RAND CORPORATION

Research Report

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Is the National Nuclear Enterprise Workforce Postured to Modernize the Triad?

Insights and Options from a Quick-Turn Assessment

Since the end of the Cold War, the health of the national nuclear enterprise workforce has been a matter of abiding concern to senior U.S. officials. The two government agencies with principal responsibility for this workforce—the U.S. Department of Defense (DoD) and the U.S. Department of Energy (DOE)'s National Nuclear Security Administration (NNSA)—have had to contend with adverse demographic trends, recruitment and retention challenges, and intense competition for specific skills and expertise, especially in scientific and engineering fields, to maintain a workforce with the capabilities and experience needed for nuclear-related duties. The challenges affecting this workforce have been highlighted in several reviews undertaken in the wake of widely publi-

KEY FINDINGS

- Many retirement-eligible personnel are expected to exit the nuclear enterprise workforce soon, leaving behind a large number of employees with limited experience.
- There are some initiatives in place to promote the transfer of knowledge from retiring personnel to early and midcareer employees, but those efforts are small in scale.
- The private sector can be a fierce source of competition, at times seeking the same people as DoD and NNSA while offering higher compensation.
- Many training and development activities with DoD and NNSA have been specifically developed for the nuclear enterprise context.
- Poor working conditions threaten morale and retention across the nuclear enterprise. Employee dissatisfaction with facilities and information technology was repeatedly mentioned in interviews and surveys.

Abