get realistic cost proposals back and realistic schedules, especially in a competitive environment. That is really key to ensure that you have that, so you know that whatever they are delivering to you is actually going to be executable. When you review proposals to make sure that you put in place the right contract strategy, the right contract incentives that are going to incentivize success.

Senator COTTON. Okay. General Thompson, what do you think about that?

General THOMPSON. Mr. Senator, I agree. I have got some experience, not on the acquisition side, but in the operational side of the NRO, and it really is that aspect of discipline in the execution of a program from start to finish and the tendency not to decide that each successive article needs to improve in capability, but rather, to provide consistent and expectations up front and throughout the schedule that makes it important.

Senator COTTON. Okay. One interesting note from the war in Ukraine is that most people assess that Ukraine's communications or internet access would be cut off in the first days, really the first hours of the war. That did not happen, and it still has not happened. I think that is, in part, based on satellite-based internet.

What lessons have we learned about what we can do, should we ever face a similar conflict with Russia and China, where they are trying to deny us that?

Mr. CALVELLI. Well, I think the one lesson that I have seen is that by adding and integrating commercial capabilities, that you are going to diversify your architecture and make it much more resilient, and so that has really been a great piece of the puzzle to actually watch happen how a commercial technology and commercial capability has added resiliency along the way.

General THOMPSON. I would add to that that, I think what we are seeing as a result of their ability to be prevented from using space capabilities is also a reflection of these new proliferated architectures that are very difficult to deny overall. You may be able to deny a piece of it, but you can't eliminate the capability at large.

As we look, we are beginning a new Force design activity to look at the future of space-based communications and data relay, not only bringing in commercial capability, but absolutely, that proliferated architecture that makes a network that is very difficult to defeat in total, is another element of what I think we are learning from Ukraine.

Senator COTTON. All right. Mr. Plumb, any thoughts on that?

Mr. PLUMB. Yes, Senator. I would just add, I think it is a really good example of resilience means different things for different constellations and functions. So, for ISR [intelligence, surveillance, and reconnaissance] or for, actually, for missile-warning, missile-track, that is a proliferated set of orbits with IR [infrared] sensors. But SATCOM, in particular, on your question, there is a lot of commercial capacity. There is more coming in using that as a totally different approach to get to the same end, which is resiliency. It is really important.

Senator COTTON. All right. Thank you.

General Thompson, the budget brief highlights a $36 million investment in climate initiatives. Can you tell me a little bit more about that?

General THOMPSON. Yes, sir, two things. First of all, it is really a matter of understanding our base infrastructure, the facilities, the power infrastructure. Most of our space capabilities are operated from home station. They operate 24/7. They have to operate in peacetime and wartime, and most of that is focused on ensuring that the power systems and the means by which our bases operate under all conditions can be sustained, regardless of peacetime, conflict, climate conditions, and things like that. That is part of it.

The second aspect is, we do own part of the weather and meteorological mission for the Department of Defense and the Nation, and part of that investment includes our space-based environmental monitoring and some of the tools and techniques that we use to do that, as well.

Senator COTTON. Okay. Thank you.

Senator KING. Senator Rounds?

Senator ROUNDS. Thank you, Mr. Chairman.

Gentlemen, first of all, thank you for your continued service to our country.

Mr. Calvelli, massive amounts of data are sent and received through space every second. In order to maintain our technological edge, integration of artificial intelligence and quantum computing will be necessary to process all of this data in a timely manner. What are your thoughts on how we acquire this type of capability?

General Thompson, to the extent that you can in this open session, can you describe and assess what our adversaries, specifically China, are doing in these areas.

Mr. Calvelli?

Mr. CALVELLI. I think one of the challenges on the AI [artificial intelligence] front is making sure that our data is accessible by algorithms down the road, and so, we have had a lot of history of closed architectures. What you really want to do is make sure your ground systems are open, that your data is exposed through application programming interfaces, and that future algorithms, whether that be machine-learning algorithms or AI algorithms can actually access the data. I think that is going to be one of the biggest keys to getting the data accessed.

As far as quantum computing goes, we are really, as a Nation, I believe, in the research and development stage of that and I think that the Nation needs to continue that. I honestly don't know from what sort of, the role of the services in that area. But I do believe that we need to, as a country, really spend money and foster the ability for this Nation to develop quantum techniques. It is going to drive a whole road of encryption down and high-speed processing that I think we want to stay the leader as a Nation.

Senator ROUNDS. If I could, just to clarify, because when we talk about this, I think people kind of pull everything together on it, AI is here, and it is being integrated now; is that fair to say?

Mr. CALVELLI. Yes, I agree.

Senator ROUNDS. Thank you.

General Thompson?

General THOMPSON. Senator, just a few comments in regard of Russia and China, and I will say, primarily China, but it applies to Russia, as well. I would argue that while the creativity and ingenuity and energy in our academic and commercial sector is tremendous, and in many cases, our asymmetric advantage, the Chinese, for sure, have a plan and an expectation to lead the world in AI by 2030. They have made that public. They are making great advances; in some cases, on their own, in some cases because many of their scientists and engineers study in American universities. So, they have a plan to outpace us in that regard and they are certainly capable adversaries. So, I would say this is absolutely an

area of competition that we need to expect and be attentive to in the years to come.

Senator ROUNDS. Thank you, General.

I just want to follow-up on that because I think the next step on this is talking about the other areas. We have been competing against our adversaries in air, land, sea, cyberspace, and now we see them most certainly challenging us in space. Both China and Russia have conducted antisatellite operations and have weaponized space. I mean weaponized space in an attempt to deter and counter U.S. effectiveness in space.

To the level that you can in this open forum, can you describe the threats our adversaries are posing to us in space, and do you have the authorities and resources needed to be able to respond to these threats?

The reason why I bring it up, once again, is as the Chairman of the Committee has indicated, if we need to make policy changes to respond, now is the time to get that out or we are going to end up waiting another year.

General THOMPSON. In terms of their capabilities, in fact, we have become much better at declassifying and communicating those capabilities in an unclassified sense. I said in my opening statement that they can threaten us kinetically and non-kinetically in every domain.

As you mentioned, the Russians conducted a destructive antisatellite missile test in November 2021. The Chinese did that in 2007. They have been rapidly fielding capabilities ever since. Both have on-orbit capabilities that attack our satellites directly. Both also have multiple ways to attack us through cyberspace, laser dazzling and RF [radio frequency], and so I would say, absolutely, they can threaten us in every regime and by every means available.

Senator ROUNDS. What would be your response, General, to those who say that space is not or should not be thought of as a warfighting domain?

General THOMPSON. Senator, I would say that, first of all, Russia and China have voted, and they have already decided that it is. Our primary purpose as a Space Force is to make sure that we can deter them from making it a true domain of conflict in the direct sense, and if not, should they go to that, it is our job to ensure that we can continue to operate effectively in space regardless.

Senator ROUNDS. Thank you.

Thank you, Mr. Chairman.

Senator KING. Now I want to call on the only person in this room who has ever been to space, Senator Kelly.

Senator KELLY. Thank you, Mr. Chairman, and I do miss it.

Senator KING. Especially around here.

[Laughter.]

Senator KELLY. I wasn't going to say that. No, but it is great to have the opportunity to serve again in a different role.

General Thompson, I have a question about Space National Guard and this topic came up in last week's Air Force posture hearing. I understand that currently, the National Guard's space capability is organized in 17 units, across seven states, in Guam, and is made up of nearly 1,500 airmen, or 15 percent of the Space Force.

As General Raymond mentioned last week, the National Guard has been involved in the space mission for 25 years. When asked about the prospect of a Space National Guard last week, General Raymond indicated that there are two ways to ensure that we maintain that capability. One was to either have a separate Space National Guard and the other was to take the capabilities from the Guard and move them into one combined, Active Duty and Reserve component.

Now, that second option assumes that current Air National Guard members will transfer to the Space Force under a mixed, full-time, part-time Active component model. This ignores the fact that many folks who joined the Air National Guard, they did so because of geographic stability that it offers the members and their families, as well as the opportunities sometimes to serve their state.

General Thompson, what are your thoughts on the advantages of establishing a Space National Guard, and to your knowledge, is the Department of the Air Force assuming that those nearly 1,500 guardsmen would transfer into a combined, Active Duty and Reserve component, if we did take that approach?

General THOMPSON. Senator, you certainly characterized the current state and situation very well. The Guard has served effectively in the Air Guard beside Space Forces of, at the time, the United States Air Force for decades. We cannot do without the capability and missions that they provide today moving into the future.

If, in fact, we do not create a Space National Guard, and as you stated, the administration has come out with a statement of policy to say that we do not want to create a Space Guard, we do have to do that assessment in, ultimately, planning and preparation to move those forces. We are doing an assessment right now of that. We do not make the assumption that any number of Guardmembers will make that transition; that option would certainly be presented to that if it came to that point. We are making no assumptions about whether those members would accept or desire that transfer or not. We are certainly, as part of our assessment, determining what would be required to replace those members, by Space Force members, the numbers it would take, the training time it would take, the training resources it would take, and the corresponding degradation in mission as we bring those units back up to full status.

So, there are some that think that a large number of Guardmembers may transition. There are others that don't believe that is the case. In our current assessment, we are not making the assumption that a large number of Guardmembers would transition.

Senator KELLY. When do you think you will have this evaluation analysis done?

General THOMPSON. It is ongoing at this time. We anticipate that it will be done in time to support the next budget request.

Senator KELLY. Okay. Thank you.

Another quick question, General, in my remaining time about space debris. My understanding is that the Space Surveillance Network is currently tracking over 25,000 objects.

Does that mean that you have state vector on 25,000 objects and how small can you currently track something?

General THOMPSON. Yes, sir. The updated number is now approaching 40,000 objects——

Senator KELLY. Forty.

General THOMPSON.—and that is correct. We have what we call "custody," which is a state vector that is updated routinely. We reliably track objects down to about 10 square centimeters in radar cross-section. If you made a fist, the size of your fist or perhaps a tennis ball, that is the size of the object we can track reliably.

I will say even conservative estimates say there are probably at least 10 times as many other objects that are smaller than that in space that we cannot track.

Senator KELLY. So, that 40,000 number, presumably would go up, not necessarily because there are more debris objects populating LEO [Low Earth Orbit], but just that you are finding more; is that accurate?

General THOMPSON. It could if, in fact, we had more advanced sensors that had the reliable ability to track smaller and smaller objects.

Senator KELLY. How often do you find yourself, you know, looking for something and despite having the state vector, you can no longer find it?

General THOMPSON. Senator, I would say that we encounter hundreds to thousands of objects a day that we need to go back and decide what the state vector is, and that is because they are in odd orbits. They are on the edge of being large enough or small enough, and in some cases, because of their size and shape, operate unlike most of the objects in orbit, which is to say, not in a Keplerian manner, as you understand it.

Senator KELLY. All right. Well, let's work together to continue to refine this, because as these number of objects go up, I think we are going to need, you know, better capability because it just puts our assets and those of our allies at risk.

General THOMPSON. Yes, sir.

Referring back to the last question, this is a perfect application for AI, artificial intelligence and machine learning, as well, to help us with that problem.

Senator KELLY. All right. Thank you, General.

Senator KING. Senator Tuberville?

Senator TUBERVILLE. Thank you very much.

Just to follow-up on that, if one satellite is destroyed, how many pieces, basically, on average, would come from one average satellite?

General THOMPSON. Senator, it depends on method. When the Chinese destroyed their test satellite in 2007——

Senator TUBERVILLE. Completely destroyed, right?

General THOMPSON. Completely destroyed.

They created over 3,700 pieces of debris that we could track, and, again, there are large, perhaps 10 times as many smaller pieces we cannot.

The Russians——

Senator TUBERVILLE. Which was last year, right, Russia?

General THOMPSON. The Russians, last year, created more than 1,500 pieces of debris of that we are currently tracking.

So, that depends on, in many cases, exactly what you are talking about, thousands of pieces of debris with a kinetic destruction.

Senator TUBERVILLE. So that is going to be a huge, huge problem in the future, correct, if they continue to test missiles?

General THOMPSON. Sir, I would say, yes, that is right. In fact, that is one of the reasons for the tenets for responsibility of behavior that were released by the Secretary of Defense last year, and the statement made by the administration about destructive ASAT testing.

Senator TUBERVILLE. Now, they are there forever, right?

General THOMPSON. Not quite forever, but for years to decades, certainly, depending on the orbital regime.

Senator TUBERVILLE. Our lifetime?

General THOMPSON. Yes, sir.

Senator TUBERVILLE. Yeah. This is kind of for all of you, you know, very simple: What would you say is the most successful aspect of the National Security Space Launch program, what is the most successful thing that we have done?

Mr. PLUMB. Thank you, Senator.

I think that the ability to do, one, make sure we have the two providers and do these things in block-buys, it seems to be driving down costs, we were just talking about this before the hearing, and it provides some stability to those contractors. So, I think it looks like a success from where I sit.

Senator TUBERVILLE. Is the cost going down or up as we speak? I know in your purview——

Mr. PLUMB. I feel like my acquisition colleague should answer that, if that is all right, sir?

General THOMPSON. Sir, I know what I would say is that over the life of the program, based on the previous approach to launch and what we pursue today in the National Security Space Launch program, we believe we have saved over $7 billion in terms of what we would have paid using the past program.

I will tell you, based on the current growth in the commercial launch industry in recent years, the addition of that competition is helping to drive costs down and may very well drive them further down in the future.

Senator TUBERVILLE. We couldn't make it without the commercial people, could we? Or it would be very expensive?

General THOMPSON. No question, it would be more expensive without commercial providers.

Mr. CALVELLI. Yes, I would add to that by saying having two distinct companies providing launch services, I think, is great for the Nation; the more the merrier.

Senator TUBERVILLE. Yes.

General THOMPSON. Senator, if I may?

Senator TUBERVILLE. Yes. Go ahead.

General THOMPSON. So, the Major "DT" Thompson was the investigating officer on the last National Security Space Launch accident in 1999. I will tell you, one launch at a time, for almost 100 national security launches and more missions: success. Every one of

those launches is the most important factor of the National Security Space Launch program for 22 years.

Senator TUBERVILLE. Mr. Calvelli, as a transition from the single launch procurement awards to block-buys reduced the price of space launch? Has it reduced it?

Mr. CALVELLI. So, I don't know specifically on NSSL [National Security Space Launch], but my understanding, in general of space, when you do things in a block, it does help you to reduce the costs, yes.

Senator TUBERVILLE. General?

General THOMPSON. Yes, Senator, absolutely.

Senator TUBERVILLE. Absolutely. As the Department considers the next launch procurement contract, what new requirements will be included to ensure the United States beats China and Russian efforts to impact our space capabilities?

Either one—anybody?

General THOMPSON. Yes, Senator. In terms of new requirements from an operational sense, right now, the answer is not many significantly in this specific sector. We still have the same sorts of reference missions and payload designs that we need in this phase.

Where, I will tell you the new opportunities and new requirements are in a couple of areas. The first is in smaller and responsive launch to deal with things like the potential rapid replenishment of capabilities is one area of potential growth. The second is, as we see a lot of interest and energy in on-orbit servicing and maneuver, and so, an approach that not only launches the satellites to orbit or perhaps moves them around in orbit, refuels, and replenishes them; those are a couple of areas of what I will call the space launch enterprise that are growing, specifically related to National Security Space Launch in phase 3, very similar in terms of the requirements for the next phase.

Senator TUBERVILLE. Yeah, thank you.

I was excited about seeing the IG [inspector general] report yesterday moving a little bit closer possibly to get Space Command to Redstone Arsenal and, you know, we are military friendly and look forward to that possibly happening.

Thank you, all. Thank you very much.

Senator KING. Thank you for that advertisement for the State of Alabama.

[Laughter.]

Senator KING. Senator Cramer?

Senator CRAMER. There is nothing wrong with advocating for the hometown——

[Laughter.]

Senator CRAMER.—as long as there aren't too many of you. No, it is all good.

Thanks, you guys, for being here for your service. Thanks for this morning's briefing, as well. It was really important, and it was interesting, you know, at least the parts that I understood, and I was encouraged, so thank you.

Secretary Calvelli and General Thompson, I want to talk a little bit about one of my favorite topics under your direct command and that is, of course, the PARCS [Perimeter Acquisition Radar Attack Characterization System] Radar Facility at Cavalier. I did ask Gen-

eral Raymond and General Brown about this last week, and you might have heard that or watched it; if not, I am going to ask you the same question anyway.

I noticed that it is not funded for in the budget, the modernization. I brought it up because I am concerned, because this year's budget documents say that this radar has a, quote, high risk and equipment failures will cause unacceptable mission downtime. I don't want that to happen, and I don't think you want that to happen. It is a 50-year-old radar that is doing important work. I know there is an analog-to-digital modernization effort that the Program Office is looking at, and General Raymond told us the Space Force would address the PARCS issue in the coming budget years.

I just want to make sure that you are aware of the precarious situation that Cavalier seems to be in, and do you agree that this important 50-year technology needs a complete overhaul, if not this year, soon, to each of you?

If you want to speak to the PARCS Radar in general, that would be fine.

General THOMPSON. Yes, sir.

Senator, I will absolutely say, first of all, it does fill a critical role in our missile-warning enterprise today. Part of the assessment, and we need to sustain it for that role into the future, part of what we are looking at in that regard, as well, is as we look at advancing threats, as we look at hyperglide vehicles, as we look at fractional, orbital bombardment systems, and the ability to basically fly around the South Pole to be able to attack the United States, we are in the process of understanding what the future of missile-warning and missile-defense architecture needs to look like and the role that PARCS may play in that. We are still doing that assessment. But, certainly, in the near term, it must be sustained.

The other thing I will say, and it is to some of the discussion I had with Senator Kelly, it plays a vital role in space surveillance today, as well, and we need to ensure that that capability remains.

Senator CRAMER. All right. Thank you.

I want to spend a little time now on SDA [Space Development Agency], because I know we are at that moment here in a few months where it gets rolled in when we set up Space Force. Of course, one of the goals was, and you all are doing well at it, is streamlining acquisition, obviously, speeding up R&D [research and development], all of those important things that you are here to talk about. But SDA, when we stood that up in 2021, it really, we are noting the importance of this and of developing, preserving, really, an independent culture, which I think is best for innovation.

So, now, once it gets rolled in, maybe you guys can help me understand your commitment that SDA will preserve at least some of its independence and autonomy, while it also does important work for you and the Joint Force, of course. If you have a sense of how that might be managed, that would be helpful.

Mr. CALVELLI. Yeah, actually, you are thinking along the same way I am. I am excited about SDA coming onboard. I think they are doing some really neat stuff with their proliferated LEO system and Tranche 1 for their communication satellites. I think it is going to add new capabilities quickly because they are doing things on 2-year centers. I think it is going to add resiliency to the architec-

ture. I like their culture. I am looking forward to them coming onboard and I don't see any major changes in terms of how they do business or their culture.

Senator CRAMER. That is great. Thank you. Thank you for that.

Continuing along that topic, then, for a moment in the culture of innovation and rapid acquisition, MTA [Middle Tier Acquisition], Military Acquisition Pathway was designed to facilitate rapid prototyping and fielding the new threat-driven capabilities and time frames not met by the traditional requirements process.

Do you support granting SDA Middle Tier Acquisition authority so that they can continue to move fast, then?

Mr. CALVELLI. Yeah, from what I have seen, you know, I think on the Space Force side, there is about eight or nine programs that are used in 804 authorities. It has allowed them to go a little bit quicker.

We talked earlier about the fact that speed is really what this Nation needs, and so, yes, I would support them having 804 authorities.

Senator CRAMER. Well, maybe, and since you are on such a roll, and I am tracking with you, maybe talk a little bit more about the procurement enterprise and the reorganization and how you see that playing out, so we can, I always like to say, move at the speed of China, but I am not sure if that is the right way to put it or not, but I just know we need to be fast.

Mr. CALVELLI. Yes, so I am still getting my are arms around it. So, clearly, you know, and under my portfolio now is Space Systems Command, then you have SDA coming onboard on October 1, and then you have got Space RCO. You know, all three are unique in their own way and all three have sort of their own unique characteristics. I am not a big proponent of reorgs; I just think they are boring, they are messy, and they get nothing accomplished. So, I am looking forward to actually having these three separate elements in the portfolio and making sure they have the authorities, responsibilities, and we have the right things in place to go ahead and gain that speed and take advantage of each one's distinct strengths.

Senator CRAMER. Well, Secretary Plumb, I am out of time, but I was going to ask you, basically, the same question about cyber, and probably the role of commercial and integration of all of that, if you have a quick answer or just as a thought, that would be helpful.

Mr. PLUMB. Senator, I think that the cyber piece here, if that is what you are asking, is really important. While I don't think we fully have our hands around it, defense, in-depth for satellite architecture is hard, for ground stations, it is hard. I am in a lot of meetings about this, where we have to break through this idea that there is just a defensive perimeter, and people know this now, but getting to this is a journey.

Senator CRAMER. Well, be open with us as to how we can help, whether it is a policy issue or an oversight issue, because we need, you know, we need that culture cultivated.

But, thank you for sharing.

Thank you, Mr. Chairman.

Senator KING. Thank you. We will have the second round.

Senator Fischer?

A very practical question. I have heard the word "GPS" mentioned maybe six or eight times so far this afternoon. What if you are in an F–35 in conflict situation 35,000 feet about the Pacific and GPS goes off, what is that pilot able to do?

General?

General THOMPSON. Senator, I need to be careful, because I am neither a pilot, nor that familiar with the F–35, but I will tell you absolutely there are concerns with many of our systems today and their inability to navigate effectively over the long term with GPS denial.

Now, obviously, we do train. In fact, before I left the Air Force and transitioned to Space Force, we do train our pilots and their systems in a GPS-denied environment and how to respond. Their ability to aviate and fly safely is generally assured, but, obviously, there is likely to be a mission impact.

But, it does absolutely go to your point that while GPS is the world standard, it is perhaps, fair to say we have come to rely on it solely and exclusively and too heavily, and certainly within the Department, there are activities ongoing to augment it, to supplement it, to provide additional means of being able to navigate and position and conduct missions.

Senator KING. I would think it would be a high priority. I remember several years ago hearing that Annapolis was going back to teaching celestial navigation, but I understand they really aren't. They are talking about it, but they haven't really done it.

But somebody has got to be thinking about this because in a conflict, if I am the adversary, the first thing I am going to do is try to knock out GPS in order to blind us.

General THOMPSON. Senator, inside all of the services, especially inside, the Army is probably leading right now. The Navy is not far behind. But the Air Force, as well, they are looking at a host of technologies and methodologies for positioning and navigation.

The one that you specifically referred to, in fact, they are developing techniques for celestial navigation automatically, without a navigator, a human navigator, required.

Senator KING. There has got to be a way to automate a sextant.

General THOMPSON. Yes, sir, absolutely.

Frankly, to be able to do it in daylight when the human eye can't see stars. There is technology in that regard.

Many years ago, onboard navigation and inertial navigation systems were the way we conducted business in the 1950s and 1960s before GPS was rampant. It is time to reinvest in those technologies and those capabilities, I think, to advance them.

There is even techniques that allow systems to measure the magnetic field of the earth and based on the variations in the earth's magnetic field, figure out where you are. Terrain mapping. There are a lot of ways to solve this problem and I would say probably inside the Department of Defense, I think we finally have enough people who have woken up to the fact that GPS is the world standard, will remain the world standard for a long time, but we have to be prepared for those who wish to deny us GPS and operation to be able to fight through and defend.

Senator KING. Thank you. I appreciate that and I hope that that is an urgent consideration.

Dr. Plumb, in your testimony, you said something, touched on international discussions, international negotiations. How is that going? Is that real? Is there any interest? I mean, this strikes me as an area where we could have a space version of UNCLOS [United Nations Convention on the Law of the Sea], not that we couldn't get that through the Senate, but——

[Laughter.]

Mr. PLUMB. That is—I will leave that joke on the table.

Senator KING. Yeah.

Mr. PLUMB. But, Senator, actually, the United Nations open in a working group is just meeting. I will point out that Canada has joined us in their commitment to not conduct destructive ASAT testing, which is one small piece of this. There are several other like-minded nations in support.

Our goal there is, you know, a fewfold. One is to go with an open mind and welcome ideas on ways to increase transparency and ensure a stable space environment. The fact that these discussions are ongoing in looking at a way to build both, norms and hopefully keep debris-mitigation standards in force. Right now, we have UN [United Nations] mitigation guidelines, but not everyone follows them. There is quite a bit going on.

We are right at the beginning of it, but I think there is value and there is momentum. I do think the vice president's announcement gave us a little bit of a kickstart, which helps, too.

Senator KING. Final question: Is there systematic coordination, and by that, I mean an organized council or some body that does the coordination between Space Force, NRO, NASA [National Aeronautics and Space Administration]? I mean, I just worry that we are, there may well be duplication and overlap in terms of launch and satellite development.

I would hate to, I mean, I know from the Intelligence Committee, we spend a lot of money with NRO on satellites and I would hope that there would be coordination so that we are not duplicating.

Mr. CALVELLI. Actually, there is. From my time at the NRO, there actually used to be, and I think there still is, quarterly meetings with NRO, NASA, and the Air Force to, and now the Space Force, just to make sure that they do coordinate and understand what each one is working on. So there is actually a pretty tight relationship across all three of those organizations.

Inside the Space Force, there is the Space Acquisition Council that this committee put in place that helps to integrate across all of the services across the Pentagon for space features and then SSC [Space Systems Command] and other teams have a lower-level council called the Program Integration Council, does the same, as well.

So, there is actually, sir, a lot of teamwork going on across the community for space.

Senator KING. Good. Thank you.

Senator Fischer?

Senator FISCHER. Thank you, Mr. Chairman.

Dr. Plumb, section 1609 of last year's NDAA required the Department to review the classification level of space programs to de-

termine whether they could be reduced or declassified. It is my understanding that you are leading this effort. Can you update us on the status, please?

Mr. PLUMB. Yes. Thank you, Senator, for this opportunity.

So, I have been looking at that. My team has been looking at it and looking at it with General Raymond's staff. That is an enormous tasking. It is far beyond any 90-day deadline.

I think, fundamentally, the place I am going on this, and I am speaking for myself here, not the Department yet, is that probably all of those things, the hundreds and hundreds of things that are classified for the Space Force are probably appropriately classified. The fundamental question is, does the classification guide need to be redone, which is sort of a follow-on task.

So, I will be working with you and this committee, as well as on the House side, to try to find the right way forward to make this scope correctly. If that is the test that we need to get addressed, then we need to get to that.

Senator FISCHER. Are there any efforts being made to declassify threat information that we receive?

Mr. PLUMB. So that, of course, is not that 1609 piece, but it is important. I will note that DNI Haines annual threat assessment that just, I think she was on the Hill yesterday on it, it is stamped February, but I just saw a copy of it yesterday, so it does go farther than I think previous things on both, as General Thompson has been pointing out, as well.

You know, China and Russia both have on-orbit and ground-based antisatellite systems targeting United States and allied satellites. I think that is a new statement.

So, there is some effort there. You could argue whether we could do more, but, you know, all of these things, we have to be careful about what would we, you know, what is the intelligence gain and loss on any of these issues.

Senator FISCHER. Yeah, you know——

General THOMPSON. Senator?

Senator FISCHER. Oh, go ahead.

General THOMPSON. Senator Fischer, if I may?

The Defense Intelligence Agency just released a very extensive, unclassified report about competition in space. I have not seen that level of communication on, in an unclassified sense into adversary threat systems in a long time. It is a very good product and I think it has taken us a long way where we need to go in terms of communicating those threats.

Senator FISCHER. Okay. I think it is extremely important, without putting any of our people or our systems or our ways that we find information in jeopardy, to be able to get some kind of information out to the public, but also to certain think tanks who assume that they understand what is taking place in classified briefings and they don't even sometimes come close to what is discussed in those briefings and they make statements and generalizations and they take positions on false information.

But I think it would be especially helpful, as I said, for the public to understand threats that this country faces and I do believe our people would be very, very supportive of programs that are in

place, or that are being put in place, to protect this country. Thank you.

Senator KING. Senator Tuberville?

Senator TUBERVILLE. I want to ask one crazy question here. Is there, with the need of speed in the future, is there any thought of nuclear power in space?

Mr. PLUMB. Absolutely, there is. NASA, I think, has a large portion lead. If DOD is working on it, I haven't uncovered that piece yet. But, roughly, there is a lot of advantage to some form of nuclear propulsion, long-duration missions, including manned missions, you know, a larger power source. These are being looked at, but space nuclear propulsion is an expensive thing to look at and do safely, and in practice, but it is being worked. I think NASA has the lead.

General THOMPSON. Yes, Senator.

Recent national space policy has reinvigorated to look at nuclear power for electrical power generation and for nuclear propulsion; in fact, the Defense Advanced Research Projects Agency has a nuclear propulsion prototyping activity going on.

But in terms of NASA, NASA is looking at potential nuclear power for use for moon-basing. We are absolutely looking at it for propulsion and power generation on orbit going forward.

Senator TUBERVILLE. If we are going to do any planet-hopping, you know, getting there a lot quicker is going to make it, in the future, you know, Star Trek and all that stuff.

I have one company, and my NSA told me about it, EOS Defense Systems, they have a low-cost method of removing space debris. Have you ever heard of them out of Huntsville?

General THOMPSON. Senator, I have not, specifically.

I will tell you that our space works, our innovative engine for space activities in a project called Orbital Prime, just put out a call to research activities and proposals, recently awarded 125 different initiative contracts to go forward. It is very possible, I don't know for sure, it is very possible they are one of those companies. But it is specifically focused on that young, innovative, early companies looking for ways to help us with the debris problem. It is very possible they are part of that, but, unfortunately, I can't tell you for sure that is the case.

Senator TUBERVILLE. That is a good idea, you know, commercially doing it, making money out of it. We can send those names to Russia and China so they can clean up their mess as we go.

So, thank you all very much.

Thank you, Mr. Chairman.

Senator KING. Senator Cramer, any additional questions?

Senator CRAMER. None from me, thank you.

Senator KING. Thank you.

Well, thank you very much. It has been a very informative hearing. I appreciate your testimony today and as I said, I want to reiterate what both, Senator Fischer and I and Senator Rounds mentioned: Any thoughts, ideas, suggestions, desires, in terms of the National Defense Act, get them to us in very short order.

Thank you very much. This hearing is adjourned.

[Whereupon, at 5:40 p.m., the Committee adjourned.]

[Questions for the record with answers supplied follow:]

QUESTIONS SUBMITTED BY SENATOR JACKY S. ROSEN

SPACE NATIONAL GUARD

1. Senator ROSEN. General Thompson, last week General Raymond testified before the SASC that the Air National Guard has been performing Space missions for over 27 years and "he cannot do his job without them." He then stated there are only two options to effectively and efficiently continue those Space missions. He said and I quote, "Best way is one of two. Either have a separate Space National Guard or take the capabilities in the Guard and move them into this one component." In your best military advice what is the most effective and efficient way to not lose this critical space capability?

Gerneral THOMPSON. As General Raymond stated in his testimony, space professionals in the Air National Guard and Air Force Reserve are critical to the Space Force. USSF cannot execute our missions today without their operational capability.

The Department of the Air Force developed a new approach to military talent management and submitted a legislative proposal to establish and implement the Space Component. The proposal, if enacted into law, will merge existing regular Space and Air Force Reserve space professionals into a new component that provides the Space Force with a system that offers options for full and part time service, expands the continuum of service, and strengthens recruiting and retention in the long term.

As documented in the Statement of Administration Policy for H.R. 4350—National Defense Authorization Act for Fiscal Year 2022, the Administration opposes establishing a separate Space National Guard. The Department of the Air Force continues to work within the Administration on alternatives that are efficient, effective and appropriate for space units and personnel.

2. Senator ROSEN. General Thompson, what is the estimated cost to establish a Space National Guard? What is the estimated cost to move those missions into the proposed USSF Single Component? Will you lose any critical space capability if those moves come to fruition?

Gerneral THOMPSON. Section 913 of the National Defense Authorization Act for Fiscal Year 2022 directed the Department to prepare a report that included a discussion on the costs of establishing a Space National Guard. Coordination of that report continues.

The DAF is working on a plan that would rebuild the space missions currently performed by the Air National Guard within the Space Component by fiscal year 2025, which will include estimated costs.

COMMERCIAL TECHNOLOGIES

3. Senator ROSEN. Secretary Calvelli, DIU has invested in the commercial technology Orbital Outpost to study, prototype, and rapidly field for DOD and Intelligence Community (IC) space-related missions. Yet two years since DIU invested in Orbital Outpost, this technology still has not been on-ramped through the DOD or the IC. What actions are you taking to ensure commercial technologies that we have already invested in, such as Orbital Outpost, are adopted by the DOD and IC??

Secretary CALVELLI. The rapid growth of the commercial space sector provides a significant opportunity for the DOD to utilize innovative commercial capabilities and production processes to deliver critical space capabilities. Each mission area must be evaluated to determine the risks involved in order to achieve the proper balance between government and commercial capabilities. Being brand new to the position and to the DOD, I intend to take a balanced, risk-informed approach to incorporating commercial space capabilities that leverages the agility, innovation, and value of commercial systems without compromising critical national security missions.

ADVANCING THREATS

4. Senator ROSEN. General Thompson, the Space Force now has a seat on the Joint Chiefs, which is critical given space power is a foundational support to the entire Joint Force. However, China and Russia continue to advance their technology and capabilities in space that degrades the United States's ability to support our Joint Force Team. These advancing threats will significantly impact our way of life, how we deter conflict, and how we project force as a Nation. Given current policy restrictions, what is the Space Force doing to develop flexible, responsive, reusable, and multi-domain systems that can meet current and projected threats that seek to deny our advantage in space?

Gerneral THOMPSON. As the Space Force prepares for future conflict with China as a pacing threat, we are designing a next-generation enterprise architecture that balances performance, resiliency, cost, technology readiness/manufacturability, and speed of delivery in order to field capabilities that address the full-scale of evolving threats in the next 5 to 10 years. The major feature of this approach is the replacement of small numbers of very large, very capable satellites with larger numbers of smaller, lower cost satellites in proliferated and distributed constellations.

This approach aligns with the 2022 National Defense Strategy, which outlines the need to build enduring advantage by accelerating force development and modernizing space capabilities with an eye towards future near-peer fights.

5. Senator ROSEN. General Thompson, the Space Force's number one unfunded priority is $326 million for classified programs. In the appropriate setting, can you please share with the Committee additional specific details on this request and the urgent capabilities that this funding would provide?

Gerneral THOMPSON. Yes, we are coordinating a time to provide this brief.

QUESTIONS SUBMITTED BY SENATOR DAN S. SULLIVAN

COBRA DANE

6. Senator SULLIVAN. Secretary Plumb and General Thompson, as our missile defense architecture ages, we must prioritize capability modernization to meet combatant commander requirements and adequately defend the homeland. As such, I commend Space Force's commitment to allocate $77 million through 2027, including $18.6 million in 2023, to sustain and modernize the COBRA DANE radar system located in Shemya Island, Alaska. This system, and others like it, are critical to our ballistic missile defense and supporting our Space Domain Awareness. What other Space Force investments are necessary to further modernize our aging domain awareness infrastructure?

Secretary PLUMB. In addition to radar infrastructure, investments in modern data analytics tools and software are key to maintaining DOD's space domain awareness mission. My understanding is that the Space Force has developed an aggressive plan to decommission the decades-old Space Defense Operations Center (or SPADOC) software by January 2023. This aging software would be replaced by a new, scalable system that is better able to ingest radar data and track the rapidly growing number of man-made space objects. Additionally, the Department is assessing investments that may be needed to better integrate and fuse sensor data from non-DOD sources to increase the robustness of Space Domain Awareness.

The Space Force has also requested more than $4.7 billion in fiscal year 2023 to begin deployment of a new, space-based missile warning and missile tracking architecture, which is directly related to the missile defense mission.

Gerneral THOMPSON. First, adversary advances in the areas of hypersonics and maneuvering warheads mean we must radically modernize our missile warning/missile tracking (MW/MT) infrastructure. The key element of the new architecture is a space-based, proliferated hybrid constellation of sensors that will provide global, launch to impact track of these weapons and be resilient in the face of attack. This MW/MT constellation features prominently in the Space Force portion of the '23 President's Budget.

With regard to Space Domain Awareness, the Space Force continues to rely on its global suite of ground and space-based sensors and is fielding the new Deep Space Advanced Radar Concept, which will track sophisticated threats in and around geosynchronous orbit. In addition, the Space Force will continue to assess and use data from commercial and allied sensors to enhance the SDA mission.

Finally, terrestrial and space weather sensing is critical to provide the surface, cloud, and atmosphere forecast U.S. expeditionary troops require for operations, training, and tactical planning. USSF is investing in the Weather System Follow-on Microwave program to enhance real-time weather observations while preparing to sunset the legacy and dying Defense Meteorological Satellite Program (DMSP).

ARCTIC COMMUNICATIONS

7. Senator SULLIVAN. Secretary Calvelli and General Thompson, in 2021, the Air Force invested $50 million to test polar satellites in low Earth orbit. These satellites will be closer to Earth, resulting in reduced launch costs and faster data transmission. Throughout 2021, the Air Force sponsored launches of dozens of satellites, tested laser links for communications between the satellites, and installed cold-hardened ground terminals across the Arctic region. If this system works as

planned, US Forces will enjoy reliable Arctic communications for missions ranging from search and rescue to complex training exercises. It will also enable the civilian populace to obtain adequate Internet access essential to participation in the modern economy. Could you provide more detail on how these low-earth orbit satellites enhance joint force communications in the Arctic?

Secretary CALVELLI. The Department's investments in ISR, domain awareness, and communications broadly are important for homeland defense priorities and are particularly central to our ability to operate in the Arctic region. Low-earth orbit constellations enhance joint force communications in the Arctic by dramatically improving the capacity, latency, and robustness of our communications in this very challenging operating region. Using a portion of the $50M investment in 2021, we deployed and tested OneWeb satellite communications terminals at Thule Air Base in Greenland. Previously, the entire base population of several hundred airmen and guardians were sharing a very limited communications link that provided about 2 percent of the throughput of a typical home internet connection. OneWeb Low Earth Orbit satellites and terminals have resulted in a 50X improvement in throughput at the site, while also reducing communications latency by a factor of 5.

Gerneral THOMPSON. Building on Secretary Calvelli's comments: This investment has allowed the guardians and airmen at Thule to begin utilizing data-intensive services that were previously unavailable while also benefiting from dramatically improved morale network performance, including communications with family members around the globe. By expanding low earth orbit communications from multiple vendors to the Arctic region, we are gaining a powerful tool to ensure robust communications for the joint force in all theaters, particularly the challenging Arctic environment.

8. Senator SULLIVAN. General Thompson, in an Arctic Strategy brief provided to my staff on May 10, 2022, Air and Space Force representatives mentioned an Arctic Communications Roadmap Study that is expected to be released shortly. Could you go into more detail on this study and when we should expect to see it?

Gerneral THOMPSON. The Air Force and Space Force jointly developed a comprehensive set of Department-wide solutions expected to improve Command, Control, Communications, and Intelligence, Surveillance and Reconnaissance to support emerging Arctic missions. The roadmap also identifies multi-domain investment opportunities capable of providing diverse communication options for the Armed Forces. The Arctic

Communications Roadmap has been approved and will be provided through appropriate channels shortly following the QFR release.

ACQUISITIONS

9. Senator SULLIVAN. Secretary Calvelli, what are today's top acquisition challenges that threaten the development, deployment, and sustainment of space systems to guarantee users the benefits of space capabilities?

Secretary CALVELLI. Space acquisition plays a pivotal role in outpacing our strategic competitors. Challenges include: speed of delivery; discipline in program execution; stovepiped architectures; and ensuring ground systems are ready before launch. Exercising program management discipline is critical to ensure we deliver new capabilities on schedule, on cost and meeting requirements. This needs to be done to maintain our technological advantage. Architectures need to be agile, resilient and integrated in order to ensure synchronization and take advantage of our partners across the services, interagency and international. We must also increase our ability to leverage commercial capabilities.

10. Senator SULLIVAN. Secretary Calvelli, in detail, how do you recommend we address your top acquisition challenges?

Secretary CALVELLI. Your continued support for acquisition flexibility will remain critical as we seek to deliver space capabilities that keep us ahead of our threats, as well as your continued help in providing on-time authorization and funding so that we in turn can execute and deliver capabilities to outmatch our adversaries.

CLEAR SPACE FORCE STATION TOURS

11. Senator SULLIVAN. General Thompson, the community surrounding Clear Space Force Station is eager to host guardians and their families if Air Force policies permit accompanied tours. I understand that the Space Force has the authority to implement two or three year accompanied tours for guardians assigned to Clear SFS. Do you and General Raymond need any additional authorities to implement such a policy?

Gerneral THOMPSON. Unfortunately Clear SFS will likely remain an unaccompanied tour for the near future due to the lack of quality of life and family-related programs, and resources on station or in the surrounding area. Twelve Active Duty guardians, 105 National Guard personnel, and more than 20 airmen are currently assigned to Clear.

a. Anderson is the closest town, population <200 per 2020 census (~6 mi away) with very limited services available
b. Nenana is the next closest town, population <400 per 2020 census (~20 mi away) with very limited services available
c. Fairbanks is the closest metro area, approximately a 2 hour drive

Exceptions to policy could be granted (with a waiver from OSD), but would require thorough vetting to ensure the member could find housing in Anderson or Nenana, while understanding the limited community and family support services within the within the normal commuting distance of 50 miles.

DEPARTMENT OF DEFENSE AUTHORIZATION REQUEST FOR FISCAL YEAR 2023 AND THE FUTURE YEARS DEFENSE PROGRAM

WEDNESDAY, MAY 18, 2022

UNITED STATES SENATE,
SUBCOMMITTEE ON STRATEGIC FORCES,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

MISSILE DEFENSE STRATEGY, POLICIES, AND PROGRAMS

The Subcommittee met, pursuant to notice, at 4:30 p.m. in room SR–232A, Russell Senate Office Building, Senator Angus King (Chairman of the Subcommittee) presiding.

Committee Members present: King, Kelly, Fischer, Rounds, Sullivan, and Tuberville.

OPENING STATEMENT OF SENATOR ANGUS KING

Senator KING.—budget submission for the Missile Defense Agency and missile defense policies in preparation for fiscal year 2023 National Defense Authorization Act (NDAA). The Department of Defense (DOD) has submitted to the Congress a Missile Defense Review (MDR) and Nuclear Posture Review (NPR) along with the National Defense Strategy (NDS).

While this overall document is classified and we await an [laughter] unclassified version, and await, and await an unclassified version—we would like to have that, by the way—it continues the policy of defending the homeland and deterring attacks against the United States while assuring our allies, through a Regional Missile Defense Strategy. I would note it also continues the policy of reliance on our nuclear deterrent to protect against large and sophisticated attacks against our Homeland from intercontinental ballistic missiles, air-launched ballistic missiles, or sea-launched ballistic missile threats from near-peer adversaries such as Russia and China.

Missile defense has two new aspects that we hope to examine in today's hearing. First and foremost is the defense against hypersonic missiles, which do not follow a ballistic trajectory. Second is the requirement to protect Guam against any threats that China might pose. This is a daunting task that requires integration of missile defense systems from the Army, Navy, and Missile Defense Agency, and one I hope we will learn more about in today's hearing.

The President's Budget submission for the Missile Defense Agency is $9.6 billion, a decrease from the fiscal year 2022 enacted level of $10.3 billion. I would like to know how the fiscal year 2023 budget request continues your effort for Homeland and regional missile defense as well as defense against new threats such as hypersonic missiles.

Again, let me thank today's witnesses for agreeing to appear. After opening statements we will have rounds of 5-minute questions for the witnesses.

Senator Fischer?

STATEMENT OF SENATOR DEB FISCHER

Senator FISCHER. Thank you, Mr. Chairman, and welcome to all of our witnesses today. We appreciate you appearing before us today and we look forward to hearing from each of you.

Overall, the budget request for fiscal year 2023 is a significant improvement over what the Administration proposed last year, and contains robust funding for the Next-Generation Interceptor program as well as for the defense of Guam.

While I am happy to see the Department finalize its plan for defending Guam and dedicate significant resources to do so, I cannot help but feel that this effort is already behind. The last two INDOPACOM commanders sought support for this project, and this subcommittee proposed to begin funding it 2 years ago, an effort that was ultimately rejected in favor of further study. In the time that has passed, the threat has only gotten worse.

Additionally, I continue to be concerned about the overall level of funding for missile defense proposed in this year's budget proposal. Compared to the fiscal year 2022 appropriation the Missile Defense Agency's budget would decline by over $700 million, a reduction of over 7 percent, at a time when threats are growing and the Department's purchasing power is being eroded by the effects of inflation.

I look forward to hearing more from our witnesses about these issues and about how the fiscal year 2023 request would impact their mission.

Thank you, Mr. Chairman.

Senator KING. Thank you. Our witnesses today are the Honorable Dr. David Honey, Deputy Under Secretary of Defense for Research and Engineering; Honorable John F. Plumb, Assistant Secretary of Defense for Space Policy; General Glen VanHerck, Commander, U.S. Northern Command and North American Aerospace Defense Command; Lieutenant General Daniel Karbler, Commanding General, U.S. Army Space and Missile Defense Command; and Vice Admiral Jon Hill, Director, Missile Defense Agency.

Secretary Honey, please.

STATEMENT OF THE HONORABLE DAVID HONEY, DEPUTY UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

Mr. HONEY. Chairman King, Ranking Member Fischer, and distinguished members of the Strategic Forces Subcommittee, thank you for the honor to appear before you today and to provide testimony on behalf of the Department of Defense for the Senate Armed

Services Committee hearing on missile defense. I am pleased and appreciate the opportunity to discuss this important topic.

In a rapidly evolving threat environment, U.S. adversaries are developing more lethal weapons by advancing technology in areas such as ballistic, hypersonic, and cruises missiles that threaten the safety and security of the United States and our allies. In support of the National Defense Strategy priorities, the Department of Defense created the Office of the Under Secretary of Defense for Research and Engineering to set the strategy for technology and innovation while addressing the needs of the joint force. Directed energy, a defense-specific technology, is a key critical technology area we are developing to counter a wide variety of current and emerging threats with the goal of rapid response and engagement at the speed of light.

This is a joint effort that is being largely supported and carried out by the Office of the Undersecretary of Defense for Research and Engineering, the Missile Defense Agency, the Air Force, the Army, and the Navy. The scope of the effort spans countering cruise missiles in the near term, hypersonic missiles in the near and medium term, and ballistic missiles in the long term.

To address the threat of adversaries' cruise missiles, a number of key technologies and capabilities crucial for countering cruise missiles will be demonstrated over the next 2 years. The OUSD(R&E) High Energy Laser Scaling Initiative, also known as HELSI, is funding industry to develop and deliver high-energy laser technology for cross-domain applications across the Department.

The Department is also developing high-power microwave weapons for a wide range of missions, including countering drones, cruise missiles, and hypersonic missiles. There is the Microwave Technology Testbed at MDA, the Remote Electromagnetic Disruption of Critical Advanced Threat, also known as REDCAT, at the Navy, and the Counter-Electronic High-Power Microwave Extended-Range Air Base Air Defense, CHIMERA, at the Air Force.

Lastly, countering hypersonic and ballistic missiles will require substantially more laser power. Therefore, under the HELSI effort, R&E [Research & Engineering] will begin scaling laser powers in fiscal year 2023, and is examining opportunities to accelerate the scaling significantly. This combined with improved beam control systems will allow capabilities against hypersonic and ballistic missiles to be developed by the services and Missile Defense Agency.

Chairman King, Ranking Member Fischer, Members of the Subcommittee, the R&E is committed to setting the technology and innovation strategy to advance defense-specific technologies, such as directed energy, and deliver these critical capabilities to the warfighter. We will continue to support these joint efforts to increase readiness as well as the capability and capacity of fielded homeland and regional missile defense systems while investing in advanced technology that offer new ways to counter a diverse set of threats.

Thank you again for the invitation to testify and I look forward to answering the committee's questions. Thank you.

[The prepared statement of Mr. Honey follows:]

PREPARED STATEMENT BY HONORABLE DAVID A. HONEY

Chairman King, Ranking Member Fischer, and distinguished Members of the Strategic Forces Subcommittee, thank you for the honor to appear before you today and provide testimony on behalf of the Department of Defense for the Senate Armed Services Committee Hearing on Missile Defense. I am pleased and appreciate the opportunity to discuss this important topic.

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Thank you again for the invitation to testify and I look forward to answering the committee's questions. Thank you.

Senator KING. Dr. Plumb?

STATEMENT OF THE HONORABLE JOHN PLUMB, ASSISTANT SECRETARY OF DEFENSE FOR SPACE POLICY

Mr. PLUMB. Chairman King, Ranking Member Fischer, and members of the committee, thank you for inviting me again to testify today, today on missile defense strategy policies and programs.

The missile threat continues to evolve, and as Secretary Austin has stated, China is the Department's pacing threat. China has advanced its missile capabilities over the last 20 years to counter the United States and the Indo-Pacific and to intimidate and threaten its neighbors, including Taiwan.

Russia is developing, testing, and deploying new missile that pose challenges for United States missile warning, and Ukraine, Russia has launched well over 1,500 missiles as part of an unprovoked campaign that has caused the deaths of thousands.

North Korea continues to improve, expand, and diversify its missile capabilities, posing an increasing risk to the United States Homeland, our forces, allies, and partners. North Korea has accelerated its missile testing in recent months, including the launch of long-range missiles.

Iran maintains a large and growing inventory of regional missiles as well as uncrewed aerial system, UAS, which it uses both directly and via proxy groups to strike its neighbors. Iran's nascent space program could shorten its pathway to a future long-range missile capability.

In light of these threats, the Department reassessed its missile defense policy, including inputs from interagency stakeholders, allies, and partners, in the 2022 Missile Defense Review, the MDR. As you have noted, the classified MDR was provided to Congress in late March.

Missile defenses contribute to deterrence in many ways. They provide resilience, they complicate adversary attack plans and reduce adversary confidence, they raise the threshold for potential conflict, they help assure our allies and partners, and they limit damage from missile attacks, which in turn provides additional decision space for senior leadership.

The Department's top priority is to defend the homeland and deter attacks against the United States. The President's Budget Request includes significant investments in homeland missile defense, including $2.8 billion to develop the Next-Generation Interceptor and for the service life extension of our GBIs; $4.7 billion to fund the transition to a resilient missile warning and missile track satellite architecture—and it is important to note that this is not part of the MDA budget. This is $4.7 billion for the Space Force—$278 million for new, over-the-horizon radars to enhance our ability to detect cruise missile attacks on the Homeland; and $892 mission to field missile defense capabilities to augment the THAAD [Terminal High-Altitude Area Defense] battery on Guam. Guam, like all United States territories, is unequivocally part of the United States Homeland, and a missile strike against Guam is a direct attack against the United States.

For regional defense the Department is also strengthening our missile defenses to counter regional threats that include hypersonic threats. The President's budget request invests heavily in regional ballistic cruise and hypersonic missile defenses, including $3 billion for Army ballistic and cruise missile defense programs, including the procurement of 252 more Patriot Interceptors; $2 billion for Aegis BMD [ballistic missile defense], including procurement of 57 more SM3 missiles; $335 million for THAAD development, procurement, and testing; $1.3 billion for hypersonic missile tracking and defense; and $825 million for counter-UAS solutions.

The sobering reality of the tragic events in Ukraine, in which Russia has used and continues to use a broad array of missiles to attack, and in my opinion terrorize, civilian populations highlights the extent to which our adversaries are prepared to use missiles in a conflict. Missile defenses are critical for defending the U.S. Homeland and for defending our deployed forces and our allies and partners. The Department and the Administration remain committed to improving them.

I look forward to working with the Congress to advance this shared goal, and I thank you and look forward to your questions.

[The prepared statement of Mr. Plumb follows:]

PREPARED STATEMENT BY DR. JOHN PLUMB

INTRODUCTION

Chairman King, Ranking Member Fischer, and distinguished Members of the Committee, thank you for inviting me to testify before you today on the Department's missile defense strategy, policies, and programs.

As the Assistant Secretary of Defense for Space Policy, I am responsible for the overall supervision of Department of Defense (DOD) policy pertaining to strategic capabilities essential for integrated deterrence including space, cyber, missile defense, nuclear weapons, and countering weapons of mass destruction.

I am honored to appear alongside General Glen VanHerck, Commander, United States Northern Command (NORTHCOM) and North American Aerospace Defense Command (NORAD), Vice Admiral Jon Hill, Director of the Missile Defense Agency (MDA), Lieutenant General Daniel Karbler, Commander of the U.S. Army's Space and Missile Defense Command (SMDC), and Dr. David Honey, Deputy Under Secretary of Defense for Research and Engineering (DUSD R&E).

Adversary advances in missile technologies, the marked increase in deployed systems, and the documented use of missiles in conflicts around the world show that missiles have become a common and expected facet of modern warfare. This makes our missile defeat and missile defense efforts more important than ever.

In this testimony I will examine how the missile threat has evolved; provide an update on U.S. missile defense policy as informed by the 2022 Missile Defense Review (MDR); and discuss the path forward to address growing missile threats in the Department's fiscal year 2023 budget.

Missile Threat Evolution

Offensive missiles are increasingly weapons of choice for Russia, China, North Korea, and Iran, for use in conflict and to coerce and intimidate their neighbors both in peacetime and crisis.

- *People's Republic of China (PRC):* As Secretary Austin has stated, China is the Department's pacing threat. China has dramatically advanced its development of conventional and nuclear armed ballistic and hypersonic missile technologies and capabilities over the last twenty years, through intense and focused investment, development, testing, and deployments. China is using increasingly sophisticated and proliferated space-based intelligence, surveillance, and reconnaissance (ISR) and improved command and control (C2) systems, to drive better precision and accuracy of its missiles. Many of China's systems are intended to deter and counter United States forward presence, force projection, and operations, especially in the Western Pacific region and give China the ability to further intimidate and threaten its neighbors, including Taiwan.
- *Russia:* Over the last ten years, Russia has prioritized modernization of its intercontinental range missile systems. Russia is developing, testing, and deploying new, diversified capabilities that pose new challenges to United States missile warning systems. Russia's regional missile arsenal underpins its anti-access/area-denial (A2/AD) strategies that are designed to undermine NATO's ability to project force in response to crisis or conflict. Russia has developed and fielded a suite of advanced precision-strike missiles that it has employed with devastating operational and tactical effect in conflict including in Ukraine and Syria. In Ukraine, we have witnessed Russia employ over 1,500 missiles of all types, often targeting civilians and civilian infrastructure, as part of its unprovoked campaign that has caused the deaths of thousands of innocent men, women, and children.
- *North Korea:* North Korea continues to improve, expand, and diversify its conventional and nuclear missile capabilities, posing an increasing risk to the United States Homeland and United States forces, allies, and partners in the region. Most of North Korea's ballistic missiles have an assessed capability to carry nuclear payloads. North Korea has accelerated its missile testing in recent months that included the launch of a long-range missile.
- *Iran:* Iran maintains a large and growing regional missile and UAS capability, which it leverages via its regional proxy groups to coerce and threaten its neighbors, and ensure regime survival. Iran's proxy wars in Yemen against Saudi Arabia and the United Arab Emirates (UAE), and in Gaza and Lebanon against

Israel, further demonstrate its willingness to use missiles and UAS capabilities to strike targets of any type including civilian populations. Iran's nascent space program could shorten its pathway to a future long-range missile capability.

- *Non-State Actors:* Non-state actors also pose a threat to U.S. regional interests, including our allies and partners. On today's battlefields, non-state actors are employing increasingly complex offensive UAS, rocket, and missile capabilities. State sponsors are proliferating technology and weapons systems to non-state groups, which have used them indiscriminately against innocent civilians. The recent attack on an oil facility in Saudi Arabia is just one example of this emerging threat.

United States Missile Defense Policy Update

The Department reassessed its missile defense policy as part of the 2022 MDR, which DOD provided in full to Congress in classified format on March 28 as an integrated element of the 2022 National Defense Strategy (NDS).

It is important to underscore the fully integrated approach that DOD took to conducting the 2022 MDR as part of the development of the NDS and alongside the Nuclear Posture Review (NPR). This approach ensured tight linkages between these key elements of our strategy and our allocation of related resources. The NDS establishes four priorities for the Department:

1. Defending the homeland, paced to the growing multi-domain threat posed by the PRC.
2. Deterring strategic attacks against the United States, our allies, and our partners.
3. Deterring aggression—while being prepared to prevail in conflict when necessary—prioritizing the PRC challenge in the Indo-Pacific region, then the Russia challenge in Europe.
4. Building a resilient Joint Force and defense ecosystem.

The 2022 MDR was developed over a nearly year-long process. It incorporates inputs from civilian and military stakeholders throughout the Department and across the interagency, and takes into account viewpoints solicited during extensive consultations with our allies and partners.

Missile defenses represent a key element within an integrated deterrence framework that weaves together all instruments of national power. It does this by:

- providing resilience to our deterrence and defense posture through both active (e.g., kinetic and non-kinetic intercept systems) and passive (e.g., redundancy, hardening, dispersal) means of defense;
- complicating adversary attack plans and reducing confidence of attack success;
- raising the threshold for potential conflict;
- offering leverage for diplomatic efforts and assuring allies and partners;
- providing military options that may be less escalatory than employing offensive systems;
- and limiting damage from attacks, thus expanding the decision making space for senior leaders.

Missile defenses and nuclear capabilities remain complementary. U.S. nuclear weapons present the credible threat of a robust response and overwhelming cost imposition, while missile defenses contribute to deterrence by denial. If deterrence fails, missile defenses can potentially mitigate effects from an attack.

As the scale and complexity of the missile threat increases, the Department recognizes that to stay ahead we need to implement a comprehensive missile defeat approach which includes missile defense but is complemented by the credible threat of direct cost imposition through nuclear and non-nuclear means. Missile defeat encompasses a range of activities in all domains designed to counter the development, acquisition, proliferation, potential and actual use of adversary offensive missiles of all types, and to limit damage from such use.

Homeland Defense

Our missile defense policy guided the development of the Fiscal Year 2023 Missile Defeat and Defense budget submission. In line with the NDS, our top priority is to defend the homeland and deter attacks against the United States. To achieve this strategic objective, the President's

Budget requested $2.8 billion to fully fund efforts to improve the capability and reliability of the Ground-based Midcourse Defense (GMD) system. These efforts include the development of the Next Generation Interceptor (NGI) to augment the existing the Ground-based Interceptor (GBI). The GMD system offers an important measure of protection for the United States. GMD also contributes to reassuring our

allies and partners that the United States will not be coerced by threats to the homeland from states like North Korea.

The United States of course maintains the right to defend itself against attacks from any source, but GMD is neither intended for, nor capable of, defeating the large and sophisticated intercontinental ballistic missile, air-launched ballistic missile, or sea-launched ballistic missile threats to the United States Homeland from Russia or China. The United States relies on strategic deterrence to address these threats.

The Department is taking necessary action in our fiscal year 2023 budget to enhance our domain awareness and warning capabilities. . The President's Budget Request funds a number of defensive measures including $278 million for new over-the-horizon radars to improve our ability to detect and decrease the risks from cruise missile strikes against U.S. critical assets. The President's Budget Request also includes $4.7 billion to fund the transition to a new, resilient missile warning and missile tracking architecture that will both improve our capability to warn against and track new types of missile threats while also improving our resilience against growing counter-space threats.

Guam, like all United States territories, is unequivocally part of the United States Homeland, and a missile strike against Guam would be a direct attack against the United States. After assessing the increased missile threat to Guam, the Department requested $892 million in its fiscal year 2023 budget for the Missile Defense Agency, the Army, and the Navy to develop and field missile defense capabilities to augment the existing Terminal High Altitude Area Defense (THAAD) battery currently emplaced on the island. This will contribute to the overall defense of Guam and bolster United States military posture in the Indo-Pacific region.

Regional Defense

The Department evaluated the regional missile threat to our deployed forces and allies and partners, and concluded that we must strengthen our regional missile defenses to counter all missile threats—including hypersonic threats—regardless of origin. The United States must continue to develop defenses against regional hypersonic missile threats, to include building a persistent and resilient sensor network to characterize and track all hypersonic threats, improve attribution, and enable engagement. The President's Budget request makes significant investments in regional ballistic, cruise, and hypersonic missile defense capabilities to accomplish these objectives. The transition to a resilient missile warning and missile tracking architecture supports missile defense of the homeland as well as regional missile defenses.

United States deployed forces, allies, and partners face the proliferation of lower-tier threats, such as rockets and armed UAS. Our adversaries will continue to seek ways to use these relatively inexpensive, flexible, and expendable systems. The Department is working to field technical and integrated counter-UAS solutions to ensure we can collectively meet the range of threats and appropriately hedge against future advancements.

Strengthening International Cooperation with Allies and Partners

The United States is committed to working with NATO and our other allies and partners to maintain a credible level of regional defensive capability against all missile threats from any adversary. This means we must continue to look for new ways to protect our collective forces, preserve our freedom of maneuver, and strengthen our security commitments. Over the next year, we intend to focus on:

- Identifying opportunities to coordinate on national missile defense policies;
- Aligning operational planning to maximize U.S., ally and partner capabilities;
- Capturing lessons learned from both real and simulated events such as exercises;
- Sharing information on air and missile threats;
- Developing and exchanging missile defense visions;
- Improving information protection efforts; and
- Supporting ally and partner missile defense modernization and capability development.

We view the missile defense capabilities of our allies and partners as indispensable contributions to our shared defense and integrated deterrence interests.

CONCLUSION

The sobering reality of the tragic events in Ukraine, in which Russia has used a broad array of missiles to attack and, in my opinion, terrorize civilian populations, highlights the extent to which adversaries are prepared to employ missiles in con-

flict. The centrality of missile attacks as a component of Russia's aggression in Ukraine is not an isolated occurrence—the use of missiles is becoming increasingly commonplace in conflicts worldwide.

Missile defenses are a critical capability for defending the U.S. Homeland, our deployed forces, and our allies and partners. Missile defenses are also an important contribution to the Department's broader integrated deterrence framework. The United States remains committed to improving our homeland and regional missile defenses as we work to deter conflict, and to prevail in conflict if deterrence fails. I look forward to working with the Congress to advance this shared goal.

Thank you again for this opportunity to testify. I look forward to your questions.

Senator KING. General VanHerck?

STATEMENT OF GENERAL GLEN VANHERCK, USAF, COMMANDER, UNITED STATES NORTHERN COMMAND AND NORTH AMERICAN AEROSPACE DEFENSE COMMAND

General VANHERCK. Chairman King, Ranking Member Fischer, distinguished members of the subcommittee, it is my honor to represent the men and women of the United States Northern Command and North American Aerospace Defense Command as we defend Canada and the United States. I appreciate the opportunity to testify alongside Dr. Honey, Dr. Plumb, Vice Admiral Hill, and Lieutenant General Karbler.

NORTHCOM and NORAD face the most dynamic and strategically complex environment in our respective histories. Strategy competitors have openly declared their intent to hold our homeland at risk in an effort to advance their own interests and limit our options and ability to respond.

North Korea continues to test nuclear-capable ballistic missiles with increased range and lethality, while Russia and China have fielded and continue to invest heavily in advanced long-range cruise missiles, hypersonic missiles, and delivery platforms. As we have seen throughout Russia's unprovoked and irresponsible invasion of Ukraine, Russia has fielded large numbers of long-range cruise missiles, including hypersonic missiles, that can cause enormous damage to infrastructure, create strategic effects with conventional warheads.

These conventional precision strike capabilities and advanced delivery platforms are designed specifically to hold critical infrastructure in the homeland at risk below the nuclear threshold, in order to disrupt and delay our ability to project power globally while attempting to undermine our will to intervene in a regional crisis overseas.

In my view, missile defense of the homeland starts with a strategic deterrent, to include the options and survivability provided by a reliable and effective nuclear triad. But as I testified before the full committee, I am concerned that deterrence by cost imposition does not adequately account for the conventional capabilities our competitors have already fielded. This over reliance increases the risk of miscalculation and escalation because it limits our national leaders' options in crisis and conflict.

To account for the full range of our competitors' nuclear and conventional capabilities, it is necessary to balance deterrence by cost imposition with deterrence by denial, an integrated deterrence that employs all elements of national influence. This integrated approach leverages both military and non-military capabilities in

order to provide our leaders with a wide range of timely deterrence options.

To be clear, we must continually demonstrate to potential aggressors that an attack on the homeland will result in failure. We do that by demonstrating reliable and effective capabilities that cause potential adversaries to doubt their chances of an effective attack on the homeland. This is why I continue to support Vice Admiral Hill's plan to field the Next-Generation Interceptor by 2028, or sooner if possible.

Deterrence by denial also includes demonstrating homeland readiness, responsiveness, and resiliency along a range of kinetic and non-kinetic capabilities to defend the homeland. NORTHCOM's support to civil authorities and our security cooperation relationships with allies and partners are critical to integrated deterrence, as is NORAD's mission to provide threat warning and attack assessment and defend the approaches to North America. In this strategy environment, we cannot wait for our competitors to act. It is vital that we get ahead of our competitors' decision-making and provide our national leaders with timely and informed options needed to achieve favorable outcomes.

With that necessity in mind, NORTHCOM and NORAD are focused on four strategic principles in our homeland defense design, starting with all-domain awareness, from under sea, on orbit, and everything in between, to include the cyber domain. Simply put, we have to be able to see the threats in order to deter and, if required, defeat them.

I want to thank the subcommittee for your support of the over-the-horizon radars on my fiscal year 2022 unfunded priorities list. Over-the-horizon radar will significantly improve my ability to detect and track threats in the air, maritime, and space domains. I ask for your continued support in authorizing the funding requested for over-the-horizon radar in the fiscal year 2023 President's budget.

All-domain awareness is required to achieve information dominance, which is the use of advanced capabilities like machine learning and artificial intelligence to quickly analyze, process, and deliver data to decision-makers at the speed of relevance. By doing so, we will increase senior leader decision space and enable decision superiority over competitors.

Finally, today's problems are global and all-domain, and they demand globally integrated strategies, plans, and actions. Missile threats to the homeland inherently originate beyond my area of responsibility, so it is vital that we have the ability to detect potential threats and share data rapidly between commands, agencies, allies, and partners around the world. These strategic priorities are vital elements of our ability to execute a layered defense in the execution of the National Defense Strategy and integrated deterrence.

I will end by thanking the committee for all you have done to support our soldiers, sailors, airmen, marines, and guardians as they defend the homeland. Thanks for the opportunity to appear and I look forward to your questions.

[The prepared statement of General VanHerck follows:]

PREPARED STATEMENT BY GENERAL GLEN D. VANHERCK

Chairman King, Ranking Member Fischer, and distinguished Members of the Subcommittee: thank you for the opportunity to testify today. I am proud to lead the men and women of United States Northern Command (USNORTHCOM) and North American Aerospace Defense Command (NORAD) as we defend the United States and Canada in an increasingly complicated and dynamic strategic environment. Our commands continue to face multiple simultaneous challenges from capable, highly advanced competitors who have openly declared their intent to hold our homelands at risk in an effort to advance their own strategic interests.

Today, strategic competitors, rogue nations, and non-state actors possess the capability to strike institutions and critical infrastructure in the United States and Canada. These threats, along with the realities of modern global competition, drive USNORTHCOM and NORAD to think globally and seek innovative capabilities that increase senior leader decision space and help to expand the range of available options for deterring in competition, de-escalating in crisis, and—if necessary—defeating in conflict.

As the U.S. combatant command responsible for homeland defense, for providing defense support of civil authorities, and security cooperation with allies and partners in our area of responsibility, USNORTHCOM is facing the most dynamic and strategically complex set of challenges in the history of the command. Together with NORAD, the distinct, complementary United States-Canada bi-national command responsible for aerospace warning, aerospace control, and maritime warning for the United States and Canada, our commands are taking decisive institutional and operational measures to defend our homelands.

DEFENDING THE HOMELANDS

In my testimony before the Committee last year, I described a rapidly evolving geostrategic environment in which our competitors were continuing to take increasingly aggressive steps to gain the upper hand in the military, intelligence, economic, and diplomatic arenas. For decades, the United States has been accustomed to choosing when and where the Nation will employ the military lever of influence and project power around the globe from a homeland that was assumed to be secure. Our competitors have studied this operating model for the last 30 years and have developed strategies and capabilities intended to offset our military advantage and disrupt our force flows.

Quite bluntly, my ability to conduct the missions assigned to USNORTHCOM and NORAD has eroded and continues to erode. Our country is under attack every day in the information space and cyber domain. Competitors are spreading disinformation, actively sowing division and fanning the flames of internal discord with the intent to undermine the foundation of our nation, our democracy, and democracies around the world. These competitors are also constantly seeking to exploit security vulnerabilities and policy gaps, especially in the cyber domain. They are preparing for potential crisis or conflict with the intent to limit decision space for our senior leaders by holding national critical infrastructure at risk, disrupting and delaying our ability to project power from the homeland, and undermining our will to intervene in a regional crisis.

The threat to North America is complex. Over the last year, our competitors have accelerated their fielding of kinetic and non-kinetic capabilities specifically designed to threaten our homeland. Of equal or greater concern is their relentless, coordinated effort to weaken the institutions and alliances at the core of our strength and influence while expanding their own influence internationally. Today, our competitors hold our homeland at risk in multiple domains and are working constantly to exploit perceived vulnerabilities.

Russia and China continue to aggressively pursue and field advanced offensive cyber and space capabilities, cruise missiles, hypersonic weapons, and delivery platforms designed to evade detection and strike targets in our homeland from multiple vectors of attack and in all domains. USNORTHCOM and NORAD's ability to defend against modern threats requires improved all-domain awareness, updated capabilities, and policies and strategies that reflect the current strategic environment and the advanced capabilities of our competitors. Meanwhile, I require access to ready and trained forces to operate throughout the USNORTHCOM area of responsibility, including the Arctic, to respond in crisis and quickly execute homeland defense campaign plans.

My mission to provide timely and accurate threat warning and attack assessment requires increased domain awareness and breaking down information stovepipes that restrict the flow of needed information to decision makers in the United States and Canada. The ability to detect a threat, whether from a cyber-actor or a cruise

missile, is a prerequisite to defeating the threat. Timely and accurate detection, tracking, and assessment of potential threats provides critical decision space and time to national leaders, while an inability to do so limits available response options.

Lack of domain awareness contributes to increased risk of miscalculation, unnecessary escalation, and potential for strategic deterrence failure. Maintaining our strategic advantage begins with improving domain awareness globally, including in the approaches to North America. Incorporating artificial intelligence and machine learning into existing capabilities will allow users to pull needed information from existing data sets and share that data with leaders at all levels to expand their decision space and options necessary to achieve desirable outcomes.

To ensure our ability to compete in the current strategic environment, DOD plans, force structure, and logistics must evolve beyond 9/11-era threats and outdated assumptions regarding competitor capabilities, strategies, and ambitions. In order to deter modern competitors, we must make clear that we have the capability to fight in and from the homeland. Further, policy determinations are needed regarding what key infrastructure is to be defended, and from what threats, in order to develop realistic assessments and plans for the defense of critical infrastructure that fully account for advancing competitor capabilities and strategies.

In order to defend the homeland in this complex strategic environment, USNORTHCOM and NORAD have shifted our efforts to left-of-conflict strategies, emphasizing integrated deterrence in competition, and dramatically improving our ability to provide leaders with needed decision space on a day-to-day basis. To be successful in competition, DOD must develop and implement globally integrated plans, strategies, operations, and exercises that incorporate all levers of influence, to include the essential contributions of our international allies and partners.

COMPETITORS AND THREATS

Russia

Russia is the primary military threat to the Homeland, and their focus on targeting the homeland has provided the model other competitors are beginning to follow. First, Russia has invested significant resources to modernize all three legs of its nuclear triad in an effort to ensure its ability to deliver unacceptable damage on our homeland during a conflict. In December 2019, Russia fielded the world's first intercontinental ballistic missiles (ICBMs) equipped with a hypersonic glide vehicle (HGV) payload. These weapons are designed to glide at extremely high speeds and maneuver at low altitudes in order to complicate our ability to detect and track. In the next few years, Russia seeks to field a new heavy-lift ICBM that President Putin claims will be able to deliver nuclear warheads to North America from both northern and southern trajectories. Weapons such as these are designed to circumvent the ground-based radars utilized by USNORTHCOM and NORAD to detect and characterize an inbound threat, and challenge my ability to provide threat warning and attack assessment. The impact is the loss of critical decision space for national-level decision makers regarding continuity of government and the preservation of retaliatory capabilities, resulting in an increase in the potential for strategic deterrence failure.

Over the last 15 years, Russia has also executed a systematic program to develop offensive capabilities below the nuclear threshold that Russian leaders believe will constrain United States options in an escalating crisis. Their capabilities include very capable cyber capabilities like those demonstrated by Russia-based actors during last year's ransomware attack on the Colonial Pipeline. Russia has also invested in counter-space capabilities like the direct-ascent anti-satellite weapon that Russia recklessly tested in November 2021.

To augment these non-lethal capabilities, Russia has fielded a new family of advanced air-, sea-, and ground-based cruise missiles to threaten critical civilian and military infrastructure. The AS–23a air-launched cruise missile, for instance, features an extended range that enables Russian bombers flying well outside NORAD radar coverage—and in some cases from inside Russian airspace—to threaten targets throughout North America. This capability challenges my ability to detect an attack and mount an effective defense. In the maritime domain, Russia has fielded the first two of their nine planned *Severodvinsk*-class guided missile submarines, which are designed to deploy undetected within cruise missile range of our coastlines to threaten critical infrastructure during an escalating crisis. This challenge will be compounded in the next few years as the Russian Navy adds the Tsirkon hypersonic cruise missile to the *Severodvinsk's* arsenal. All of the Russian cruise missile capabilities present a significant domain awareness challenge. Additionally, these advanced cruise missiles and their supporting platforms will limit national

leadership decision space and my ability to provide threat warning and attack assessment, which directly influences my ability to support continuity of government operations and provide support to USSTRATCOM missions. Again, the potential consequence is an increased risk of strategic deterrence failure.

China

China is our pacing threat and a long-term geostrategic challenge. China is increasingly exerting its economic and military clout around the globe as its leaders pursue a national goal of supplanting the rules-based international order with an approach that is more aligned with China's national interests. Like Russia, China has begun to develop new capabilities to hold our homeland at risk in multiple domains in an attempt to complicate our decision making and to disrupt, delay, and degrade force flow in crisis and destroy our will in conflict.

China has maintained the ability to strike our homeland with strategic nuclear weapons since the early 1980s, but today its nuclear capabilities are growing rapidly in quantity and sophistication. China's Fractional Orbital Bombardment System test in July 2021 delivered a hypersonic glide vehicle (HGV) and demonstrated the weapon's ability to survive reentry and perform high-speed and maneuvering glide after orbiting around the globe—a feat Russia never attempted before fielding their own HGV-equipped ICBMs two years ago. When fielded, China's ICBM-class HGV will be able to evade current ground and space-based early warning capabilities due to its low-altitude approach and ability to maneuver midcourse, which compounds the detection and warning challenges I already face from Russia's Avangard HGV and advanced cruise missiles.

In the coming years China will augment its homeland-threatening cyber capabilities with a growing long-range conventional strike capability of its own. In October 2019, China unveiled its first bomber capable of air-to-air refueling, the H–6N, which will be able to threaten targets in Alaska with air-launched ballistic or cruise missiles. Later this decade, China seeks to field its Type 095 guided missile submarine, which will feature improved quieting technologies and a probable land-attack cruise missile capability. While China's intent for employing its long-range conventional strike capabilities is not fully known, these weapons will offer Beijing the option of deploying strike platforms within range of our critical infrastructure during a conflict, adding a new layer of complication to our leaders' crisis decision-making.

North Korea and Iran

North Korea's successful flight testing of an ICBM capable of reaching the continental United States and detonation of a thermonuclear weapon underscores its leaders' determination to develop capabilities to threaten our homeland and constrain our options in crisis and conflict. In October 2020, North Korea unveiled a new ICBM that is probably even more capable than the weapons it last tested in 2017. Moreover, North Korea's launch last October of a submarine-based ballistic missile suggests Kim Jong Un may soon resume flight testing his most capable weapon systems, including a new ICBM design.

Iran maintains asymmetric capabilities to threaten our homeland in the cyber domain. In 2022, Iranian officials have threatened to carry out terror operations inside the United States and elsewhere around the world, in addition to its persistent support of threats by terrorist organizations like Lebanese Hezbollah. While Iran has announced a self-imposed range limit of 2,000 kilometers on its fielded ballistic missile force, its persistent advancement of ballistic missile technologies probably could increase its missile range outside of the region.

Violent Extremist Organizations

While the strategic capabilities of our peer competitors are the most pressing concern for USNORTHCOM and NORAD, violent extremist organizations such as ISIS and al Qaeda remain committed to attacking the United States and our allies. The Taliban's takeover in Afghanistan will likely provide new opportunities for groups like al Qaeda to plot against the West, while homegrown violent extremists (HVEs) challenge our law enforcement partners by using simple attack methods that continue to present the most likely international terrorist threat to the Homeland. Violent extremist groups continue to hone their tactics in response to a shifting operational environment and have maintained their focus on attacking civil aviation and U.S. military personnel and installations.

Transnational Criminal Organizations

Transnational Criminal Organizations (TCOs) continue to inflict enormous damage and create instability through corruption, violence, and illicit trafficking. International criminal syndicates have flooded the United States with illegal drugs that

contributed to the deaths of over 100,000 U.S. citizens in the 12-month period from April 2020 to April 2021, while harming people and weakening institutions throughout the Western Hemisphere. As TCOs battle over territory and brazenly undermine the rule of law, they create obvious opportunities for exploitation by strategic competitors seeking to broaden their global coercive strategies and increase influence and presence in the Western Hemisphere.

Mitigating the harm done by TCOs is a national security imperative for the United States and our international partners that requires an overarching whole-of-government policy and plan for interagency action that takes into consideration the vast resources and widespread influence wielded by the TCOs and their international criminal confederates. USNORTHCOM's ability to counter malign influence in our region is complicated by the destabilizing influence of TCOs in our area of responsibility, and national policy and DOD planning must take that reality into account.

INTEGRATED DETERRENCE

Strategic deterrence remains the foundation of homeland defense, and I believe it is absolutely necessary to maintain a reliable and effective nuclear triad. However, reliance on deterrence by cost imposition is currently over-weighted and significantly increases the risk of miscalculation by limiting our national leaders' options following an attack. Given our competitors' advanced conventional capabilities, it is vitally important to move toward a model of integrated deterrence that employs all elements of national influence, leverages alliances and partnerships, and provides leaders with a wide range of timely deterrence options.

Integrated deterrence fuses traditional deterrence by cost imposition—in which an adversary is deterred by fear of costs that outweigh the benefit of an attack—with deterrence by denial, which causes a potential adversary to doubt the likelihood of a successful attack. Imposing costs on an aggressor that outweigh the potential benefits of an attack, demonstrating resiliency, and displaying a range of kinetic and non-kinetic response capabilities are all elements of deterrence by denial. This approach dramatically expands the military, diplomatic, and economic options available to national leaders in competition, crisis, and conflict and helps to avoid miscalculation and unnecessary escalation.

Integrated deterrence also involves competing in the information space under a strategic framework, while working with allies and partners to counter competitors' malign influence in the USNORTHCOM area of responsibility and beyond. Building the capacity to compete in the information environment reduces the risk of instability and strategic miscalculation that can stem from disinformation and other influence operations.

Demonstrations of resiliency, hardening, and the ability to recover from damage to communities and infrastructure also generate a deterrent effect. USNORTHCOM's defense support of civil authorities (DSCA) mission in the aftermath of wildfires, hurricanes, floods, and other contingencies in communities across the United States routinely showcases the ability of USNORTHCOM and the interagency community to respond quickly and effectively to natural and manmade disasters.

USNORTHCOM's track record of supporting coordinated responses and rapid recovery is the direct result of ongoing interagency planning, coordination, and exercises that ensures our readiness to support our partners at a moment's notice. To be clear, DSCA is a homeland defense mission, and USNORTHCOM's visible support to civil authorities remains a critical focus for the command, especially as environmental change contributes to more frequent and intense fires and damaging storms.

Finally, we must continue to foster the partnerships and alliances that provide the United States and our international partners with what is perhaps our most distinct asymmetric advantage. NORAD is an obvious example of the enormous benefit to shared security and regional stability generated by international cooperation. In addition, it must be noted that our relationships with NATO, the FIVE EYES community, and our regional defense and security cooperation partners in Canada, Mexico, and The Bahamas have a profound deterrent effect for the common benefit of all. USNORTHCOM and NORAD continue to foster these valuable alliances and partnerships.

HOMELAND DEFENSE DESIGN

Homeland defense starts well outside the USNORTHCOM area of responsibility and necessarily involves our fellow combatant commands as well as our international allies and partners. Deterring and defending against advanced competitors

that have the capability to hold the homeland at persistent risk requires an approach that emphasizes increased decision space and leverages all elements of national power over cost-prohibitive and narrowly focused kinetic defenses. DOD's ability to deter and defend against advanced global threats requires a shift from regional approaches to a global perspective that accounts for the realities of the modern strategic environment.

I believe it is necessary to accept near-term risk in order to compete against advanced, globally focused peers well into the future. Leaders must make difficult choices today in order to avoid impossible dilemmas tomorrow—to include divesting legacy systems and capabilities that consume significant personnel and fiscal resources and are of little to no use in today's strategic environment.

Therefore, a homeland defense enterprise that is capable of deterring and defeating threats is essential to a globally integrated forward fight and supporting broader national strategic objectives. The ability of the United States to deter in competition, de-escalate in crisis, and defeat in conflict is dependent on our collective ability to detect and track potential threats and friendly forces anywhere in the world, while delivering data to decision makers as rapidly as possible. This provides leaders with the time and informed options needed to achieve a favorable outcomes for the United States. That reality is the basis for the central principles of USNORTHCOM and NORAD homeland defense design: all-domain awareness, information dominance, decision superiority, and global integration.

Domain Awareness can be achieved through an integrated network of sensors from the seafloor to space, including cyberspace, in order to detect, track, and deter potential threats. I need improved domain awareness to increase warning time and provide leaders at all levels with as many options as possible to deter or defend against an attack. Global all-domain awareness will generate a significant deterrent effect by making it clear that we can see potential aggressors wherever they are, which inherently casts doubt on their ability to achieve their objectives.

I am grateful to the Committee for your support of the over-the-horizon radar (OTHR) that was included on USNORTHCOM's unfunded priority list for Fiscal Year 2022. OTHR is a proven technology that will provide persistent surveillance of the distant northern approaches to the United States and mitigate the limitations of the Cold War-era North Warning System, while contributing to broader domain awareness challenges including space domain awareness. The ability to detect air-breathing and spaceborne threats in the approaches to Canada and the United States will be significantly enhanced by fielding OTHR as soon as possible. It is also vital to move quickly toward advanced space-based sensors capable of detecting hypersonic weapons, including hypersonic cruise missiles, and other advanced systems designed to evade detection. Modernizing and expanding the Integrated Undersea Surveillance System (IUSS) is equally important as Russia and China continue to field highly advanced guided missile submarines.

While some new domain awareness platforms will be required, it is possible to make exponential improvements in our nation's ability to detect and track potential threats by improving the ways data is collected, processed, and shared. As I testified last year, the technology already exists to apply artificial intelligence and machine learning to collect and rapidly distribute information gathered from sensors around the globe. Current processes rely on human analysts to comb through enormous volumes of data, and it can take days or weeks to process, exploit, and distribute critical information—if it is ever processed at all. We will always need expert human analysts in the loop, but I need the ability to tap into that technology to dramatically speed the delivery of information to leaders at all levels who need it.

Success in competition, crisis, and conflict depends on effectively distributing and integrating the data collected from domain awareness capabilities to establish information dominance over competitors and adversaries. To unlock the full value and potential of our intelligence and sensor networks, information must be integrated, appropriately classified, and rapidly shared to allow commands, agencies, allies, and partners to collaborate globally in real time and across all domains.

The potential for this capability has already been demonstrated in USNORTHCOM's Global Information Dominance Experiments (GIDE), which provided combatant commanders, intelligence and operations directors, and other participants at multiple sites with a shared, customizable, and near real-time data set. The data gathered by existing global sensors provided leaders, analysts, and operators with the information needed to make assessments and recommended courses of action that were coordinated across multiple commands in a matter of hours. Speeding the flow of information to senior civilian decision makers and commanders enabled significantly more options to achieve desired outcomes.

Decision superiority means increasing decision space and options to provide senior leaders. The ultimate goal of decision superiority is to provide multiple paths to

avoid conflict through the application of all available elements of national power, rather than emphasizing options that are only available after a conflict has already begun. To successfully defend the homeland, we must provide leaders with pertinent information and as much time as possible to deter and de-escalate before a situation escalates out of control.

Finally, I believe it is critical for the entire defense enterprise to shift its culture and vision toward global all-domain integration. Too often, DOD posture development, communications, planning, exercises, and operations are stovepiped and isolated in ways that do not reflect the reality that all challenges are global and all-domain in nature. The Department increasingly understands that competitors would likely intend to strike the Homeland in an effort to prevent flowing U.S. forces toward a regional crisis or conflict. And, in the event that the United States and our allies become engaged in a regional crisis or conflict, other competitors would likely exploit that opportunity to their own advantage—which could quickly lead to simultaneous crises in multiple theaters.

Global challenges cannot be overcome with a hodgepodge of isolated regional plans. Success in competition, crisis, or conflict is increasingly dependent on moving past outdated parochial approaches in favor of greater focus on competition rather than restricting options and absorbing unnecessary costs by continuing to over-emphasize crisis and conflict. With that in mind, USNORTHCOM, our fellow combatant commands, the Services, and our Canadian partners have demonstrated the immediate impact of improved information sharing and collaboration between commands and allies in all phases of competition, crisis, and conflict.

The current regional approach to plans, strategies, and force design is outdated and more influenced by bureaucratic inertia than the realities of the modern strategic environment. The same is true of stagnant acquisition practices and cumbersome civilian hiring rules that only impede progress and hinder the Department's ability to move at the speed of relevance necessary to compete in today's environment.

RISK MITIGATION

Risk mitigation must be a shared whole-of-government responsibility focused on broad nodes, enterprises, and capabilities rather than attempting to establish a priority-ranked list of specific sites or facilities to be protected. Mitigating the risk associated with an attack on the United States requires policy determinations about what must be defended from kinetic and non-kinetic attack. Those policy decisions, in turn, allow USNORTHCOM, NORAD, and our mission partners to determine the best ways to protect priority assets and resources.

Importantly, risk mitigation is the responsibility of the DOD, as well as a number of other interagency partners at the federal, state, and local levels. Risk mitigation requires a dedicated policy framework and deliberate interagency planning and coordination. Notably, the deterrent effect of resiliency and effective consequence management requires far fewer resources and less expense than direct defense systems.

Ballistic missile defense (BMD): Defending the United States against intercontinental ballistic missile (ICBM) threats from rogue nations remains a critical priority for USNORTHCOM and an important component of integrated deterrence. While current BMD capability and capacity is sufficient to defeat a limited ballistic missile attack from a rogue nation, North Korea's ongoing development of increasingly complex and capable strategic weapons requires the Next Generation Interceptor to be fielded on time or early, and for the Long Range Discriminating Radar in Alaska to achieve full operational capacity on schedule.

The ballistic missile defense system is not capable of intercepting hypersonic glide vehicles; I cannot defend, nor am I tasked to defend, against a hypersonic glide vehicle attack. It is imperative that the Department of Defense develop and field an integrated space-based domain awareness network capable of detecting and tracking ICBMs, hypersonic weapons, and cruise missiles as quickly as possible. I require the ability to detect, track, and assess potential missile threats of all types to immediately determine whether an attack is underway and provide national leaders with as much time and as many options as possible.

Cruise Missile Defense: Russia has the capability today to hold targets in the United States and Canada at risk with long-range air- and submarine-launched conventional cruise missiles. These highly precise and stealthy systems highlight the need for policy determinations regarding what must be defended along with continued demonstrations of resiliency and hardening. It is also necessary to quickly improve domain awareness by fielding sensors such as OTHR and the integrated undersea surveillance system (IUSS)—and by integrating and sharing the collected data with global stakeholders. To successfully deter aggression and defend the

homeland, we must be able to detect and track the submarines, aircraft, and surface ships that carry weapons systems capable of striking the homeland before they depart from their home stations. We also need to improve our capability to defeat those launch platforms before they are within range of their targets.

It is vital that we accept risk today in order to compete against highly advanced and determined peers in the near future. As an example, the military Services must be allowed to retire aging platforms, especially those that cannot survive in combat against highly advanced and lethal capabilities already fielded and proliferated by our peer competitors. The Department must re-invest the savings from those divestments to resilient domain awareness and other capabilities necessary to increase the decision space that will provide national leaders with options to deter, de-escalate, and defeat threats. Those difficult choices are critical to integrated deterrence today and avoiding the unthinkable tomorrow.

THE ARCTIC

The Arctic demonstrates how regional challenges increasingly take on global implications that require a global framework. The Unified Command Plan designates the Commander of USNORTHCOM as the DOD's Advocate for Arctic Capabilities in recognition of the fact that the region encompasses a vast geographic area overlapping the areas of responsibility of three separate geographic combatant commands and includes eight sovereign nations with inherent interest in the region. It is critical that USNORTHCOM, our fellow geographic combatant commands, the U.S. interagency, and our fellow Arctic nations continue our shared efforts to ensure the Arctic remains peaceful, stable, prosperous, and cooperative. This is especially true in light of the increasing potential for resource competition and opportunities for commercial enterprise, both of which must be balanced with the inherent rights of Arctic states to control their territorial waters and resources within their Exclusive Economic Zones.

Diminished Arctic ice has led to increased access to sea lanes, longer shipping seasons, and expanded access to subsurface minerals and proteins, although environmental changes are also increasing operational hazards and introducing new uncertainties. Those changes, in turn, now require clear communication and coordination among Arctic allies, partners, and competitors. A continued rules-based international order in the Arctic has served the international community well for decades, and forums like the Arctic Council are critical to emphasizing the value of the Arctic as a cooperative region where countries consistently work together to solve shared challenges.

Rising competition near the United States and Canada is of significant concern for USNORTHCOM and NORAD. The Arctic strategies published by DOD and each of the military Services demonstrate the shared understanding of the need to adapt policy, capabilities, and resourcing to meet the challenges and requirements associated with operating in the Arctic. However, the Services and the Department must accelerate implementation of those strategies or risk falling further behind rapidly advancing competitor capabilities, which jeopardizes USNORTHCOM and NORAD's ability to execute the commands' missions in the high north.

Likewise, Canada remains our essential partner in the NORAD mission and in ensuring NORAD's capability and capacity to deter aggression and defend the United States and Canada from airborne and maritime threats. That contribution includes investment in modernizing sensors, infrastructure, and platforms that ensure NORAD's ability to successfully conduct aerospace warning, aerospace control, and maritime warning. Those capabilities are vital to homeland defense and to our nations' capability to project forces forward in support of operations overseas, including meeting NATO commitments.

I am excited by the opportunities for building partnerships in the Arctic and the continued shared effort to maintain the stability and security of the entire region. The upcoming Arctic Security Forces Roundtable, to be held in Alaska in May 2022, will provide the United States with a rare opportunity to host an international forum focused specifically on Arctic security and military cooperation. USNORTHCOM and NORAD have important roles at the Arctic Security Forces Roundtable, and I am looking forward to joining Arctic military counterparts to make this a productive and forward-thinking event.

Likewise, the newly established DOD regional center, the Ted Stevens Center for Arctic Security Studies, in Anchorage will provide an important venue for academic, diplomatic, and military Arctic experts to address key challenges in the region, in alignment with DOD strategic guidance. None of those challenges, from mitigating the operational impacts of climate change to avoiding miscalculation resulting from undue militarization of the Arctic, can be overcome unilaterally. USNORTHCOM

will continue to leverage the strength of our regional alliances and partnerships to enhance regional security cooperation and support a secure and stable Arctic.

DEFENSE SUPPORT OF CIVIL AUTHORITIES (DSCA)

USNORTHCOM's defense support of other federal agencies during the COVID–19 pandemic, hurricanes, wildfires, and Operation ALLIES WELCOME has tested the command in unexpected ways over the past year. While our DSCA mission can be time- and resource- intensive, USNORTHCOM support to our interagency partners continues to strengthen relationships, validate plans, and demonstrate the ability of the U.S. interagency enterprise to respond quickly and effectively to contingencies. In addition to supporting American citizens in need, these missions provide a visible deterrent effect by demonstrating flexible response options and effectively executing plans to mitigate and recover from the effects of disaster and other emergencies.

In 2021 and 2022, USNORTHCOM continued DOD's COVID–19 support by deploying military medical providers to civilian medical facilities around the country. Building on existing pandemic response plans and quickly adapting to lessons learned during the pandemic, USNORTHCOM's support to the Federal Emergency Management Agency and the Department of Health and Human Services provided much-needed relief to hospitals overwhelmed by COVID–19 caseloads.

USNORTHCOM is also proud to work alongside the Department of Homeland Security and the Department of State throughout the Operation ALLIES WELCOME mission to evacuate, house, and resettle tens of thousands of Afghan partners and their families following the collapse of the Afghan government. With the support of the military departments, USNORTHCOM has been responsible for providing safety and security, shelter, food, and other essential services for Afghans who contributed to the United States mission in Afghanistan as they await resettlement in the United States.

SECURITY COOPERATION

Global alliances and partnerships provide the United States with a critical asymmetric advantage over our competitors. USNORTHCOM's military-to-military partnerships with Canada, Mexico, and The Bahamas remain critically important, and those ties continue to pay significant dividends as we work toward improving regional security, strengthening military ties with regional partners, and expanding interoperability. These efforts contribute to improved shared domain awareness and domain control, while strengthening the institutions that support our common strategic objectives. By working together toward these objectives, USNORTHCOM is supporting our partners' important contributions to regional security while emphasizing our shared prioritization of the rule of law, human rights, and denying our competitors the opportunity to expand their presence and malign influence.

The Mexican Secretariat of National Defense (SEDENA) and Secretariat of the Navy (SEMAR), are steadfast security partners and remain a bulwark against encroaching competitor presence and influence in Central and South America. USNORTHCOM was proud to host the annual United States-Mexico Bilateral Military Cooperation Roundtable in August 2021, during which key military leaders from USNORTHCOM, SEDENA, and SEMAR refined our shared efforts toward improved domain awareness, domain control, and institutional strengthening. In September 2021, I was also honored to personally attend the Mexico Aerospace Fair—commonly known as FAMEX—to demonstrate USNORTHCOM's commitment to the security relationship with our Mexican military partners and to join the Secretaries of SEMAR and SEDENA in reaffirming Mexico's vital contributions to the security of our region and our shared commitment to countering common threats.

Our partnership with The Bahamas remains critical. USNORTHCOM and The Bahamas' Bilateral Security Cooperation Framework provides a distinct and important venue for developing and implementing mutual objectives that contribute to regional security. Due to The Bahamas' geographic location along the United States southern approaches, domain awareness and domain control are in the vital national interests of both the United States and The Bahamas. In October 2021, I met with the new Bahamian government and my Royal Bahamas Defence Force counterpart in Nassau for the activation of a maritime surveillance radar donated by DOD that has already significantly improved our collective ability to detect and monitor traffic in the approaches to The Bahamas and the United States. China has expanded economic investment and visible diplomatic presence in The Bahamas and has highlighted the lack of a confirmed United States ambassador in an ongoing information campaign to boost Chinese influence while weakening that of the United States.

CONCLUSION

The global strategic environment will remain complex and extraordinarily dynamic for the foreseeable future. Our competitors already possess the capability to strike the homeland with kinetic and non-kinetic means, and they will take full advantage of slow responses, technological shortfalls, and policies that do not reflect the realities of the modern era.

USNORTHCOM and NORAD, in concert with our interagency colleagues, will continue our unending mission to defend our homelands and protect our citizens from threats in all domains, institutions, culture, and process. However, our commands' ability to effectively deter threats to the homeland will increasingly rely on improved domain awareness and providing leaders with the time and options necessary for success. Just as important, it is critical for military leaders and civilian policymakers to acknowledge that all regional challenges have global implications and present potential risk to the U.S. Homeland. Our competitors have demonstrated their intent to leverage any opportunity to advance their own interests—often to the detriment of our own.

Defense of the Homeland and continental defense remains the absolute priority for both USNORTHCOM and NORAD, and our commands' constant vigilance will be a key element of the integrated deterrence that safeguards our citizens and advances our vital national interests. It is my profound honor to lead all of the proud United States and Canadian military and civilian personnel of USNORTHCOM and NORAD as they stand our never-ending watch over our nations. I look forward to working with all of our vital partners as we continue to advance those efforts in the defense of our nations. We Have the Watch.

Senator KING. Thank you, General.

General Karbler?

STATEMENT OF LIEUTENANT GENERAL DANIEL KARBLER, USA, COMMANDING GENERAL, UNITED STATES ARMY SPACE AND MISSILE DEFENSE COMMAND

lLieutenant General KARBLER. Chairman King, Ranking Member Fischer, distinguished members of the subcommittee, I am honored to again testify before you representing an incredible People First organization of more than 3,000 soldiers and civilians across 10 time zones and 22 locations. These amazing professionals provide space, high-altitude, and missile defense forces and capabilities to Army and joint warfighters. Let me express my sincere appreciation for your continued support of our people and their families.

My role remains unchanged from previous testimony. I serve as the Commander of the Joint Functional Component Command for Integrated Missile Defense. As the Army's proponent for Air and Missile Defense, or AMD, I provide U.S. Northern Command, the soldiers who stand ready to defend our Nation from intercontinental ballistic missile attacks. I serve as the Army's Service Component Commander to both U.S. Strategic Command and U.S. Space Command, and I serve as the Army's AMD enterprise integrator.

We have witnessed significant changes over the past year, to include the largest employment of offensive missile systems in Europe since World War II in Russia's invasion of Ukraine. Like Russia, other potential adversaries across the globe are developing, fielding, and normalizing the use of increasingly diverse, robust, and lethal offensive missile systems in an attempt to gain coercive power and strategic advantage over the United States and our allies and partners.

It has never been more imperative that we strengthen our capabilities to deny our adversaries the benefits of using these weapons. We will accomplish this through continued investment and

sustainment of combat-ready, integrated, and lethal AMD forces. Space capabilities, combined with our allies and partners, will also prove essential in ensuring our nation's security.

To address the challenges of the ever-changing landscape we continue to implement new ways of accomplishing our mission and enhancing our capabilities. To briefly outline a few enhancements, our space and missile defense soldiers and civilians have completed an upgrade to our Joint Tactical Ground Stations at our four global theater missile warning company locations. These upgrades include our missile warning, missile defense cueing, and battlespace characterization in support of multidomain operations.

We have relocated two European-based United States Patriot batteries to Poland and one to Slovakia. This defense relocation reinforces our Nation's commitment to article 5 and proactively counters any potential threats to U.S. and allied forces in NATO's [North Atlantic Treaty Organization] eastern region.

During a joint March 2022 exercise, an air defense battalion under the European-based 10th Army Air and Missile Defense Command successfully deployed four Maneuver-Short Range Air Defense Stryker-based platforms throughout NATO's eastern region, a move of over 1,500 miles which culminated in a successful live fire in Estonia. Support to testing and exercises remains a priority.

Earlier this year, Air Defense Artillery soldiers participated in THAAD Flight Test-21, where two Patriot Advanced Capability-3 Missile Segment Enhanced interceptors were integrated with THAAD software to successfully intercept two short-range ballistic missiles. This integration enables earlier interceptor launch and results in increased defended area or battlespace.

Our soldiers also recently completed Phase 1 of the Integrated Air and Missile Defense Battle Command System initial operational test and evaluation, in full support of the Army's number one AMD modernization effort.

Let me close by again highlighting our most important asset, our people, who remain committed to accomplishing our no-fail national security mission. Despite the challenges of the COVID–19 pandemic, our professionals continue to provide space and missile defense capabilities to support combatant commanders. It is our people who make us strong. It is our people who make winning possible. I consider it an honor and a privilege to lead and serve alongside them and request the continued support of Congress to sustain our ability to recruit, develop, retain, and resource such a highly qualified and mission-ready team. When you put people first, winning happens.

I look forward to addressing your questions. Thank you.

[The prepared statement of General Karbler follows:]

PREPARED STATEMENT BY LIEUTENANT GENERAL DANIEL L. KARBLER

INTRODUCTION

Chairman King, Ranking Member Fischer, and distinguished Members of the Subcommittee, thank you for your continued support of our Service Members, Civilians, and Families and your continued support of the Army, U.S. Strategic Command (USSTRATCOM), U.S. Space Command (USSPACECOM), Department of Defense (DOD), and the space and missile defense community. Thank you also for in-

viting me to highlight the importance of space and missile defense capabilities and ongoing enhancements that enable the defense of our Nation, forward stationed and deployed forces, allies, and partners.

Today, with my assigned roles, I bring both an Army and a joint perspective on effective space and missile defense capabilities. Within the Army and joint communities, my responsibilities encompass several mission areas.

As commander of the U.S. Army Space and Missile Defense Command (USASMDC), I serve as the Army's force modernization proponent and operational integrator for space, missile defense, and high altitude capabilities. In short, USASMDC provides trained and ready space and missile defense forces and capabilities to the warfighter and Nation. With regard to missile defense, I am the Army Service Component Commander responsible for planning, integrating, coordinating, and providing Army missile defense forces and capabilities in support of USSTRATCOM missions. Additionally, I am a supporting commander to the Commander, U.S. Northern Command (USNORTHCOM), for the Ground-based Midcourse Defense (GMD) System. In the space mission area, I am the Army Service Component Commander to USSPACECOM, providing trained and ready Army space warfighters and capabilities to compete, fight, and win in the space domain.

As the Army's air and missile defense (AMD) enterprise integrator, I synchronize the balanced execution of the Army's AMD posture across the functions of force planning and sourcing requirements, combat and materiel development, AMD acquisition, and life cycle management. I coordinate with the AMD community of interest to balance priorities, inform resourcing decisions, and pursue innovative approaches in order to fulfill our AMD mission requirements.

Finally, as Commander of USSTRATCOM's Joint Functional Component Command for Integrated Missile Defense (JFCC IMD), I am responsible for providing operational-level global missile defense expertise in support of USSTRATCOM's Unified Command Plan (UCP)-assigned global missile defense operations support mission. In the missile defense arena, this includes plans integration, operations support, asset allocation recommendations, and support to missile defense capability development on behalf of combatant commanders (CCDRs). These efforts deter adversaries, assure allies, and defend U.S. deployed forces, allies, and partners against missile attacks.

The world has changed greatly since my testimony last year. We have witnessed the largest use of offensive missile systems in Europe since World War II in an unprovoked invasion of a sovereign nation by the Russian Federation in Ukraine. Like Russia, other potential adversaries globally are developing and fielding increasingly more diverse, robust, and lethal offensive missile systems in an attempt to gain coercive power and strategic advantage over the Nation and our allies and partners. It has never been more imperative that we deny them the benefits of using these weapons. We will accomplish this through continued investment and sustainment of combat ready, integrated, capable, and lethal AMD. Space capabilities, combined with our allies' and partners' abilities as part of a comprehensive approach to integrated deterrence, will also prove essential in ensuring our Nation's security.

PEOPLE FIRST

USASMDC and JFCC IMD, both comprised of multi-component soldiers, airmen, sailors, marines, guardians, and dedicated civilians and contractors, cannot carry out our wide-ranging, no-fail national security missions without the commitment of our greatest asset—our people. We prioritize "People First" as we recruit, train, and develop Army space and missile defense professionals. Six values are embedded in our People First mandate: communication, recognition, trust, teamwork, transparency, and empowerment. Despite the many challenges introduced by the COVID–19 pandemic, our professionals continue to provide space and missile defense capabilities that support combatant command (CCMD) plans and operations. It is our people who make us strong; it is our people who make winning possible.

RECENT CONTRIBUTIONS AND UPGRADES TO ARMY SPACE AND MISSILE DEFENSE CAPABILITIES

The people of USASMDC and JFCC IMD continue to learn new ways to operate, accomplish our missions, enhance capabilities, and support global theaters. Throughout the last several months, we have realized essential space and missile defense operational, capability, and training successes, a few of which follow.

- We recently completed an upgrade of our Joint Tactical Ground Stations (JTAGS) configuration at our four theater missile warning company locations. This upgrade provided a significant improvement in our missile warning, mis-

sile defense cueing, and battlespace characterization capabilities in support of Multi-Domain Operations (MDO). It also enabled us to keep pace with rapidly growing, complex, and capable threat systems.
- In March 2022, the Army relocated two European-based Patriot missile defense batteries to Poland. This defensive relocation served to reinforce our Nation's commitment to article 5 and proactively counter any potential threats to U.S. and allied forces in the eastern NATO region.
- During a March 2022 joint exercise, a subordinate air defense regiment under the European-based 10th Army Air and Missile Defense Command successfully deployed four Maneuver-Short Range Air Defense (M–SHORAD) Stryker-based platforms to the eastern NATO region. This deployment demonstrated the Army's newest short range air defense system's ability to defend maneuver forces against unmanned aerial systems (UAS), rotary-wing, and fixed-wing air threats.
- Our Army Space Training Division (ASTD) served as the lead proponent for equipping Army divisions and training centers with essential training aid devices that enable organizations to train in a degraded and disrupted space operations environment. With fielding completed, ASTD will lead future efforts on life cycle replacement of these devices.
- The USASMDC Technical Center leveraged commercial synthetic aperture radar imaging of current interest locations and, using artificial intelligence and machine learning algorithms, provided key operational data to tactical warfighting organizations.
- Support to significant testing and exercises remains a priority. Earlier this year, Air Defense Artillery (ADA) soldiers participated in the Terminal High Altitude Area Defense (THAAD) Flight Test-21, where two Patriot Advanced Capability-3 (PAC–3) Missile Segment Enhanced (MSE) interceptors were integrated with THAAD software to successfully intercept a short range ballistic missile. This integration enables earlier interceptor launch and results in a longer fly-out time, which increases the defended area or battlespace. Our ADA soldiers also recently participated in the initial operational test and evaluation of the successful Integrated Air and Missile Defense Battle Command System (IBCS) test. During this event, IBCS maintained continuous tracking of two cruise missile targets by fusing together data from multiple sensors while degraded by electronic attack. Finally, we continue to deploy Army space professionals to numerous joint and partner nation exercises and wargames.
- In addition to exercise support, operational deployments to CCMDs continue. Our 1st Space Brigade rotated an Army Space Control Crew to U.S. Indo-Pacific Command (USINDOPACOM), an Army Space Support Team to both U.S. Central Command (USCENTCOM) and U.S. European Command (USEUCOM), and Space Control Planning Teams to USEUCOM and USSPACECOM.
- Our Force Tracking Mission Management Center continues to support global operations in the USCENTCOM, U.S. Africa Command, and other CCMD geographic areas of responsibility. The Center provided vital management and dissemination of friendly force tracking data to theater commands.

U.S. ARMY SPACE AND MISSILE DEFENSE COMMAND

To accomplish our vision of providing space, missile defense, and high-altitude forces and capabilities to support joint and combined warfighting readiness in all domains, USASMDC is organizationally aligned to accomplish three major tasks. These include: providing forces and capabilities for current operations; preparing forces and capabilities for the future fight; and researching and developing Army technologies to provide future advancements in space, air, and missile defense capabilities.

The command aligns its activities to these priorities:
- Accomplish our mission as a People First team of empowered, innovative, ready, and resilient professionals.
- Provide trained and ready forces for space, missile defense, and high-altitude missions.
- Conduct integrated planning and synchronized operations in the execution of our space and missile defense missions.
- Prepare for future conflict.

PROVIDING FORCES AND CAPABILITIES FOR CURRENT OPERATIONS

In accordance with Title 10 responsibilities, USASMDC is a force provider of missile defense capabilities. Our first major task is to provide trained and ready missile defense forces and capabilities to CCDRs. USASMDC soldiers serving in the Home-

land and in remote and austere forward-deployed locations operate the GMD and AN/TPY–2 Forward-Based Mode (FBM) radars. Highlights of the capabilities provided to current operations and readiness by our missile defense professionals include:

Support to Homeland Missile Defense: Soldiers from the 100th Missile Defense Brigade (MDB), headquartered in Colorado Springs, Colorado, and 49th Missile Defense Battalion, headquartered at Fort Greely, Alaska, stand ready to defend our Nation from intercontinental ballistic missile (ICBM) attack 24/7/365. In support of USNORTHCOM, Army National Guard and Active component soldiers operate the GMD Fire Control Systems located at the Fire Direction Center in Alaska; Missile Defense Element in Colorado; a detachment that oversees operations at Vandenberg Space Force Base, California; and a detachment that secures GMD sensor infrastructure at Fort Drum, New York. At the Fort Greely Missile Defense Complex, 49th Missile Defense Battalion military police secure interceptors and command and control (C2) facilities from physical threats. These security soldiers perform their duties in some of the most austere conditions in the United States, with winter temperatures plummeting to 50 degrees below zero and fewer than 4 hours of sunlight in the winter months.

1st Space Brigade Soldiers provide CCDRs certified AN/TPY–2 FBM missile defense batteries that support strategic and regional missions. These batteries are globally located in five strategic, yet remote and austere locations, where they provide ballistic missile search, track, and discrimination operations in support of both homeland and regional defense. These soldiers continuously demonstrate our Nation's commitment to defend deployed forces, allies, and partners from ballistic missile attacks.

Support to Global Missile Defense Test and Development: Soldiers from the 100th MDB and 49th Missile Defense Battalion participate in GMD test activities and work with Missile Defense Agency (MDA) developers on enhancements to the GMD. The MDA's testing regime, conducted through a series of ground-based and operational flight tests, emphasizes operational realism during test design and execution. This realism enables system operators to sustain and improve their proficiency and validate the system's operational employment.

Space Support to Missile Early Warning: Space-enabled capabilities are essential for missile defense operations. They provide and enable communications; positioning, navigation, and timing (PNT); intelligence; and surveillance to meet the demands of modern warfare. In support of joint force commanders, USASMDC continues to provide missile warning within the USEUCOM, USCENTCOM, and USINDOPACOM theaters of operations. The 1st Space Brigade's forward stationed JTAGS theater missile warning companies are essential for USSPACECOM's assured missile warning mission. They are operated by USASMDC soldiers who monitor launch activity and other events observed by infrared sensor platforms and quickly provide information to members of the AMD and operational communities. The JTAGS forward stationing reduces the risk of solely relying on long-haul communications and ensures the resilience of USSPACECOM's comprehensive missile warning system.

PREPARING FORCES AND CAPABILITIES FOR THE FUTURE FIGHT

USASMDC's second major task is to develop future missile defense forces and mature current capabilities. The Space and Missile Defense Center of Excellence (SMD CoE) is the Army's force modernization proponent responsible for managing change to Army doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy (DOTMLPF–P) requirements for space, strategic missile defense, and high-altitude capabilities. The SMD CoE trains and educates agile, adaptive, and ready soldiers and leaders; executes life cycle management for Army space operations officers; develops Army Space soldiers; and enables informed decision making.

To carry out its mission, the SMD CoE executes practices established by U.S. Army Training and Doctrine Command and Army Futures Command to meet force management and Army modernization enterprise responsibilities. These functions include performing concept development, capabilities determination, and capabilities integration relative to DOTMLPF–P for process change, integration, and transition for materiel development.

Specifically, in the training arena, SMD CoE conducts the Army's institutional soldier qualification training and education for space and GMD mission areas. The SMD School writes, coordinates, and publishes Army doctrine for space and GMD while also integrating space training and education in curriculum across all Army proponent schools, operational unit home stations, and pre-deployment training

events. These efforts prepare soldiers across all warfighting functions to integrate Army and joint space and missile defense capabilities and effects in the conduct of MDO.

RESEARCH AND DEVELOPMENT OF ARMY TECHNOLOGIES

USASMDC's third major task is to provide critical technologies to address future needs that will enhance warfighter effectiveness. USASMDC's Technical Center supports joint warfighters by providing science, technology, and test and evaluation expertise to enable warfighter dominance both today and in the future. The Technical Center contributes to warfighter and joint force success in four major areas: directed energy (DE); tactical responsive space and high altitude; test and evaluation; and hypersonic and strategic weapons.

Directed Energy: The Technical Center is the Army lead for high-energy laser technology development. High-energy lasers complement kinetic systems in addressing rocket, artillery, and mortar threats; UAS; and cruise missiles. Additionally, the Technical Center is exploring high-power microwave technology for use in interdicting a multitude of improvised threats. As systems are fielded, the Technical Center will continue developing new and improved DE technologies for insertion into weapon systems to maintain warfighter dominance.

Tactical Responsive Space and High Altitude: As the Army lead for space and high-altitude research, development, and engineering, the Technical Center identifies, develops, demonstrates, and integrates technologies in the areas of responsive space, space superiority, and high altitude. Working with other Army, DOD, and industry partners, the Technical Center focuses on persistent beyond line-of-sight communications for forces in remote areas; functionally effective resolution imagery; solutions for assured PNT; ground C2 systems; and direct downlink of tactical data feeds.

Test and Evaluation: As an invaluable part of the Army test and evaluation enterprise, the Technical Center supports developmental and operational AMD defense testing with a suite of low-cost ballistic missile targets, transportable and configurable launchers, and test execution and evaluation. These ballistic missile targets are critical to threat-representative, operationally realistic testing of high-priority Army systems such as Patriot, THAAD, and IBCS, with future testing planned for the Lower Tier Air and Missile Defense Sensor (LTAMDS).

Hypersonic and Strategic Weapons: Since completing the Nation's first successful hypersonic weapon test in 2011, the Technical Center has continued supporting hypersonic testing for the Army, Navy, and Air Force, from test planning and design through mission execution and post-flight analysis. Additionally, the Technical Center is continuing to develop capabilities that enable rapid systems development and fielding through integration and interoperability testing, sensor and C2 design, flight test analysis, verification and validation, and warfighter training within an independent laboratory infrastructure.

Missile Defense Testing Assets and Range: The Technical Center also oversees the Ronald Reagan Ballistic Missile Test Site (RTS) at U.S. Army Garrison-Kwajalein Atoll, Republic of the Marshall Islands. The RTS is a vital national asset that provides live-fire developmental and operational flight testing of offensive and defensive missile, hypersonic, and space systems; equatorial satellite launch capability; space object tracking and characterization; and atmospheric science research. This unique range and test facility, located 2,300 miles west-southwest of Hawaii, provides test support to MDA, NASA, the U.S. Air Force, and other agencies.

The RTS supports developmental and operational testing of both homeland and regional missile defense systems, as well offensive ballistic missile testing for the Air Force Global Strike Command. Hypersonic system testing has become a significant element of near-term test planning at RTS. In concert with its testing mission and using a suite of the world's most sophisticated radar systems, to include the U.S. Space Force's Space Fence, RTS also supports space object identification and space domain awareness missions in support of USSPACECOM. This mission includes space object tracking and characterization, providing critical orbital information on new foreign launches and high-resolution images in support of space situational awareness.

ARMY CONTRIBUTIONS TO THE NATION'S MISSILE DEFENSE CAPABILITIES

The DOD will adopt a new strategic course in 2022, with a new National Security Strategy, National Defense Strategy, Nuclear Posture Review, and Missile Defense Review. The Army will establish its corresponding strategy nested in Office of the Secretary of Defense (OSD) guidance. USASMDC will update the Army Air and Missile Defense 2028 vision document to meet these directives and enable MDO. To

achieve an AMD force capable of supporting the Army of 2030, we must continue modernizing and developing AMD capabilities, building sufficient AMD capacity for MDO, and ensuring AMD forces are trained and ready. We must also ensure that our capabilities and associated C2 systems are resilient and interoperable with joint and allied forces. Accomplishing these essential tasks will allow us to provide deterrence through deployments and forward stationing and enable a more robust, comprehensive defense by coordinating and integrating with our allies and partners.

Army AMD is undergoing its most significant modernization program in the last four decades, as it is one of the Army's six modernization priorities receiving substantially increased investment. The AMD Cross Functional Team (CFT) serves as the Army's modernization lead and works closely with the other Services, Joint Staff, and MDA toward joint integrated AMD (IAMD) capabilities. The Program Executive Office Missiles and Space is the Army's materiel developer for these capabilities and works closely with AMD CFT and U.S. Army Aviation and Missile Command. A summary of the Army's AMD strategic direction and major programs follows.

Air and Missile Defense Readiness: Multiple factors—including the enduring demand from CCDRs, the transition to great power competition and its associated complex threat set, and the overdue and critical need to modernize the Army's AMD force—have all converged to impact Army AMD force readiness. High operational demand of missile defense forces to support joint warfighters continues stressing Army AMD force readiness, modernization, and soldier welfare. Enduring high operational tempo and limited deployment predictability negatively impact soldier readiness and family well-being. Currently, twice as many ADA soldiers are dwell restricted as compared to the overall Army. In an effort to improve soldier predictability and readiness, the Army has established a new unit life cycle modernization model known as the Regionally Aligned Readiness and Modernization Model (ReARMM). It is critical that the ADA Branch leverage ReARMM to inform the Joint Staff and OSD on force availability and improve deployment predictability for AMD soldiers.

Mission Command: Closely linked to AMD readiness is the ability to provide low density, high demand AMD mission command elements. These elements are pivotal to laying the foundation for and creating an environment that supports integration of Army AMD forces into joint and combined C2 architectures. During the past few years, the Army has activated an additional active component ADA brigade headquarters in USINDOPACOM and rotated a National Guard ADA brigade headquarters to USEUCOM. Also in the USEUCOM theater, the Army will soon stand up an active component ADA brigade headquarters.

Integrated Air and Missile Defense Battle Command System: The IBCS program is a top Army AMD modernization priority that integrates current and future AMD sensors and weapons into a common integrated fire control capability, allowing warfighters to fully integrate AMD capabilities across all echelons. The IBCS is the direct replacement for mission command nodes in the Patriot weapon system, headquarters elements, and airspace management cells. It also allows rapid convergence of sensors, shooters, and mission command components on an integrated fire control network. Once fully fielded, IBCS will provide a game-changing capability that allows appropriate tailoring and scaling of AMD forces to meet the given threat. The quantity and mix of capabilities can be dynamically retasked into a formation with an inherent, integrated mission command system to build tiered and layered defenses. In addition, IBCS open architecture enables rapid integration of legacy and developmental sensors and shooters that provide capabilities to defeat emerging threats in MDO. This year, the IBCS program entered low-rate initial production and began initial operational testing and evaluation.

The IBCS program will field common mission command nodes for Army AMD forces to defend against manned aircraft, UAS, air-to-ground missiles, tactical ballistic missiles, cruise missiles, and rockets, artillery, and mortar (RAM) attacks. Ultimately, IBCS will operate with air surveillance and fire control capabilities across the Army, Air Force, and Navy, and with joint and multinational AMD forces at all echelons, thereby enhancing AMD force lethality. By dismantling the current system-centric mission command paradigm, it will dramatically increase systems capability and facilitate open industry competition in support of the AMD community. The IBCS is one of the Army's contributions to Combined Joint All Domain Command and Control, currently in development between the Army and Air Force; continued experimentation to link with C2 systems for Army and joint fires is ongoing. Additional efforts are currently underway to support IBCS interoperability with MDA's Ballistic Missile Defense System, exploring the feasibility and potential benefits of integrating IBCS with MDA's Command and Control, Battle Management, and Communications (C2BMC) program.

Terminal High Altitude Area Defense System: THAAD is a key component of the ballistic missile defense system-of-systems architecture and designed for area defense against short, medium, and intermediate range ballistic missiles. It is a mobile and globally transportable, low density, high demand asset that has a unique endo-and exoatmospheric intercept capability using proven hit-to-kill technology. There are currently seven operational THAAD batteries, two of which are forward stationed in Guam and the Republic of Korea in response to the North Korean nuclear and missile threat. Development efforts associated with United States Forces Korea Joint Emergent Operational Need (JUONS) improved Patriot and THAAD interoperability, as successfully demonstrated in a recent THAAD/Patriot MSE developmental and operational test where THAAD software used two MSE interceptors to engage a ballistic missile target. As directed in the 2019 Missile Defense Review, the Army, in conjunction with OSD and MDA, reassessed the THAAD requirement to eight batteries.

Patriot/Patriot Advanced Capability-3 Missile Segment Enhancement: The Army Patriot force remains the cornerstone of AMD protection for our deployed forces, friends, and allies. The PAC–3 MSE is a high velocity, hit-to-kill, surface-to-air missile capable of intercepting and destroying tactical ballistic missiles and air-breathing threats. The PAC–3 MSE, a follow-on variant of the PAC–3, is in full-rate production and the latest generation hit-to-kill PAC–3 interceptor in the Patriot force to meet global capability requirements. The PAC–3 MSE fills the engagement gap between THAAD and PAC–3 missiles while also defeating advanced threats earlier, at greater range, and with increased lethality. The PAC–3 MSE's improved capability is achieved through a higher performance solid rocket motor, modified lethality enhancer, more responsive control surfaces, upgraded guidance software, and insensitive munitions improvements.

Patriot must continually modernize through software and hardware upgrades to address obsolescence and evolving threats, and to best utilize extended battlespace performance afforded by the PAC–3 MSE interceptor. Modernization efforts provide combat identification enhancements, address upper-tier debris mitigation, improve PAC3 MSE interceptor performance, and enable increased Army and joint interoperability. The Army leverages the program's stable funding profile to reduce price risk to the government through firm fixed price contracting and value engineering initiatives. In doing so, the Army mitigates obsolescence and counters emerging threats through hardware and software improvements. In addition to the integration efforts with the LTAMDS radar and IBCS, the Army supports the MDA-led integration of PAC–3 MSE interceptors and launchers into the THAAD weapon system. These new integrated capabilities expand battlespace by leveraging the THAAD AN/TPY–2 and Patriot radars together to detect threat targets at greater ranges. They will be pure fleeted across all Patriot battalions beginning in Fiscal Year 2023. In addition, to overmatch the near-term evolving threat, the Army is continuously improving Patriot while moving toward an IBCS architecture that enables kill-chain contributions from a wider spectrum of Army and joint sensors and weapon components.

Lower Tier Air and Missile Defense Sensor: Replacing the current Patriot radar, LTAMDS will provide networked sensing capabilities in lower tier missile defense battlespace and enable full capability of the PAC–3 MSE. The LTAMDS significantly improves legacy Patriot radar by providing expanded range and 360-degree coverage combined with the benefits of a networked sensor on the Army IAMD integrated fire control network. This modern technology will reduce current Patriot radar operations and sustainment costs by offsetting system equipment requirements and enhancing reliability and maintainability. Recent program successes include approval of an updated acquisition strategy that enables rapid prototyping and major capability acquisition, as well as approval of the LTAMDS PNT strategy. The Army plans to begin testing LTAMDS prototypes with IBCS and the Patriot family of interceptors, with the objective of fielding four sensors under urgent materiel release to a Patriot battalion by the end of 2023.

Indirect Fire Protection Capability: Indirect Fire Protection Capability (IFPC) is a ground-based weapon system designed to acquire, track, engage, and defeat cruise missile, UAS, and RAM threats. The Army's IFPC must integrate with IBCS as its C2 to enable an MDO-ready Army by 2030. In accordance with the Fiscal Year 2019 National Defense Authorization Act, the Army completed acceptance and fielding of two Iron Dome system batteries as an interim cruise missile defense capability. This past February, the Army supported Operation Iron Island, an Army executive order requirement that served as an opportunity to gain awareness of the system in an operational environment.

The Army is currently executing a competitive acquisition strategy to develop and field an enduring IFPC capability integrated with IBCS. IFPC Increment 2 will be an industry built solution for a launcher, and interceptor, and an all-up-round-mag-

azine. This weapon platform will integrate with IBCS fire control with Sentinel as the primary organic sensor. In September 2021, the Army announced the award of a rapid prototype agreement with an industry partner for development and delivery of 16 launchers and 60 interceptors for IFPC Increment 2.

Army Long-Range Persistent Surveillance: The Army Long Range Persistent Surveillance (ALPS) passive sensor provides continuous, 360 degree, long range surveillance against fixed-and rotary-wing aircraft, UAS, and cruise missile threats and has demonstrated the ability to integrate into joint and Army C2 systems, including IBCS. In response to multiple CCDR requirements, ALPS completed a USCENTCOM deployment last year and is currently being fielded in the USEUCOM and USINDOPACOM theaters.

Counter-Small Unmanned Aircraft Systems: Technological advances and the proliferation of commercial and tactical UAS in both reconnaissance and attack capabilities have matured to the point where they present a significant threat to Army operations from both state and nonstate actors. To address these threats, the Army continues to serve, at the direction of the Secretary of Defense, as the executive agent for countering UASs, having established the Joint Counter-Small UAS (C-sUAS) Office (JCO). Key JCO focus areas include developing joint requirements and materiel solutions, as well as joint training and doctrine. The JCO continues to work across DOD to synchronize and coordinate the development of C-sUAS technologies that meet Service-specific and joint requirements. Development efforts such as high-power microwave and DE are critical to ensuring the Army maintains pace with both commercial and state developed UASs. In response to a warfighter JUONS, the Army recently deployed over 500 man portable, fixed site, and mobile C-sUAS systems and continues adapting to changing theater UAS threats. The Army is now focused on providing critical C-sUAS capabilities to divisions in the operational force while growing protection of vital fixed and semi-fixed sites. For instance, in support of the Immediate Response Force in Europe, the Army has provided the 82nd Airborne Division kinetic and non-kinetic C-sUAS capabilities, allowing the division to detect, track, and defeat sUAS.

Maneuver-Short Range Air Defense: In response to identified operational needs, M–SHORAD will provide maneuver forces a dedicated, Stryker-based air defense capability against fixed-wing, rotary-wing, and UAS threats. In Fiscal Year 2018, the Army approved and began developing initial M–SHORAD systems that integrate existing Army capabilities into Stryker combat vehicles. The program successfully delivered four first unit equipped systems to an artillery regiment in April 2021 and remains on track to deliver four M–SHORAD battalions by Fiscal Year 2024. The Army also continues maturing high energy laser and electronic warfare technologies to increase M–SHORAD capabilities in support of the maneuver force. Ultimately, M–SHORAD battalions will contain a mix of complementary DE and kinetic intercept systems to protect the maneuver force.

JOINT FUNCTIONAL COMPONENT COMMAND FOR INTEGRATED MISSILE DEFENSE—INTEGRATING AND SYNCHRONIZING MISSILE DEFENSE

The Joint Functional Component Command for Integrated Missile Defense (JFCC IMD) is USSTRATCOM's integrating element for global missile defense. USSTRATCOM formed JFCC IMD to execute its UCP-assigned missile defense responsibilities, enabling the headquarters to focus on integration and advocacy. Established in 2005 and headquartered at Schriever Space Force Base, Colorado Springs, Colorado, JFCC IMD is manned by a cohesive team of subject matter experts from the Army, Navy, Air Force, Space Force, and Marine Corps, as well as Government Civilian and Contractor personnel.

The JFCC IMD is the recognized subject matter expert across the missile defense enterprise in matters of global missile defense operational support, policy, plans, intelligence, communications, training and education, and operational risk assessment. The command's principal mission is to integrate these transregional missile defense functions across the joint and combined warfighting force. On behalf of USSTRATCOM and other CCDRs, JFCC IMD champions warfighter priorities and operational needs. These include continued development of a robust missile defense sensor network, integrated discrimination capabilities, redundant and resilient C2 networks with enhanced cybersecurity defenses, and improved means of intercept for all missile and hybrid threats.

The JFCC IMD works across DOD and alongside allies and key partners to improve integration of existing capabilities, maximizing efficiency and effectiveness in global missile defense missions. Integration is the essential force multiplier—a critically important mission enabler that JFCC IMD directly supports. As a functional

component command of USSTRATCOM, JFCC IMD supports designated UCP responsibilities along four lines of effort:

- Synchronizing global missile defense planning, global force management, and missile defense security cooperation activities.
- Conducting global missile defense operations support, to include asset management, alternate execution authority, federated intelligence support, and network monitoring and protection.
- Executing above element, joint, and combined global missile defense training and education, exercises, and experimentation.
- Advocating for, and recommending acceptance of, global missile defense capabilities, conducting analyses and assessments of current and future capabilities, and supporting tests.

To accomplish these efforts, JFCC IMD maintains close collaborative relationships with CCDRs, MDA, OSD, the Joint Staff, Services, intelligence community, and our allies and partners. The JFCC IMD continually seeks to enhance deployed forces' capabilities while gaining operational experience and confidence in our collective ability to defend the Nation, deployed forces, allies, and partners. Some key efforts to enhance missile defense planning and capabilities for both homeland and regional architectures follow.

Expansion and Integration of the Missile Defense Architecture: In response to the evolving strategic environment, JFCC IMD continues to bolster homeland and regional missile defense capabilities and further the global missile defense mission through advancement of new capabilities. These advancements include the Aegis Ashore site in Poland; continued development of the Standard Missile-3 Block IIA; the Long Range Discrimination Radar, Clear Space Force Station, Alaska; Space-based Kill Assessment; MDA's Hypersonic and Ballistic Tracking Space Sensor; Space Development Agency's Tranche 1 Tracking Layer; the Next Generation Interceptor for homeland defense; and the Glide Phase Interceptor for regional hypersonic defense. Given the challenges associated with integrating these capabilities into a global architecture, JFCC IMD, in support of USSTRATCOM, provides essential collaboration with CCDRs to assess and address transregional gaps in the areas of planning, policy, capabilities development, and operations.

Integrated Missile Defense Asset Management: The JFCC IMD, in coordination with USSTRATCOM and CCDRs, manages missile defense operational readiness posture, coordinates global missile defense system maintenance, and supports MDA and Service tests. The asset management process allows JFCC IMD to continually assess system readiness to defend against missile attacks and recommend adjustments to optimize overall missile defense architecture.

Cybersecurity of the Missile Defense System: The JFCC IMD, in coordination with USSTRATCOM and MDA, conducts the cybersecurity service provider mission for missile defense architecture to ensure cyber defenses and operations are planned and executed across the globe. Working with key stakeholders, JFCC IMD enhances the cyber defense posture of the missile defense operational architecture against malicious activity. The JFCC IMD also collaborates with mission partners to incorporate realistic cybersecurity testing in support of the warfighter capability acceptance process. Additionally, JFCC IMD works closely with the Joint Staff, CCMDs, and MDA to educate, train, and exercise cybersecurity protocols to ensure the highest levels of global missile defense readiness.

Global Force Management: USSTRATCOM, as the designated Joint Functional Manager for Missile Defense, relies upon JFCC IMD to evaluate and recommend to the Joint Staff risk-informed sourcing of missile defense requirements. Due to the low density and high demand nature of missile defense assets, all sourcing decisions have a direct and significant impact on other CCDRs' campaign and contingency plans. The JFCC IMD continues refining this approach, ensuring integrated capabilities are appropriately postured to counter transregional threats in accordance with the current National Defense Strategy, Missile Defense Review, and Department steady-state priorities. This globally integrated approach serves as the baseline for risk-based recommendations to the global force management process, enabling senior leaders to make informed decisions.

Allied and Partner Missile Defense Integration: Given that we will never have enough active defense capacity, integrating our allies and partners into a common and mutually supportive architecture is a critical warfighter priority. We must move beyond merely enabling the independent "burden sharing" of allies and partners to an environment of mutual trust and information sharing that empowers truly integrated planning and operations enabled by combined force development, simulation, experimentation, testing, and exercise. We must acknowledge that future major conflicts should not be fought alone and that our greatest strategic advantage is the

power of our alliances and partnerships. We should not hamstring this historic advantage with continued policies and practices that hinder collective action.

The Nimble Titan Campaign of Experimentation, a biennial series of multinational missile defense experiments, is one venue aimed at promoting this increased cooperation. This event brings together subject matter experts from allied and partner nations to explore the national policy and military interfaces and dynamics involved in collaborative coalition and alliance missile defense planning. Meeting this intent is necessary to developing regional defense designs, C2 relationships, and collective, bilateral, and multilateral policy. Nimble Titan fosters greater confidence in combined missile defenses and provides a means to advance U.S. efforts in collaboration, interoperability, and operational integration with our allies and partners.

Joint Missile Defense Training and Education: Even with ongoing challenges posed by COVID–19, JFCC IMD, in coordination with USSTRATCOM, the Joint Staff, Services, and CCMDs, continues developing comprehensive and innovative training programs to close gaps between Service, joint, and regional missile defense training and education. The JFCC IMD's Joint Ballistic Missile Defense Training and Education Center offers 18 mission-focused resident, online, and mobile training team courses including orientation, asset management, C2BMC situational awareness, and general and flag officer seminar training. During 2021, JFCC IMD instructors executed 169 courses that trained more than 4,100 students worldwide. Enhancing collective advantage, JFCC IMD also provides training courses to allies and partners through both military to military and Foreign Military Sales training venues. Additional foreign training opportunities are anticipated as the COVID–19 pandemic wanes globally.

Warfighter Inputs to Capability Development: The JFCC IMD helps streamline and accelerate MDA's efforts to provide integrated kill chain capabilities (sense, C2, and effect) to warfighters as quickly as possible to meet increased threat developments. As multiple reviews have identified, the Nation must streamline requirement generation and reform acquisition and fiscal processes and cultures to enable MDA and the Services to quickly develop, test, and deliver effective, reliable, and sustainable missile defense capabilities. Our adversaries are not waiting, so we must change our typical ways with innovation, adaptability, risk acceptance, and speed. The JFCC IMD collaborates with CCDRs, MDA, and the Services, as well as their respective test agencies, to leverage emerging technologies to enhance existing systems, explore innovative operational concepts, and prioritize maturing technological advancements with the most promising near-term potential. To that end, JFCC IMD continues optimizing the collaboration inherent in the warfighter involvement process as an operational proponent for required missile defense capabilities and performance enhancements.

Sustaining our competitive advantage through innovation and expedience depends on well-resourced and operationally relevant test campaigns, as well as high fidelity modeling and simulation infrastructure and forward looking wargaming to challenge assumptions regarding our future missile defense readiness and posture. In testing over the past year, JFCC IMD supported demonstration of the selectable 2-and 3-stage GMD interceptor, which will improve the effective engagement and defeat zone of incoming threats; several data collections of hypersonic vehicle flight tests to characterize sensor performance; and test planning for an upcoming operational flight test to demonstrate the Long Range Discrimination Radar's capabilities.

Comprehensive Missile Defeat: As I have highlighted, adversary offensive missile and hybrid systems are increasingly complex and challenging in their delivery means and scale. As such, an optimal missile defense requires both defensive and offensive capabilities to defeat potential threats. By sustaining a capability to not only attack the adversary's ability to launch missiles but also destroy them after launch, a comprehensive approach can lower overall costs and reduce risk of failure. Creating this comprehensive posture—involving the integration of both defensive and offensive capabilities -will require balancing a variety of approaches within our capability set.

Importantly, as we continue developing innovative capabilities, it is imperative that we implement integrated deterrence as the framework that weaves together all instruments of national power. These actions include diplomacy at the forefront and advancing cross-domain deterrence together with the capabilities and actions of allies and partners to ensure the costs and risks of adversary aggression remain disproportionate to any conceivable benefit. These capabilities must include conventional kinetic, DE, cyber, and electromagnetic attack as part of a comprehensive approach. Each individual approach provides opportunities to reduce the burden on active defenses; however, none alone is a "silver bullet" to defeating the threat. As such, our future offensive materiel solutions will likely be a mix of guns, missiles,

electronic warfare, cyber, space, and DE weapons. To this end, we must understand how each of these systems complement one another and strive for a balance that allows prelaunch attack operations and offense-defense integration, and then organize to operationalize these capabilities and maximize their contributions to missile defense.

In summary, JFCC IMD continues to expand our Nation's global missile defense architecture and explore developing capabilities to maintain operational advantage against current and future threats. We maintain our competitive edge through integrated planning and operational support, development of warfighters through education and training, expansion of collective capabilities in collaboration with our allies and partners, and rapid delivery of innovative and impactful capabilities to warfighters that enhance national security.

CONCLUSION

Chairman King and Ranking Member Fischer, as members of the joint missile defense community, the Army and USSTRATCOM continue pursuing enhancements to the Nation's IAMD systems, from tactical to strategic levels of warfare. As outlined here, USASMDC and JFCC IMD perform a broad set of critical national security missions. These missions include providing professional warfighters and capabilities to support current operations, ensuring they are prepared for tomorrow's fight, and developing the new technologies required to achieve and maintain technological advantage against our adversaries. Our trained and ready soldiers, operating GMD elements in Colorado, Alaska, New York, and California, and from remote, globally deployed locations, remain ready to defend the homeland against ICBM attack. As a force provider to CCDRs, we provide essential regional sensor capabilities, ballistic missile early warning, and space-enabled communications. Our regional forces continue to leverage allied collaboration and planning efforts in developing integrated and interoperable defenses against various threat sets. USSTRATCOM, through JFCC IMD, continues to integrate missile defense capabilities to counter global missile threats and protect our Nation, deployed forces, and allies and partners.

While operational, doctrinal, and materiel developments are essential, our most important assets are the thousands of soldiers, sailors, airmen, marines, guardians, civilians, and contractors who deploy and employ our IAMD systems. As recognized by Department leadership, the strength behind our outstanding workforce is their families. Their contributions and sacrifices are foundational to the dedication and performance of our workforce—the role and support of our families empowers mission accomplishment.

I appreciate the opportunity to address missile defense matters and look forward to addressing your questions.

Senator KING. Thank you, General.

Admiral Hill?

STATEMENT OF VICE ADMIRAL JON HILL, USN, DIRECTOR, MISSILE DEFENSE AGENCY

Vice Admiral HILL. Good afternoon, Chairman King, Ranking Member Fischer, distinguished members of the subcommittee. It is a great honor to be here with some incredible key partnerships here to testify before you today.

I would like to first start by recognizing and thanking those who operate from abroad and here at home, operating the Integrated Missile Defense System, and then, of course, my Missile Defense Agency team, comprised of military, civilian, and contractor workforces that ensure that the warfighters can operate those systems.

Our fiscal year 2023 budget was mentioned as $9.6 billion to continue the mission of protecting the homeland, our forward-deployed forces, our friends, and allies.

A little bit back on the threat. Everyone has mentioned it. I want to put a finer point on it. When you think about advanced ballistic missiles, long-range cruise missiles, hypersonic missiles, what that

really means, down at the warfighter level, is heavy maneuver, large numbers, at high speed, with 360-degree attack. That is a challenge.

Rather than walking through all of the elements of the Integrated Missile Defense System that we have deployed globally and operated by our services, I want to focus in on what I see as the three top priorities for President's budget 2023.

Priority one is the no-fail mission of defend the homeland against ballistic attacks from the rogue nations. I want to thank Congress for the great support on the service life extension program. We are making great progress. We are on track, ahead of schedule. We have got the first round that we refurbished back in the hole now, number two is inbound, and rounds three, four, and five are being processed now. That is going to extend the reliability of our in-service fleet——

Senator KING. I would prefer you not use the term "inbound" in this room. It makes me a little nervous.

[Laughter.]

Vice Admiral HILL. Yes, sir. I will scratch that from the script.

Then I would like to switch on over to Next-Generation Interceptor. As was mentioned earlier, we are at light speed working very closely with General VanHerck and his team to ensure that the two contractors that we put in place last year about this time, March of 2021, are tracking to get to first in placement around the 2028 time frame. Right now both are performing so well that they are anticipating, and our team believes that we are tracking towards 2027. That is incredible. That means flight testing earlier. That means ground testing earlier. That means we have a better sense of where we are as we move forward to upgrade the numbers of interceptors and the capability that we will be bringing forward.

Priority two—and the reason it is priority two is not just because it is a territory with U.S. citizens living on it. It will be one of the most difficult things we do as an agency, and that is the defense of Guam. We have a current architecture with a ship stationed up forward and we have a THAAD battery on the island. We have a clear set of operational requirements from INDOPACOM [U.S. Indo-Pacific Command]. We finalized the architecture in President's budget 2023. The Department did provide funds in fiscal year 2022 to accelerate, and then Congress added a plus-up for us to do that.

Our plan is to leverage mature systems to expand so that we have emerging capabilities tied in, and I think the most important thing that we will bring to the table is a single command and control structure. Critically important for the Pacific Defense Initiative, so we are staying very close to INDOPACOM as we move through this development.

Priority three, really driven by the threat, and that is the hypersonic missile defense that has been mentioned by everybody. We are leveraging our existing sensors today to get indications and warnings, so we are not starting at zero. Our command and control battle management deployed globally has the ability to pull in the space assets that are available, the land-based assets, the sea-based assets, to get us track on hypersonics when they fly through the field of view. Our command and control battle management

system, C2BMC, is running a prototype today that provides indications and warning to INDOPACOM.

Where we are going in fiscal year 2023 is we will have our first two Hypersonic and Ballistic Tracking Space Sensors, HBTSS, in space, operating in an inclination to where we can collect data from testing we do in the INDOPACOM region. We are going to get fire control data where we can leverage our weapons.

What we have deployed today for hypersonic defense, with the sea base, is the sea-based terminal capability. I mentioned that already. That has been deployed for a while. We are on Increment 2 of that capability and moving out towards Increment 3. When I say that, that means we are expanding the threat set to take on a larger number of those hypersonic threats.

Where we need to go is away from the terminal area. You have to defend there but it is the most difficult place to engage because you really do not know where a terminal is going to be, because it is maneuvering and it is high speed. So we are moving to get to a layered defense capability, and in the President's Budget 2023 we are going forward with the Glide Phase Interceptor. We have three companies on board now, and we will be down-selecting to two later this year.

Chairman King, Ranking Member Fischer, Members of the Subcommittee, MDA continues to increase readiness, resiliency, and cybersecurity and the capability and capacity of homeland and regional defenses while investing in advanced technology. We are committed to attracting and building a strong, talented, future workforce, and our capabilities-based approach and unique acquisition authorities enable MDA to deliver by, through, and with the services to the combatant commands to meet their requirements.

I appreciate your continued support for the Missile Defense Agency, the people, and the missile defense mission. I look forward to answering your questions. Thank you.

[The prepared statement of Admiral Hill follows:]

PREPARED STATEMENT BY VICE ADMIRAL JON A. HILL

Good morning, Chairman King, Ranking Member Fischer, and distinguished Members of the Subcommittee. The Missile Defense Agency (MDA) budget request of $9.628 billion for fiscal year 2023 enables the continued execution of the MDA mission to design, develop and deploy a layered Missile Defense System (MDS) to defend the United States and its deployed forces, allies, and friends from increasingly diverse missile threats. MDA's proposed investments for fiscal year 2023 reflect missile defense guidance issued in the classified 2022 Missile Defense Review, which was provided to Congress on March 28, 2022, along with the 2022 National Defense Strategy, and are aligned with the February 1, 2022 "USD(R&E) Technology Vision for an Era of Competition."

Potential U.S. adversaries are developing more advanced ballistic, hypersonic, and cruise missile systems, increasingly making them more mobile, survivable, reliable, accurate, and capable of achieving longer ranges. Current and future missile threats pose the growing technical challenges of high velocity, heavy maneuver, large numbers, and the exploitation of combination attacks involving unmanned aerial vehicles. MDA continues to collaborate with Combatant Commanders and the Services to support current and future needs for missile defense capabilities. The Department periodically re-examines missile defense roles, responsibilities and authorities. For example, the Joint Staff is implementing its Integrated Air and Missile Defense (IAMD) Capability Portfolio Management Review (CPMR) to continuously review threats, identify capability gaps, and make cost/risk tradeoff recommendations. I support this effort. I also consider the Warfighter Involvement Process, or WIP, currently led by U.S. Strategic Command and the Joint Functional Component Com-

mander for Integrated Missile Defense, to be essential, as it is currently constituted, to the U.S. missile defense enterprise. I believe the existing missile defense governance process, including the WIP, is unique and necessary for the voices of the Combatant Commands and the Services to be heard. The current governance process, combined with MDA's capabilities-based approach and unique acquisition authorities, are essential in supporting the Warfighter given the rapidly evolving threat environment.

DELIVERING BY, THROUGH AND WITH THE SERVICES TO MEET COMBATANT COMMAND REQUIREMENTS

MDA is developing, delivering, sustaining, and improving affordable, proven, and leading-edge capabilities to counter increasingly advanced ballistic missiles and an expanding set of hypersonic and cruise missiles.

Space and Terrestrial Sensors

We can improve sensor tracking and discrimination capabilities by leveraging the global persistence and proximity of space sensors. The Spacebased Kill Assessment (SKA) network of infrared sensors hosted on commercial satellites is planned to deliver hit and kill assessment capabilities for homeland defense. On-orbit SKA sensors have already participated successfully in a variety of flight tests and engineering activities and provide situational awareness to U.S. Northern Command (USNORTHCOM) during regular exercises. We will complete SKA hit assessment integration using a Command and Control, Battle Management and Communications (C2BMC) operational interface into the MDS in fiscal year 2024 and continue developing a follow-on kill assessment as part of the post-intercept assessment capability.

MDA continues to collaborate with the U.S. Space Force (USSF), including the Space Development Agency, and industry to develop a Hypersonic and Ballistic Tracking Space Sensor (HBTSS) capability to detect and track boosting ballistic missiles and hypersonic glide vehicles. In fiscal year 2023, we will complete development and implementation of ground systems to support satellite operations and testing and deliver two prototype satellites developed by two separate companies in support of a planned fiscal year 2023 launch to conduct on-orbit demonstrations. I also would like to recognize the critical contributions made by the two Space Tracking and Surveillance System (STSS) satellites launched in September 2009. After lasting eight years past their design life, both space vehicles were decommissioned earlier this year. STSS satellites served as an important testbed for HBTSS risk reduction activities, which included demonstrations that we can close the MDS fire control loop from space.

MDA also continues to develop, deploy, and sustain a robust, cyber-secure and networked ground- and sea-based radar architecture. We completed Long Range Discrimination Radar (LRDR) construction and Initial Fielding in 2021 at Clear Space Force Station (SFS), Alaska. The LRDR is the most advanced ground-based radar in the world. In fiscal year 2023, we will develop software for tracking and discrimination improvements, refining space intelligence data, and enhancing modeling and simulation. Following operational acceptance in fiscal year 2023, LRDR will support the Ground-based Midcourse Defense (GMD) capability against Pacific theater long-range missile threats with persistent long-range midcourse discrimination and precision tracking and hit assessment. LRDR also will support Space Domain Awareness (SDA).

The Sea Based X-band (SBX) radar supports homeland defense operations, MDS testing and data collection, and it provides SDA and precision midcourse tracking and discrimination capabilities. The SBX will continue at-sea deployment into fiscal year 2023 while conducting selected radar and vessel maintenance, software and hardware upgrades, and testing. Fabrication of the SBX replacement radome continues on schedule for installation in fiscal year 2025.

MDA continues to support the USSF in sustaining and updating the Upgraded Early Warning Radars (UEWRs) at Clear SFS, Alaska; Cape Cod SFS, Massachusetts; Royal Air Force Fylingdales, United Kingdom; Thule Air Base, Greenland; and Beale AFB, California. UEWRs support missile defense of the Homeland and detection of ballistic missile attacks and conduct general space surveillance and satellite tracking.

MDA is providing affordable software upgrades to Aegis Integrated Air and Missile Defense (IAMD) destroyers equipped with the SPY–1 radar to support the USSF SDA mission. The Aegis SDA capability is fully compatible with deployed U.S. Navy operations and has appropriate safeguards to ensure full Aegis IAMD warfighting capability is available. In April and September 2021, we worked in partnership with the USSF, Navy, and industry to demonstrate the first-ever SDA capability from

operational Navy destroyers, where the USSF tasked Aegis Baseline 9 Destroyers via C2BMC to detect, track, and report resident space objects. In fiscal year 2023, we will continue to develop, test, and deliver this upgrade to the Navy. Twenty-nine Aegis ships are scheduled to be upgraded with this capability by fiscal year 2024.

MDA also is working with the U.S. Navy to refurbish existing shipboard SPY–1 radar arrays to provide increased radar sensitivity and discrimination improvements. We also plan to integrate missile defense capability with delivery of the Navy's Air and Missile Defense Radar, the SPY–6, for enhanced engagement capability and increased raid capacity.

MDA is upgrading, sustaining, and supporting operation of 12 AN/TPY–2 radars, including five Forward Based Mode radars in Japan, Israel, Turkey, and United States Central Command. We have seven Terminal Mode radars in CONUS locations or forward-deployed with U.S. Army Terminal High Altitude Area Defense (THAAD) batteries in U.S. Indo-Pacific Command. AN/TPY–2 radar 13 production is on schedule with planned delivery as a Terminal Mode radar in second quarter fiscal year 2025 for service with THAAD Battery 8. MDA continues supporting two THAAD Foreign Military Sales (FMS) cases that include seven AN/TPY–2 radars in production for the Kingdom of Saudi Arabia (KSA) along with two operational radars in the United Arab Emirates (UAE).

Command and Control, Battle Management and Communications

C2BMC integrates the MDS and provides Combatant Commanders with global, persistent, space-based infrared, land-, and sea-sensor acquisition, tracking, cueing, discrimination, and fire-control quality data to support U.S. and coalition-partner missile defense and SDA operations. C2BMC interfaces with Service, NATO, and international systems and provides decision makers a common operating missile defense picture. C2BMC also operates an advanced prototype processing node that tracks and reports hypersonic threats in response to U.S. Indo-Pacific Command operational need.

Funding in fiscal year 2023 sustains the C2BMC planner, situational awareness, battle management capabilities, global missile defense network, and SDA in Combatant Command user nodes. The most recent C2BMC upgrade integrates LRDR and the updated BMDS Overhead Persistent Infrared Architecture into the MDS, providing situational awareness and tracking capability for hypersonic threats. This spiral significantly expands SDA capabilities for U.S. Space Command with LRDR, provides additional SDA coverage using the Aegis SPY–1 radar, and integrates on-orbit SKA sensors into the MDS. It also integrates the U.S. Army's IAMD Battle Command System into the MDS.

Homeland Defense

The GMD system protects the U.S. Homeland from rogue state ballistic missile attacks, and we are focused on delivering new capabilities to address the limited but increasingly advanced North Korean Intercontinental Ballistic Missile (ICBM) threat. In September 2021, we demonstrated the capability to select a 2-stage or 3-stage burn of a Ground Based Interceptor (GBI) booster, which enables an earlier release of the kill vehicle to greatly expand the engagement area and time to counter the inbound threat. In fiscal year 2023, we will execute an intercept flight test demonstrating this capability and the latest incremental improvements of the entire kill chain to defeat an advanced threat-representative ICBM target equipped with countermeasures.

MDA continues to upgrade the ground system infrastructure, communications network, fire control system, and missile fields to improve the reliability, capability, and cybersecurity resiliency of the GMD weapon system and support acceptance of the Next Generation Interceptor (NGI). The entire GMD weapon system is currently undergoing a Service Life Extension Program to improve GBI reliability and availability. With these ongoing efforts, we anticipate the existing GBI fleet will be extended beyond 2030.

NGI development and fielding will improve the interceptor fleet, with deliveries starting as early as 2028. The Department awarded two NGI contracts in March 2021, and our competing Industry prime contractors are advancing through the design development process with full technical rigor to deliver this new capability as soon as possible. Both designs feature multiple kill vehicle payloads to reduce the number of interceptors required to defeat a single ballistic missile threat to our Nation. Our fiscal year 2023 request will continue to mature critical technologies for the NGI booster, payload, and sensors.

Regional Defense

Globally deployed ship-based and land-based Aegis BMD capabilities are critical to the Nation's integrated defense of our deployed forces, allies, and partners

against short- to intermediate-range missile threats. In fiscal year 2023, we will continue to meet the quickly advancing threat through improvements to the Aegis BMD capability, including procuring and delivering Standard Missile (SM)-3 Block IB and Block IIA missiles, improving Sea-Based Terminal (SBT) defense, advancing weapon system and missile reliability, and enhancing Aegis BMD engagement capacity and lethality. We will continue developing Aegis BMD weapon system software to enhance functionality and leverage more-capable radars, artificial intelligence, and national technical means.

MDA continues to support protection of NATO's European territory and forces against the ballistic missile threat from the Middle East. Aegis Ashore in Romania is operational, and we plan to complete construction on Aegis Ashore Poland in 2023. Both sites are designed to launch the SM–3 Block IB and Block IIA. This past year, installation of select combat system equipment occurred in parallel with construction activity, and U.S Navy sailors moved into the residential building at Naval Support Facility Redzikowo.

We are planning to conduct in fiscal year 2022 an Aegis Weapon System flight test experiment (FEM–01), which will be an exo-atmospheric engagement to demonstrate an Aegis ship firing an SM–3 Block IIA against a Medium-Range Ballistic Missile (MRBM) target. We also plan to execute an Aegis intercept flight test campaign with Japan (JFTM–07) in which we will demonstrate the newest BMD engagement capability of the Japan (J7) Aegis BMD configuration with SM–3 Block IIA against an MRBM. We will also demonstrate Aegis ship-to-ship engage-on-remote in a simulated engagement, an IAMD capability using SM–2 surface-to-air defense missiles, and an organic engagement of an SRBM with SM–3 Block IB Threat Upgrade interceptor.

The THAAD weapon system is globally transportable and ground-based and is highly effective against short-, medium- and intermediate-range missile threats inside and outside the atmosphere in the terminal phase of flight. MDA currently supports forward-deployment of two batteries stationed in the U.S. Indo-Pacific Command area of responsibility and continues to cooperate with UAE and KSA in support of operational FMS THAAD batteries. The UAE THAAD weapon system successfully intercepted ballistic missiles launched at the UAE in January 2022, marking the first operational use of the U.S.-built system. In fiscal year 2023 we will continue THAAD development and interceptor procurement, obsolescence mitigation efforts, production and training support, the THAAD Stockpile Reliability Program, and modifications to meet growing cybersecurity threats.

MDA is providing a more robust IAMD capability, one that integrates THAAD, Army Patriot, and at-sea Aegis ships into a seamless network. THAAD/Missile Segment Enhancement (MSE) integration improves the area defended by a THAAD battery without the requirement of a dedicated Patriot battery and increases engagement opportunities while conserving THAAD interceptors. In February 2022, THAAD demonstrated control of MSE interceptors in a simulated SRBM non-intercept flight test (TH CTV–01a). TH CTV–01a verified that the latest THAAD software could allow the THAAD weapon system to compute an MSE firing solution, communicate with an M903 Launcher, and control an MSE interceptor in flight. In THAAD Flight Test (FTT)-21, a combined developmental and operational test conducted in March 2022, we used the latest THAAD software to fire two MSE interceptors to engage the SRBM target. In fiscal year 2023, we plan to conduct the first THAAD demonstration of concurrent control of THAAD and MSE interceptors against multiple MRBM targets.

In fiscal year 2022, MDA will begin engineering and planning a survivable and operationally effective IAMD architecture to defend Guam from ballistic, hypersonic, and cruise missile threats. Defense of Guam IAMD architecture would leverage proven missile defense capabilities, allow for expansion of emerging capabilities, and provide a single command and control structure. Our fiscal year 2023 funding request allows continued development, to include engineering and planning activities, environmental impacts studies, procurement on long lead items, and integration between Army and Navy assets. All early design and integration activities will support a range of architecture options, pending upcoming Departmental decisions.

We are investing in defensive capabilities to counter regional hypersonic missile threats by upgrading sensors and C2BMC for early warning, identification, and tracking of regional and strategic hypersonic threats from space (e.g., HBTSS). We also are leveraging existing systems where possible (including proven engage-on-remote and launch-on-remote capabilities) and pursuing a Glide Phase Intercept (GPI) demonstration. We are working closely with the Navy to develop, field, and upgrade the SBT capability to counter regional maneuvering and hypersonic threats in the terminal phase of flight. The SBT program already provides an initial terminal defensive capability to counter hypersonic threats, and additional improvements are

scheduled for 2024. Today, the SM–6 missile is the only weapon in the country's arsenal capable of engaging highly-maneuverable hypersonic threats. In fiscal year 2023, Aegis SBT will demonstrate a simulated engagement against a hypersonic target (FTX–40) and in fiscal year 2024 will demonstrate a salvo engagement firing two SM–6 Block IA Upgraded guided missiles against a Hypersonic Glide Vehicle target (FTM–43). Complementing this terminal capability, in fiscal year 2023, MDA will continue to develop and plan a GPI demonstration and leverage the Aegis Weapon System to provide the U.S. Warfighter increasingly capable regional defensive capabilities.

We will continue to work with North American Aerospace Defense Command (NORAD) and USNORTHCOM to develop system architecture for cruise missile defense (CMD) of the Homeland. I agree with the NORAD/USNORTHCOM Commander that modern threats require improved all-domain awareness, updated capabilities, and policies and strategies that reflect the current strategic environment and the advanced capabilities of our competitors. We have been able to make good progress on enhanced indications and warning and will continue to develop the systems architecture and conduct a demonstration of CMD capabilities using the Joint Tactical Integrated Fire Control (JTIFC) capability. JTIFC enhances integrated fire control capabilities across the Services by connecting existing sensors, command and control systems, and weapons at the tactical level through real-time sensor networks. I also share the NORAD/USNORTHCOM Commander's desire to have an Over-The-Horizon radar fielded as soon as possible to support All Domain Awareness and agree with his assessment that the air and cruise missile threat to the Homeland is a top priority.

We are continuing our cooperative missile defense relationship with Israel to help our partner develop systems to strengthen its missile defenses and increase interoperability with U.S. forces. Our two nations continue to cooperate on engineering, development, co-production, testing, and fielding of the Arrow Weapon System, the David's Sling Weapon System, and co-production for the Iron Dome Defense System. I would like to highlight our cooperative demonstration of interoperability in the successful flight test of the Arrow Weapon System and Arrow-3 interceptor conducted on January 18, 2022. In fiscal year 2023, MDA will continue co-development, testing, and co-production with Israel.

DEVELOPING TECHNOLOGY FOR FUTURE COMPETITION

With mission focus on warfighting outcomes, MDA is investing in innovative and disruptive technologies to provide leap-ahead capabilities to address the emergence of new and more advanced threats. We must continue to sustain, modernize, and expand missile defenses by pursuing rapid, yet measured, development of advanced missile defense concepts and technologies for homeland and regional defense. We will continue to develop mission-aligned disruptive technologies, solutions, and transition opportunities for future ballistic and hypersonic defense architectures, investing in the technology development necessary for the next increment of capability, including externally and internally-cooled seeker window technology, axial upper stage throttling and maneuvering capability, robust and resilient materials for hypersonic flight, secured mesh communications, and novel guidance and control capability.

MDA continually assesses emerging and disruptive technology for potential applications to missile defense utilization that are producible, reliable, and cost-effective. We are pursuing efforts in directed energy, artificial intelligence, machine learning, nanosat technology, Left-through-Right of Launch Integration, cybersecurity, and quantum science. Keys to this assessment have been our insight into the missile defense industrial base and our development of testbeds that allow us to exercise and demonstrate capabilities and test new concepts, algorithms, simulations, and software. We are also expanding technology opportunities through cooperative, collaborative engagements with our DOD partners, laboratories, allies, industry, and universities.

CONCLUSION

Chairman King, Ranking Member Fischer, Members of the Subcommittee, we will continue to increase the readiness, resiliency, cybersecurity as well as the capability and capacity of fielded homeland and regional missile defense systems while investing in mission-focused advanced technology. We are committed to attracting and building a strong, talented future workforce to meet the mission challenges of tomorrow. I would like to recognize and thank the men and women who serve in our Armed Forces at home and abroad and who operate the integrated Missile Defense System with the support of our dedicated civilian and contractor workforce. I appre-

ciate your continued support for MDA and the missile defense mission, and I look forward to answering the committee's questions. Thank you.

Senator KING. Thank you, Admiral, and thanks to all of you for your extraordinary service and work.

I want to start with some budget questions, and I do not think we are seeing the full picture when we talk about the Missile Defense Agency budget. Dr. Plumb, are there not other missile-related expenditures in other parts of the budget? I think you touched on this. I want apples to apples from last year to this year on the whole missile defense enterprise.

Mr. PLUMB. Yes, sir. I do not think I can give you the specific numbers. I will say, at least for the $4.7 billion for the transition, the first piece of funding to transition to a robust, proliferated, low-earth orbit missile warning and missile track architecture, including an architecture that can observe hypersonic weapons, that is $4.7 billion more than it was in the budget the previous year. That is a new thing.

My colleague here, Secretary Honey, was just talking about the directed energy funding. That funding is no longer part of MDA's budget. At least most of it is now with R&E, so there is a bucket of money there.

Senator KING. It would be helpful for me, Dr. Honey, for the record, not right now, but for the record of this hearing if you could give us a sort of apples to apples with all the pieces of the budget last year and this year. Can you supply that?

Mr. HONEY. Yes. We will take that for the record, sir.

Mr. HONEY. The missile defense funds for directed energy are allocated across the Department of Defense (DOD). In 2019, the Department made a decision to consolidate directed energy S&T efforts (BA 6.1, 6.2, & 6.3) within the Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)) in the Directed Energy-Joint Transition Office (DE-JTO). This office works on technologies which will be used in all of the Services/Agencies developmental programs. This office is within the OUSD(R&E) Deputy Chief Technology Officer (DCTO) for Critical Technologies (CT). It also issued a Directed Energy Roadmap to best utilize resources and leverage existing programs across the Department.

The Missile Defense Agency (MDA) collaborates closely with OUSD(R&E)/CT and the military services on directed energy capability development efforts, to include missile defense.

The directed energy budgets for the military services, MDA, and the OUSD(R&E) are shown in the chart below. The OUSD(R&E) budget funds key high energy laser technology necessary for missile defense. The total for fiscal year 2022 is $305.6 million and the total for fiscal year 2023 is $439.7 million. Additional classified details can be provided upon request.

Directed Energy Missile Defense Budget ($M)

	Fiscal Year 2022	Fiscal Year 2023
Military Services	124.2	265
MDA	52.5	15
OUSD R&E	128.9	159.7
Total	305.6	439.7

Senator KING. Thank you. I appreciate that.

Hypersonic defense. Well, I guess, let me just back up. I am disturbed by the fact that the President's Budget proposes a cut at a time when we all know that we are facing a new threat and an im-

portant one. So perhaps what you are telling me is that there is money in other places to deal with a threat by things like directed energy. Is that correct?

Mr. HONEY. Yes, Senator. That is correct. We do have funds elsewhere that are developing directed energy solutions for that particular threat.

Senator KING. Okay. Well that is what I hope you can supply it for the record, as you suggested you would.

What have we learned from Ukraine? I will direct this to any of the witnesses, but I would think the guys with the uniforms on might have some thoughts. General Karbler, what have we learned?

lLieutenant General KARBLER. Sir, a couple of lessons that I have taken personally from Ukraine and that we are applying within the air and missile defense community. First, as I said in my opening statement, we see adversaries normalizing the use of ballistic missiles. If you went back about 10 years, force-on-force ballistic missile use just was not as prevalent, and now we see Russia, as well as other adversaries, using ballistic missiles.

Senator KING. Conventional air defense does not work.

lLieutenant General KARBLER. No, sir. You need ballistic missile defense in order to be able to counter that, and with that, we recognize also that it cannot just be an active defense solution. We have got to be able to integrate offensive capabilities to take out those missiles when we are on a tail or when aircraft is on a runway or in a hangar. So the offensive-defense integration is key, as well as then the layered missile defense. So everything from THAAD to Patriot to——

Senator KING. Is it not true that most of the damage done in Ukraine has been done by artillery and missiles, not by conventional aircraft dropping bombs?

lLieutenant General KARBLER. Yes, sir, and so that layered defense would allow us from Army capabilities, THAAD, and Patriot to counter ballistic missiles as well as cruise missiles and even our counter-rocket artillery and mortar, our C–RAM systems that we have to get after those particular artillery pieces.

Senator KING. The question that I have gotten from a variety of people is why have we not provided the Ukrainians with Iron Dome or something like Iron Dome?

lLieutenant General KARBLER. Sir, the reason that we put a Patriot battery into Slovakia was because the Slovakians provided an S–300 system into Ukraine.

Senator KING. That is a rough equivalent?

lLieutenant General KARBLER. It is a rough equivalent to Patriot. As far as the United States providing Iron Dome into Ukraine, any involvement of any United States air defense forces in Ukraine would have to be a policy discussion.

Senator KING. I understand.

General VanHerck, the Arctic. Give me 30 seconds on the importance of the Arctic in terms of this process. It seems to me that has opened up a whole new level of strategic competition.

General VANHERCK. Senator, that is exactly right. So environmental change in the Arctic is creating opportunities and vulnerabilities—access to resources that did not exist years ago,

longer shipping seasons, economic prosperity. But what we are seeing is those norms and rules and international laws that have served us well since the end of World War II are under challenge, in the Arctic and elsewhere around the globe.

Senator KING. Would it help if we ceded to UNCLOS [United Nations Convention on the Law of the Sea]?

General VANHERCK. Senator, I support the succession to UNCLOS as soon as we can if we can make that happen.

Senator KING. Thank you. Thank you very much, General. Senator Fischer.

Senator FISCHER. Thank you, Mr. Chairman. Admiral Hill, I understand the Missile Defense Agency plans to deploy two satellites equipped with Hypersonic Ballistic Tracking Space Sensor. What is the Department's plan for this capability beyond these two prototypes?

Vice Admiral HILL. Senator, thank you. Great question. Just to kind of go back, what Hypersonic Ballistic Tracking Space Sensor does, it is really two functions. The B stands for ballistic targets, and that handles some of the changes that we are seeing in the ballistic flights today, and kind of think of changes in propulsion, which challenge our sensors today. So we are going to meet that challenge with HBTSS.

But what it really does is it gives us fire control quality data on hyperglide vehicles, and when I say fire control I am not talking about putting out fires. What I am talking about is very discrete positional and velocity differences so that we can get a very firm track and put a weapon on it. The weapons are very sensitive to having a very firm track, and we get that fire control data from HBTSS.

Now to your larger question of how does it fit into the broader architecture, we are very close with the Space Force. They are working that architecture. It is not complete yet. What we will do in 2023, by having those first two in air—they are built by two different companies. They will be interoperable. They are interoperable on the ground today—we will track different flight tests that we do, and we will prove that we have that data so we have the confidence to then proliferate.

We will work that closely with the Space Force over the next year to determine where they go, and there is flexibility in the sensor. It does not have to be limited to a LEO [low earth orbit] constellation. We can go with MEO [medium earth orbit], and so there is lots of flexibility, low-earth and medium-earth orbit. So we are working that with the Space Force and we will be part of that broader architecture. Thank you, ma'am.

Senator FISCHER. I know that there are other programs under development that are related to the missile warning and tracking, but are any of these other capabilities comparable in terms of being able to provide that fire control quality data that you need?

Vice Admiral HILL. Ma'am, it really is unique to HBTSS for the hyperglides. Space capability is so important, not just because we are going to catch the global maneuver, but we use it for indications of warning. It is what kicks off an engagement today. General Karbler talked a little bit about that. When we see the flash then it will go through the face of a radar, and that is how we get a

track, if we can see the track on the ground. For hypersonics, since they are very hard to see, they will normally maneuver outside the field of view of a ground-based radar or a sea-based radar, so you would need that sort of constellation in place to get to the fire control data.

Now when I look at the capabilities that are in the architecture today they are very complementary. The wide field of view, we kind of think of that as surveillance, so when we say "track" with a wide field of view that is going to contain those tracks, and then they cue the HBTSS to go and get that very fine precision track that we need to place a weapon on target.

Senator FISCHER. How long do you think you are going to be collecting all this data on these prototypes before we are ever going to see any kind of plan for what the future is going to be, for what we are going to need in the future?

Vice Admiral HILL. Yes, ma'am. If we get this right in terms of defining the architecture, and based on the data we have, we can make decisions as early as possible.

Senator FISCHER. What does that mean, as early as possible? You know, I get really nervous when I hear dates like 2028 for something, and we are pleased that it is 2027.

Senator KING. Eisenhower retook Europe in 11 months.

[Laughter.]

Senator FISCHER. Shush. How are we going to——

Vice Admiral HILL. Do not think of it as——

Senator FISCHER.—condense the time period, and maybe have to accept more risk?

Vice Admiral HILL. Perhaps, but I think right now we are not starting from zero. You know, in the storytelling of putting two up in March of 2023, there is work that is being done now in that architecture. So decisions can be made early for that proliferation and planning for that, and making sure that we have the industry lined up to execute.

Senator FISCHER. At the hearing last year I asked about the status of implementing Section 1684 of the fiscal year 2017 NDAA, which requires the Department to designate a single entity as the lead acquisition organization for defending the homeland from cruise missiles. General VanHerck and Admiral Hill, you both made clear at the time your support for making this designation.

Dr. Plumb, welcome back again. When can we expect the Department to finally resolve this?

Mr. PLUMB. Thank you, Senator Fischer. As you are probably aware, both the Secretary and the Deputy Secretary have committed to moving this forward. I am hesitant to give you a specific date but I think it is in the near future, and the Joint Staff is working on that, is my understanding.

Senator FISCHER. I would just like to note another thing I am worried about is lack of action. So it would be nice to see things move forward at a quicker pace.

Mr. PLUMB. I am pushing on it.

Senator FISCHER. Thank you. General VanHerck, in your funded priorities list it includes $50 million for cruise missile defense demonstration involving an elevated sensor. Can you describe that

project and how it would contribute to pacing the growing cruise missile threat to the homeland?

General VANHERCK. Senator, that is an opportunity to basically go all the way from the domain awareness sensor through a joint tactical fire control system—Admiral Hill talked about that earlier—to the actual execution and demonstration from a sea-based missile system to engage a cruise missile. It would help us reduce risk and move forward in the near term if we got that $50 million to demonstrate three separate engagements of capability.

Senator FISCHER. Thank you. Thank you, Mr. Chairman.

Senator KING. Senator Tuberville.

Senator TUBERVILLE. Thank you very much. Thanks for being here.

I want to follow up a little bit on what Senator King was saying earlier. General Karbler, in my former job of coaching I used to watch teams on the field, on film. Sometimes you think a lot more of them, sometimes you think less, and then all of a sudden you get them in a real game and you found out what they were.

Russia's missiles in the last 90 days, we have seen them in action. Can you give a coach's perspective and evaluation of what they have done, how they have done it? Has it been good, bad, indifferent?

lLieutenant General KARBLER. Sir, I will give you a coach's perspective.

Senator TUBERVILLE. Okay.

lLieutenant General KARBLER. The offensive line is not coordinated with the quarterback, who is not handing the ball off to the running back, and the wide receivers are jumping offsides.

What do I mean by that? We have seen him employ his missile systems and artillery disconnected from any kind of ground maneuver. Anybody that understands combined armed maneuvers knows that you need to employ both in concert with each other to accomplish whatever your campaign objectives are, and we see him not doing that, which is whether it is the missile efficacy, whether it is the incompetence of the ground forces inability to move, logistics challenges, et cetera.

From a coach's perspective, none. None of the players on the offensive have come together and moved the ball down the field.

Senator TUBERVILLE. There are missiles that they have launched, what percentage of them have worked? Do we have any idea?

General VANHERCK. I can talk about that.

Senator TUBERVILLE. Go ahead.

General VANHERCK. Probably should not talk about it in an unclassified session, but I will tell you originally we thought they were not working at a rate that was as good as ours, but what I would say is they are on par with our capabilities. Not all of them, specifically their cruise missiles. They have had challenges with some of their hypersonic missiles as far as accuracy. But I would not take away, from a strategic perspective, that Russia's cruise missiles or hypersonic missiles, their strategic capabilities have severely underperformed, okay? I just want to make that clear.

Senator TUBERVILLE. They make their own?

General VANHERCK. My understanding is the internally, not the military makes them but they have companies, contractors within Russia that make them as well. You may know more, Jon.

Vice Admiral HILL. Yes, sir. I think that explains it pretty well.

Senator TUBERVILLE. Thank you. General VanHerck, you talked about the homeland. We have got a lot of work to do defending the homeland with hypersonics in China and ballistic missiles. My understanding is that we have a majority of our F–22s and 35s in Alaska. Do we have a defense system up there that will protect them?

General VANHERCK. Senator, it depends on what we are protecting them from. I am confident in the ground-based interceptors that are there. From ballistic missiles, yes, we do have that capability. With regards to cruise missiles, hypersonic cruise missiles that are actually currently coastal defense cruise missiles in Russia, I have significant concerns about my ability to defend those assets. Not only F–22s, Senator. You have significant portions of our ballistic missile and our threat warning capabilities in Alaska. Cobra Dane is out there at Eareckson Air Station. We have the radar and we are building our long-range discriminating radar as well. I was just there, by the way. Very impressive.

Senator TUBERVILLE. Thank you. This is to anybody. You know, fixed interceptor sites, we are talking about trucking missiles in Guam, 42 trucks carrying missiles around. You know, that does not seem logical to me. The MDA is the lead architect and it looks like that we are going to have to find somebody to man and train them.

Can anybody talk about that, about Guam and the missile system that we are putting on Guam?

Vice Admiral HILL. Yes, sir. I can give you some insight there. First it was a pretty extensive Department-wide study. We did look at a number of fixed-site options, and then in the end, just given the kind of capability that we need on the island and the flexibility there we did go with mobile across the board, so the sensors will be mobile. The command and control, there is an option to be mobile. We are working that very closely with Admiral Aquilino now. When it comes to the launching systems, those are mobile.

I think the goodness that comes out of that is the investments that we make there, it is not a big engineering leap to get to that, and we have the existing Army mobile launchers. But the launchers that carry SM–3 and SM–6, the work that needs to be done to move those or have them in a mobile launcher is pretty straightforward, and so we think we can accomplish that. It does give the combatant commander options on where he can move those downstream, so we will initially site them in an area and then if we need to move them we will move them.

Senator TUBERVILLE. We once had an Iron Dome in Guam. We do not anymore. Is that correct?

Vice Admiral HILL. I will turn that over to General Karbler.

lLieutenant General KARBLER. Sir, we exercised Iron Dome. We have two Iron Dome batteries. We sent one out to Guam to exercise, to make sure it was deployable and that the soldiers could operate it. But Iron Dome is not our ultimate solution for cruise missile defense.

Senator TUBERVILLE. Thank you. Thank you, Mr. Chairman.

Senator KING. Senator Rounds.

Senator ROUNDS. Thank you, Mr. Chairman. Gentlemen, thank you all for your service to our country.

Dr. Plumb, it seems like this is the 11th or perhaps the 12th time that you have appeared before either the full committee or a subcommittee over the last few weeks, and it has been mainly concerning nuclear weapons and space. You are also the DOD principal cyber advisor, so I would like to ask you how challenging it is to serve as the OSD [Office of the Secretary of Defense] lead for space policy, nuclear weapons, countering the WMDs [weapons of mass destruction], missile defense, electromagnetic warfare, and cybersecurity, which are six significant roles. Do you have sufficient resources to execute your responsibilities?

Mr. PLUMB. Thanks for that question, Senator. It is a sizeable portfolio. It is pretty fun, frankly. It is a good suite of strategic capabilities, and I think they marry up quite well. Space layers through all of them, cyber through all of them, and they are all what I would consider strategic layers to integrated deterrence.

As far as the resources needed, the office is far more than just me. I have my DASD ships. I have the Office of the Principal Cyber Advisor.

But since you have given the opportunity here I will just say policy, in general, could use more manpower, or I guess I should just say civilians. We need more manpower resources. I think the growth in space, the growth in cyber, those two alone, and when you think that, for instance, the cyber offices are still basically staffed at the level they were 5, 6 years ago, that seems like the wrong answer.

Senator ROUNDS. Can you talk a little bit about the cybersecurity element of the both space and missile defense responsibilities and describe what you and your cybersecurity team bring to the table in this particular area.

Mr. PLUMB. That is a very important question. Cybersecurity of our own forces I think sometimes is confused with just cybersecurity, for instance, of the SIPRNet [Secure Internet Protocol Router Network] or of JWST [James Webb Space Telescope] or even maybe the NIPRNet [Non-Secure Internet Protocol Router Network]. But for the weapons systems themselves, absolutely essential. Making sure we take that into our space systems defense in-depth, is the thing I like to say at these hearings that is really important, not just a perimeter. I have had several discussions with Admiral Hill here on missile defense cybersecurity as well, and all of these things are an ongoing issue that nothing is going to be solve overnight, and it is never going to be fully solved. You have to keep improving and keep looking for what the adversary could possibly do and figure out ways to keep that in check.

Senator ROUNDS. Yes. A number of us on this committee have fought very hard to maintain key area of the DOD spectrum. As the lead for electromagnetic warfare can you tell this committee how important it is to be closely involved in the decision-making process when the Federal Government decides to conduct auctions for key DOD spectrum bands?

Mr. PLUMB. Yes, absolutely essential. Actually, my Ph.D. involved global positioning system, and so that specific issue which

I think you are referencing is absolutely essential for DOD to be able to protect its ability to operate abroad.

Senator ROUNDS. When one agency or department of the Federal Government arbitrarily decides to auction spectrum, it would appear that DOD should be directly involved in the discussions, specifically to those areas of sale. Fair enough to say?

Mr. PLUMB. I agree, sir.

Senator ROUNDS. Thank you. Admiral Hill, the United States has consistently provided missile defense capabilities in conjunction with Israel. It has been a good partnership both ways. Can you explain to this committee the importance of our relationship with Israel, specifically when it comes to missile defense for the United States and our allies and partners?

Vice Admiral HILL. Yes, sir, Senator. Thanks for that question. We have a very strong partnership, documented in an MOU [Memorandum Of Understanding], and you that half a billion dollars of the MDA budget goes to Israel. We work the full set of layered defense with Israel, from Iron Dome up to David's Sling up to the variants of Arrow to include their latest elevated sensor, the work that they do connecting all those and the networking of that. We also work with them on their target systems, and we sit side-by-side and help them engineer through what they need to do to execute a test.

Senator ROUNDS. Is it fair enough to say it is a good partnership with information flowing both ways?

Vice Admiral HILL. It is a strong partnership, and I would say it is beyond what you would normally see because we are side-by-side. There is not just the flow of information and the learning, there is definitely, you know, our people that just walk away from that having a better sense of tiered, layered defense in a really constrained area, with very short reaction times.

Senator ROUNDS. Thank you. I am about out of time but I am going to try to get in one more question, and this is for General Karbler. You mentioned relocating two Patriot batteries to Poland in March. It was a necessary move, in our opinion, and I think you did the right thing. The question I have is how much more flexibility do you have to relocate missile defense capabilities when needed, what flexibilities should you have, and what is the state of the industrial base should we need to surge missile defense capabilities?

lLieutenant General KARBLER. Yes, Senator. The Army Air Missile Defense Forces are the highest operational tempo of any Army forces that we have, so any deployment of them does stress the force. We are constantly looking at our air missile defense posture globally. We have battalions out in INDOPACOM, we have got the battalion in Germany, and then we have got battalions that support CENTCOM.

It does stress the force, and in talking with the Chief of Staff of the Army about this just last week he understands it, and the Secretary of the Army as well. They have committed to a 16 Patriot battalion as well as an 8 THAAD battery and 4 additional maneuver SHORAD battalions, so we are growing the Air Defense Force in recognition of the optempo stress that is put on our soldiers.

Senator, with respect to the industrial base capability, I would really have to defer that to the PEO [program executive office] Missiles and Space, the acquisition side. But I would tell you from my experience if I went back to Desert Storm, when we had very, very few Patriot interceptors to do ballistic missile defense, and the industry ramped up very quickly and was able to get those Patriot interceptors out to the Patriot—I was in Israel—to the Patriot units in Israel as well as the Patriot units that were in Saudi Arabia.

Senator ROUNDS. Thank you. Thank you, Mr. Chairman.

Senator KING. Thank you. We will have a second round of questions for those who have additional questions.

I think it was Admiral Hill, you used the term "fire control data" with regard to hypersonics. I wrote in my notes "fire what?" What are we firing? As you know, we have talked about this, I am gravely concerned about the strategic change in the whole scene of battle that hypersonics represent. I know we are working on it and we are talking about. I want a sense of urgency.

Tell me, Admiral, if you are the commander of an aircraft carrier 800 miles from China and they send a hypersonic missile your way, you have got about 9 minutes to figure out what to do. I want to know how close we are to having a defense. I guess the second question is, is North Korea developing hypersonic capability, because if they are that is where we need to be focusing, not on hitting a bullet with a bullet over the North Pole.

Vice Admiral HILL. Yes, sir, Senator. Thanks for that question. We often talk about hypersonics and assume we are at zero. We are not at zero. I mentioned earlier that we have a command and control battle management capability that takes the space sensors that we have today, the land-based sensors and the sea-based sensors. What is really key about sea-based is that is where the defensive capability resides today.

When a carrier strike group goes forward, to use your example, they have some number of destroyers with them, and on those destroyers today the sea-based terminal capability is on those ships. We did that based on a request from the CNO [Chief of Naval Operations], because he was concerned about the carrier-killer missile. You have heard plenty about that in the white press. It looks ballistic, so we have an ability with SM–3 in the upper tier to take out that threat, and then we have, in the lower tier, sea-based terminal which is really a capability that we insert into the SM–6 missile that the Navy produces. The Navy is producing those in number. MDA is providing the software package and the work in the combat system to control that missile. We have the capability to take on the advanced maneuvering threat in terminal.

I will say terminal is not sufficient. As I mentioned earlier, it is the most difficult place to engage—high maneuver, high speed, and again, you do not know where a terminal is. Generally, in the sea base, it is going to be after the carrier so the destroyers will operate in close quarters and ensure that they provide that protection.

Now because it is not good enough, the investments we are making in the President's budget 2023 is towards the glide-phase interceptor. When you think about having a layered defense against the glide vehicle that then dips down and comes in and does the ma-

neuver, we have the ability to stop that at the glide phase. The most vulnerable place——

Senator KING. We want the ability. You said we have the ability.

Vice Admiral HILL. We have three contractors in play right now to deliver that capability. We are moving towards a demo over the next few years, so we will down-select this year to two and we will continue to move through, and then we will deliver that demo, conduct an exercise with that.

Senator KING. Is North Korea developing hypersonics?

Vice Admiral HILL. They claim to have developed hypersonics. If you go look at the outer mold line you might be fooled and think that it is. But in terms of what we have seen, in terms of data, I am entirely confident that they have that capability today. But the fact that they are testing it ought to be of concern.

Senator KING. Director Honey, you mentioned directed energy in your testimony, I believe. That strikes me as a promising—and I know there are technical problems, but give me an update on where we are in developing directed energy, microwave or laser.

Mr. HONEY. Both classes of directed energy systems, lasers and high-power microwaves, have seen significant developments and achievements over the past several years. What I am most impressed with is the fact that we now have high-energy laser systems, 130-kilowatt class systems, that are being deployed on ships for operational testing, and we have a modular package that will be able to be deployed on Army ground vehicles as well as ships. These will be going into, as I said, operational testing around the world this coming year, and out of that we will be able to gain tremendous insights on lethality data to see how those systems will be useful in the future.

They are mainly aimed at dazzling as well as cruise missile defense, and we also have significant developments in higher-power system and lasers that we think will be very important in the upcoming few years.

Senator KING. Do you have sufficient resources to accelerate this process?

Mr. HONEY. Yes. We have sufficient resources and also the folks leading the efforts have much better insights today than they did in the past. Just through understanding where to smartly take risks they have been able to accelerate development significantly.

Senator KING. Admiral, if you were the commander of that aircraft carrier I would want this guy to be supplying you with some weapons.

Vice Admiral HILL. Thank you, sir. I would want everything that is available, and will take the power that you have now and put it on the ships if we could.

Senator KING. Thank you. Senator Fischer.

Senator FISCHER. Admiral Hill, it is my understand that the Department intends to award a production contract for 20 Next-Generation Interceptor rounds following the critical design review, and these interceptors will be deployed to the unoccupied silos at Fort Greely. But what is the plan to modernize the current fleet of 44 ground-based interceptors?

Vice Admiral HILL. Yes, ma'am. Thanks for the question. I think the best way to answer it is to just kind of clarify that we have

about three classes of the ground-based interceptors that are in service today. You have the oldest part of the fleet, you have got the midgrade fleet, and you have got the newest ones. I know that General VanHerck takes that into account when he is working his shot doctrine.

We are not real concerned about the new ones. They have a long life and their reliability will carry them into the 2030s. Our plan is to reach a decision in production around the 2024 time frame. When you get to the preliminary design review and start thinking about production there are options there because we do have the missile field that is ready to take those first 20. We will likely make a decision to fill those first 20, but the Nation has the option to start replacing some of the older ones. That is why I think it is very important to have the two contractors in play.

That is the other option we have here. You can keep them beyond the CDR and you can have a double production house, depending on where the threat goes, and if you need numbers we can build the numbers by having two contractors carry through critical design review.

Senator FISCHER. You said you are likely to have a decision made soon. When would you expect that?

Vice Admiral HILL. Yes, ma'am. I could not remember where the actual place on the chart was but it is in 2024 where we will make a production decision. Part of that discussion would be are you going to fill the missile fields or are you going to replace what you have or are you just going to keep building so that you can fully replace the existing inventory. Those are decisions that we have to make within the Department.

Senator FISCHER. Are you comfortable with that?

Vice Admiral HILL. I am comfortable that we have two contractors in play and that those options will be there to build out, fill that missile field, and then replace if we make a decision to do so.

Senator FISCHER. Is this something that you are discussing with NGI teams?

Vice Admiral HILL. Yes, ma'am, absolutely, and I mentioned a little bit earlier, actually General VanHerck mentioned the 2028 time frame for the contractors, and we are moving ahead of that schedule right now. We are going to learn a lot more as we come through development. We will come through ground testing. We will do individual component-level tests, and we will work our way to flight tests. This is a fly-it-before-you-buy-it program, so we are going to do an intercept and salvo test before we go to full production.

Senator FISCHER. General VanHerck, given what you have seen of the threat that is out there do you believe that 20 interceptors are going to be sufficient, or do you need some sort of capability to replace the 44 GBIs that are deployed currently?

General VANHERCK. Senator my assessment is when you factor in service life extension, which will give us significant reliability and data and information that will help me with my shot doctrine, and give me additional capacity, when you factor in the Next-Generation Interceptor and its capabilities, along with long-range discriminating radar, all of that, I will be comfortable when it is delivered in the 2027 to 2028 time frame.

It is a policy question going forward. Do we need to continue to develop and field additional capability and capacity as the threat develops additional capability and capacity? I remain concerned about my ability to stay up with that capacity especially.

Senator FISCHER. Thank you. Admiral Hill, the general just, I think, made an argument there against some of what we hear sometimes that we do not need to replace systems, that we just need to continue to do life extension programs. I know that seems to be the current plan, likely to be the plan for the future. But how long do you think that can continue? Do you have the same concerns that the general expressed?

Vice Admiral HILL. I do. We read the same intelligence estimates, and they are always, you know, low confidence, medium confidence. But you can kind of get a sense, based on their testing and how they have progressed over the years.

I would say there is a big difference between the GBIs that we have in service today versus what Next-Generation Interceptor brings. In this unclassified environment I will tell you that a unitary missile, think of that as a singular kill vehicle, versus a Next-Generation Interceptor with multiple kill vehicles on it, that is a huge lift in terms of how we take on the threat, because the threat will continue to evolve to have maneuvering warheads and multiple maneuvering warheads.

We need to the Next-Generation Interceptor. We can SLEP all day long those unitary missiles, and we can drive their lifetime to the right pretty far. But at the end of the day, you really need the upgrade that Next-Generation Interceptor brings because it is going to operate in a really tough space, but it does have multiple kill vehicles, which gives us a lot more flexibility.

Senator FISCHER. We have to have the resources that meet the threats that are coming too, that we get from intelligence. Correct?

Vice Admiral HILL. Yes, ma'am.

Senator FISCHER. Thank you.

Senator KING. Senator Tuberville, are you all set?

Senator TUBERVILLE. I have one question. Thank you. Secretary Honey, you talked about high-energy lasers. I have had the unfortunate—I have watched one work on the ground, from an MRAP [mine resistant ambush protected] low-energy. It was not really high-energy but it works pretty good.

Eventually, you know, you said putting them on ships and possibly in satellites. How in the world are we going to find the energy for a high-energy laser, you know, to really function the way we really want it? Are we on the R&D [research and development]—how is the R&D on that, as we speak?

Mr. HONEY. The R&D has come a long way, and that is a very good question about these particular systems because of the history behind them. Where we have seen the biggest improvements has been in the conversion efficiency of energy to actual useful output from the lasers as well as improvements in the beam control so that we do not have to have such a massive blast in order to have the weapons effects that we want.

There has been just a tremendous amount of work that has been done by the Department in these areas, but we are now seeing the payoff of those results today.

Senator TUBERVILLE. Do you see nuclear being used, energy?

Mr. HONEY. I am sorry?

Senator TUBERVILLE. Nuclear, to power higher energy, possibly?

Mr. HONEY. No, I do not see that right now as necessary. There could be, you know, always the possibility.

Senator TUBERVILLE. I am talking about for the future. You know, we are talking about Star Trek and all of that, you know, satellites that have these long beams.

Mr. HONEY. Right now, at least for the systems that we are looking at, the conventional power sources that we have look to be sufficient.

Senator TUBERVILLE. Thank you. Thank you, Mr. Chairman.

Senator KING. Senator Rounds.

Senator ROUNDS. Thank you, Mr. Chairman. I am going to follow up on Senator Tuberville's line of questioning, because it seems to me that where we are talking here about what a lot of people that would watch this would say they are talking about something really close to Star Wars or Star Trek in terms of basically shooting one missile with another missile, hitting one missile that is capable of 5,000-plus miles an hour with another missile or an interceptor that can do the same thing, or using a weapon of directed energy, like a phaser or a laser in the future.

We are talking about that right now being deployed in some specific areas today, and yet, at the same time, I think back. I just received a note that General VanHerck, your team has actually been looking at cold weather and the fact that you have got teams that have to survive in cold weather, and we have got Arctic issues and so forth. We need the basic research. I know South Dakota School of Mines and Technology has been doing work on cold weather operations and so forth. I look at that and we have got a part of the world right now that is going to become very active in terms of protecting our country, and that is the Arctic.

I am just curious, General VanHerck. What do you see in terms of the challenges of operating in the Arctic, and what are the things that we are not thinking about right now that we have just assumed we have been doing all along, and yet we have got equipment, we have got material, manpower, and so forth? What do we have to expect that we should be doing right now to make sure that within the Arctic we have done our due diligence and we have not taken anything for granted in terms of being able to operate?

General VANHERCK. That is a great question, Senator. We just completed an exercise in the Arctic, Arctic Edge, where we brought joint, and even combined with other countries to the Arctic to operate. I will tell you, there are significant lessons learned about the harsh environment where our equipment—I will not go into details but let us just say some strategic equipment that we place into the Arctic does not function because we have not equipped it to operate, and over the last 20 years we have been focused on a different environment as we developed equipment.

Research and development is crucial to continuing to ensure we buy down risk to potential future operations in the Arctic. It does not just go to weapon system as well. It goes to human performance factors—medical capabilities, medical equipment, as you sustain yourself in a harsh environment like that long term. We have

to look at the equipment we wear and the capabilities that we are going to utilize to sustain life in that environment.

What we find is that you can operate in that environment less than about 50 percent of what you would in another environment. I appreciate what your School of Mines is doing, advancing a lot of the research and capabilities to look at that. That is something I am asking for in our Defense Planning Guidance is to at least move the ball down the field and continue that research and development for ensuring the capabilities are there but also capabilities that support the human life as we sustain in the Arctic environment.

Senator ROUNDS. Thank you, sir. Thank you, Mr. Chairman.

Senator KING. To follow up on your question, Senator Rounds, I recently learned that two-thirds of the ice in the Arctic Ocean has disappeared in the last 40 years. A stunning fact.

I want to ask one more question.

Senator ROUNDS. If I may say, if I could, and yet at the same time you have a problem in that unless you have got the right kind of oil you are not going to operate very well in the Arctic conditions anyway because your machinery does not work.

Senator KING. Because it freezes.

Senator ROUNDS. Just because it freezes.

Senator KING. I would say Maine and South Dakota rather than Alabama might be able to work on that.

[Laughter.]

Senator ROUNDS. That has a lot to do with it, Mr. Chairman.

Senator KING. A question from Senator Hirono. General VanHerck, for fiscal year 2023 the Administration has not funded the development of the long-range radar in Hawaii to detect incoming threats from North Korea or China. Do our current radar and ground-based interceptors provide adequate protection of Hawaii?

General VANHERCK. Senator, I am comfortable with my capability to defend Hawaii against ballistic missiles from a rogue actor such as North Korea today. As capabilities continue to develop, as capacity increases by potential rogue actors, then I may be potentially challenged to defend Hawaii. What we are really talking about is a Hawaii radar would contribute to an underlayer significant that would give additional capability and capacity. That is a policy decision that we go down there, but today I am comfortable where we are.

Senator KING. Thank you. Thank you all very much for your responses today, for your testimony, and for your service. It has been a very illuminating hearing. I appreciate you joining us.

The hearing is adjourned.

[Whereupon, at 5:38 p.m., the Subcommittee adjourned.]

[Questions for the record with answers supplied follow:]

QUESTIONS SUBMITTED BY SENATOR ELIZABETH A. WARREN

GROUND-BASED MIDCOURSE DEFENSE SYSTEM

1. Senator WARREN. Vice Admiral Hill, and Deputy Under Secretary Honey, I am very concerned that twenty years into the program the GMD system's tests still have not been realistic by the standards of the Pentagon's own testing agency, especially with regard to the use of countermeasures the adversary might employ to defeat the defense. JASON was commissioned to look at this issue in 2012 and rec-

ommended a "red team" responsible for producing countermeasures and challenging the system, rather than the MDA itself. Has this not been taken up? If not, why not?

Vice Admiral HILL. The 2010 JASON Missile Defense Agency (MDA) Discrimination report recommended the creation of a countermeasure test program through an independent agency, with the purpose of challenging the countermeasures efforts of the MDA.

The Department of Defense (DOD) has not created a countermeasures test program through an independent agency. However, MDA has embraced the spirit of the JASON recommendation by increasing emphasis on developing threat countermeasures challenges and developing Missile Defense System (MDS) countermeasures mitigation capabilities.

Existing independent DOD organizations are involved in MDS test planning to ensure MDA is appropriately challenged regarding countermeasures testing. By adhering to DOD standards with the use of independent Operational Test Authorities, and oversight from the Director, Developmental Test and Evaluation and the Director, Operational Test and Evaluation (DOT&E), MDA ensures the credibility of all flight tests, including intercept tests with countermeasures.

With support from Intelligence Community, Federally Funded Research and Development Centers, and University Affiliated Research Centers, MDA has identified and characterized a broad portfolio of countermeasures challenges. These relationships with external entities have allowed MDA to address additional countermeasures challenges.

Altogether, these efforts have allowed MDA to address the spirit of the JASON report recommendation while executing a phased implementation plan to field incremental countermeasures mitigation improvements.

Deputy Under Secretary Honey did not respond in time for printing. When received, answer will be retained in Committee files.

2. Senator WARREN. Vice Admiral Hill, MDA has not yet completed an independent technology assessment of the three Glide Phase Interceptor (GPI) systems to determine their technological maturity. Yet MDA continues to place GPI on its Unfunded Priorities List. MDA requested $225 million for hypersonic defense (which includes GPI) in its fiscal year 2023 base budget and requested an additional $293 million for hypersonic defense in its fiscal year 2023 Unfunded Priorities List. Congress has plussed up the hypersonic defense account in every year since fiscal year 2019. Why does MDA continue to place GPI on the Unfunded Priority List, and why have previous plus ups failed to provide MDA with the resources it purports to need to advance GPI?

Vice Admiral HILL. The Department and MDA appreciate the congressional Plus Ups provided since Fiscal Year (FY) 2019 that support multiple activities to counter hypersonic threats to include Glide Phase Interceptor (GPI) initial requirements development and engineering studies, other technology maturation, engineering enablers, upgrading existing systems and collecting data on offensive hypersonic flight tests. The President's Budget 2023 request for GPI represented the Department's prioritization of available budget with program technical and programmatic risk for development of key GPI Critical Technology Elements (CTEs). The MDA Fiscal Year 202023 Unfunded Priorities List GPI item provides funding to reduce program technical and schedule risk for additional GPI CTEs. MDA recently completed technology assessment of the three Industry GPI candidate concepts to determine technological maturity and has continued the development effort for two of these missile concepts to move to a System Requirements Review in fourth quarter Fiscal Year 202022 and progress further toward a capability demonstration in the early 2030's.

3. Senator WARREN. Deputy Undersecretary Honey, the GMD program has cost more than $40 billion already. An enormous amount of money was spent on the EKV program, which has produced a system with a very poor record; the RKV program wasted $1.2 billion trying to fix the kill vehicle. What specific steps are being taken to make sure that the Next Generation Interceptor does not follow the same problematic development processes that the GBI and RKV followed?

Mr. HONEY. The Missile Defense Agency (MDA) has incorporated a number of lessons learned into the acquisition and development program for Next Generation Interceptor. These include:

- Development of Next Generation Interceptor as an All-Up-Round (AUR) with the Government requirements at the AUR level.

- Requirements traced to United States Northern Command (USNORTHCOM) Operational needs and validated through the Joint Requirements Oversight Committee (JROC).
- Requirements include threshold and objective values (coordinated through USNORTHCOM and JROC) to provide industry design flexibility.
- Establishment of a contractor proposed and MDA accepted Development Evaluation Framework identifying the design-specific Critical Technology Elements including Technology Readiness Level maturation plans through Preliminary Design Review (PDR), Critical Design Review (CDR), Qualification Testing and Flight Testing.
- Defined Knowledge Points to incentivize risk reduction earlier in the program.
- Competition with two contractors through CDR.
- Fly before you buy requiring two successful intercept tests prior to initial production decision.
- Contract options (after CDR) enabling performance-informed decisions to authorize contractor team to proceed into the next development/production phase.
- Office of the Secretary of Defense Cost Assessment and Program Execution conduct an independent cost estimate of the Next Generation Interceptor program which established the funding requested in the annual President's Budget.
- Office of the Under Secretary of Defense (Research & Engineering) will execute an Independent Technical Risk Assessment supporting each major milestone (Contract Award, System Requirements Review, PDR, CDR, etc.).

4. Senator WARREN. General Van Herck, Vice Admiral Jon Hill, Russia is apparently deploying entire new nuclear-armed weapon systems specifically because they can defeat missile defenses, and China is also developing systems to evade or overwhelm missile defenses. Are there circumstances you could envision under which you would decide it is no longer in the U.S. interest to deploy the U.S. Ground-Based Midcourse Defense system? What factors would you consider?

General VAN HERCK. Thanks for the follow up question. I too am concerned about trends from both Russia and China to hold the Homeland at risk across multiple domains. In the context of your question, the current Ground-Based Midcourse Defense (GMD) system is not designed nor is it employed to defeat strategic missile threats from China and Russia. The nuclear deterrent is the primary means to address this threat. As directed by policy, today I remain confident in my ability to defend the Homeland from a rogue actor such as North Korea. I remain concerned about my ability, specifically regarding future capacity and capability, to provide ballistic missile defense as the threats continue to adapt and evolve. This is why it is crucial to field the Next Generation Interceptor on time or early and continue with ongoing service life extension programs. I defer to OSD regarding policy to address future threats.

Vice Admiral HILL. The Ground Based Midcourse Defense system (GMD) is the foundation of United States Homeland defense against long-range ballistic missiles from rogue states like North Korea and Iran. As North Korean ballistic missile threats to the United States Homeland continue to evolve, the United States is committed to continuing to improve the GMD system, including the development of the Next Generation Interceptor (NGI), to augment and potentially replace the current Ground Based Interceptors (GBI).

The presence of GMD also serves as an important deterrent to other nations considering the development of long range ballistic missiles, as it greatly increases the cost and decreases the likelihood of credibly threatening the U.S. Homeland.

Though the United States maintains the right to defend itself from attacks from any source, GMD is neither intended for, nor capable of, defeating the large number of sophisticated Intercontinental Ballistic Missile, air and sea launched ballistic missile threats from Russia and the People's Republic of China.

Defer to Commander Northern Command and the Under Secretary of Defense for Policy (OSD-Policy) for further response.

COST ESTIMATES

5. Senator WARREN. Vice Admiral Hill, GAO's most recent report shows billions of dollars in unaccounted costs, with estimates missing about half of the total costs of actually operating these systems, and 63% of flight test costs. Despite it being DOD policy, we also lack independent cost assessments for these programs. This hurts planning and makes it more likely we will have to cancel other costly programs down the line. The Missile Defense Agency agreed with the GAO that they need to have these cost estimates. When does MDA expect to have independent cost

estimates for its major programs, and which programs will MDA have independent cost estimates for?

Vice Admiral HILL. Since President's Budget (PB) 2019, MDA has reported the complete Integrated Master Test Plan (IMTP) budget in the annual test reports to Congress. This IMTP submitted with each PB, is signed by the:

- MDA Director;
- Director, Operational Test and Evaluation;
- Deputy Director, Developmental Test, Evaluation, and Assessment;
- Commanding General, Joint Functional Component Command for Integrated Missile Defense (representing the combatant commands);
- Commanding General, U.S. Army Test and Evaluation Command;
- Commander, Air Force Operational Test and Evaluation Center;
- Commander, Operational Test and Evaluation Force; and
- Commander, Joint Interoperability Test Command.

The associated supplemental budget reports include the total cost, schedule and budget information for flight, ground, and cyber testing and test infrastructure. Since 2017, MDA has also provided the Agency's cost for executed flight tests in a semiannual report and will continue this detailed reporting in September 2022.

DOD Policy requires Independent Cost Estimates (ICEs) for all Major Defense Acquisition Programs. The Office of Secretary of Defense, Cost Assessment and Program Evaluation (CAPE) and MDA follow this policy and work together to complete required ICEs. The MDA programs which have an ICE include Next Generation Interceptor (NGI), Standard Missile–3 (SM–3) Block IIA, SM–3 Block IB, Terminal High Altitude Area Defense (THAAD), and Aegis Ashore Poland. MDA annually requests CAPE to perform ICEs for upcoming major milestone events. For Fiscal Year 202023, MDA is requesting OSD CAPE to conduct ICEs or updates for: Aegis SM–3 Block IIA, NGI, Command, Control, Battle Management and Communications, and THAAD. MDA is also requesting CAPE to review the Joint Cost Estimates (JCEs) for Army Navy Transportable Radar Surveillance (AN/TPY)–2, THAAD and Long Range Discriminating Radar.

DOD Policy also requires MDA to report in the annual Missile Defense Acquisition Report (MDAR) all operations and support (O&S) costs for which MDA is responsible, and a description of the O&S functions and costs for which a military department is responsible. However, MDA reported to GAO that we are actively working to obtain Services O&S cost estimates, and began reporting available JCEs in the PB 2023 MDAR submission to Congress. As we receive additional Service cost estimate information, we will report these costs in future MDAR submissions.

MISSILE DEFENSE AGENCY TESTING

6. Senator WARREN. Vice Admiral Hill, according to the GAO, MDA has continually been unable to satisfy its annual test plan. The Committee understands that an independent assessment has been completed on the agency's process for developing and executing the annual test plan and is awaiting Departmental comment. Are there actionable steps provided in this assessment that will help MDA achieve their test plan thereby collecting more information on the system's capabilities?

Vice Admiral HILL. The Institute for Defense Analyses (IDA) conducted an independent assessment of MDA's flight test planning and execution processes which was completed in February 2022. IDA provided the final assessment to MDA in March 2022. The Agency is in the process of implementing recommendations from the study. Areas for MDA process improvements include:

- Develop a taxonomy to monitor causes of flight test accelerations, deletions, and delays
- Develop a single-source traceable end-to-end mapping of assessment objectives to tests that address them and fulfill the Phased Implementation Plan requirements
- Develop and maintain an overall data collection strategy
- Coordinate with the Missile Defense System (MDS) Operational Test Agency (OTA) Team to better align the Operational Test Readiness Reviews and MDA Flight Test Concept of Operations (CONOPS) for earlier engagement in detailed flight test planning

MDA is conducting technical interchange meetings with all stakeholders to increase awareness and set the conditions for implementing these process improvements. Implementation is planned to be synchronized with development of the Integrated Master Test Plan (IMTP) version (v) 25.0.

7. Senator WARREN. Vice Admiral Hill—For the past four years, GAO has reported on MDA's inability to complete planned annual system-level cybersecurity

tests since 2017. Considering this cyber testing deficit, what steps is MDA currently taking to ensure that cybersecurity testing deficiencies from prior years are addressed, to conduct operational system-level cybersecurity testing on all deployed systems, and to address DOT&E identified cybersecurity limitations, vulnerabilities, and recommendations?

Vice Admiral HILL. MDA completed operational cyber testing in July 2019, including Cooperative Vulnerability and Penetration Assessments (CVPA) and Adversarial Assessments (AA), on currently fielded MDA/MDS systems. MDA has not fielded a new increment since then. Due to impacts driven by the COVID–19 pandemic, MDA re-planned Increment 6B.1 testing for the United States Northern Command and United States Indo-Pacific Command. The Agency is following the IMTP and the MDA Cyber Test CONOPS by executing CVPA and AA testing on all MDA elements in the Increment 6B.1 architecture. MDA follows the IMTP and conducts operational cyber testing on all MDA systems prior to fielding.

MDA maintains a comprehensive cyber test and assessment program by leading and supporting cyber initiatives across multiple DOD offices. MDA leads and/or supports numerous cyber test and assessment initiatives covering the cradle to grave cyber lifecycle starting with product development and ending with operations and maintenance with a constant feedback loop for continuous improvement. These efforts cover partnership and oversight from numerous offices under the DOD umbrella. The following are examples:

- Pre Fielding
  - o Developmental cyber testing prior to full release to the Government
    - ♦ Includes Cooperative Vulnerability Identification and Adversarial Cyber Development Test and Evaluation testing
      - Authority and oversight—Office of Developmental Test, Evaluation, and Assessments—DOD Cybersecurity Test and Evaluation Guidebook
  - o Rigorous cyber compliance implementation and testing under Risk Management Framework
    - ♦ Authority and oversight—National Institute of Standards and Technology Special Publication 800–37, 800–53, 800–30, and 800–137
  - o Operational Cyber Testing
    - ♦ Includes CVPA and AA testing conducted prior to fielding to the Warfighter
      - Authority and oversight—DOT&E Title 10 Authorities
  - o MDA Cybersecurity Assessments
    - ♦ Vulnerability Assessments—assessment of Research, Development, Test, and Evaluation enclaves supports risk-based authorization to connect decisions and supply chain risk decision
      - Authority and oversight—MDA Director and Authorizing Official
- Post Fielding
  - o Cyber Protection Teams in the Combatant Commands
    - ♦ Authority and oversight—Joint Force Headquarters Commanders-DOD Information Network (DODIN)
    - ♦ Combatant Commands requests for support
  - o DOD's Mission Assurance Construct
    - ♦ Physical and electronic cyber testing and assessment of fielded systems
  - o Strategic system assessments coordinated through Joint Staff Direction
    - ♦ Authority and oversight—Defense Threat Reduction Agency under DOD Instruction 3020.45
  - o Command Cyber Operational Readiness Inspection
    - ♦ Authority and oversight—DODIN Readiness and Security Inspections under Defense Information Systems Agency
  - o United States Cyber Command (USCYBERCOM) Operations
    - ♦ OPLAN 8600—Directing DODIN Operations and Defensive Cyberspace Operations—Internal Defensive Measures
    - ♦ Commanders Estimate and Mission Relevant Terrain Cyber
    - ♦ Annex N (Operational Risk Assessments)
    - ♦ Cyber Task Orders
      - Authority and oversight—USCYBERCOM and Joint Staff
  - o Strategic Cybersecurity Program
    - ♦ Assessments of Strategic Weapons Systems
    - ♦ Includes Missile Defense System
      - Authority and oversight—Joint Staff Joint Staff Joint Requirements Oversight Council Memorandum, directing the National Security Agency to conduct assessments
  - o MDA Cybersecurity Assessments

- ♦ Cybersecurity Vulnerability Tests—supports risk-based authorization decisions
- ♦ Tier II Cybersecurity Service Provider monitoring (24x7x365)
- ♦ Authority and oversight—MDA Director and Authorizing Official

o Persistent Cyber Assessments

- ♦ Completed a DOT&E funded Persistent Cyber Assessment of the unclassified MDA Enterprise unclassified network boundary—2,332 hours of effort spent evaluating the boundary with no significant cyber vulnerabilities identified
- ♦ Currently conducting an MDA funded Persistent Cyber Assessment of the classified MDA Enterprise boundary
- ♦ Currently conducting an MDA funded Persistent Cyber Assessment of the MDA Enterprise boundaries with the Threat Systems Management Office and DOT&E participation
- ♦ MDA is organized to support Persistent Cyber Assessments of fielded systems based on Combatant Command requests and risk acceptance

MDA works closely with DOT&E and the MDA OTA Team in support of cyber testing through the IMTP, ongoing leadership dialog, and processes. DOT&E is included throughout cyber testing, from development of test requirements through test execution. Cyber test findings and observation reports are presented to the Failure Review, Analysis, and Corrective Action System (FRACAS) for consideration as a Boarded Discrepancy Report (BDR) in order to track remediation for future increment builds. BDRs are taken into account during the generation of the Cyber Test Objective Memorandum (CTOM) and are criteria used during test planning. In addition, The MDS OTA Team is part of the tri-chair on the MDS Data Analysis working group where cyber concerns are addressed and responded to by MDA. MDS OTA generates issue sheets which are addressed thru the MDS Data Analysis Working Group. DOT&E and the MDS OTA Team are stakeholders across the operational cyber test phases for operational cyber test planning and execution to include CTOM, Integrated Cyber Test Team planning, and execution. Test observations also can lead to Technical Cyber risks that are assessed and presented to the MDA Risk Working Group. Many findings and correlating recommendations that are observed from the CVPA are fixed prior to the AA if feasible by the program. Verification of Fixes (VoF) is a standard test process that occurs out of test execution and test planning. VoF ensures fixes implemented from previous findings have been remediated before advancing to next phases of operational testing.

QUESTIONS SUBMITTED BY SENATOR JACKY S. ROSEN

IRANIAN MISSILE THREATS

8. Senator ROSEN. Admiral Hill, Iranian-aligned militia groups are increasingly targeting United States installations and service members in Iraq and Syria via rocket and drone attacks. Iran continues to be the world's leading state sponsor of terrorism and a threat to United States and allied interests via its ballistic missile program and support for terrorist proxies like Hezbollah, Hamas, KH, AAH, and many others. Can you update us on Iran's progress toward developing an ICBM? When do you assess Iran will be capable of fielding an ICBM, and what threat would that pose to the United States Homeland?

Vice Admiral HILL. Recommend the Committee contact Defense Intelligence Agency for authoritative intelligence.

9. Senator ROSEN. Admiral Hill, can you describe the missile threats that Iranian-aligned militia groups in the Middle East pose to United States troops and our allies?

Vice Admiral HILL. Recommend the Committee contact Defense Intelligence Agency for authoritative intelligence.

10. Senator ROSEN. Admiral Hill, do we have the assets in the Middle East, specifically outside the Green Zone in Baghdad, to protect United States and Coalition Forces in Iraq and Syria from rocket and drone attacks emanating from Iranian-aligned militia groups?

Vice Admiral HILL. I defer to my colleagues from Central Command (CENTCOM) to respond to this question on tactical counter-Unmanned Aircraft Systems threats facing our personnel and critical assets in the Middle East.

11. Senator ROSEN. Admiral Hill, CENTCOM Commander General Michael Kurilla has called Israel's incorporation into CENTCOM, "the area with some of the greatest opportunity: working toward an integrated air and missile defense." He told this Committee, "I think the addition of Israel . . . will help with that. We are collectively stronger together, and there are areas where each one brings unique capabilities." In your assessment, how would an integrated air and missile defense architecture to counter Iranian air and missile threats improve collective security in the Middle East?

Vice Admiral HILL. The United States has a long history of working with Israel and other partners in the Middle East to counter air and missile threats. There may be future opportunities to explore enhanced Integrated Air and Missile Defense cooperation along these lines, but I would defer to OSD-Policy for further inquiries on that issue. In general, the integration of multiple sensors and layered shooters increases the effectiveness of any integrated air and missile defense architecture.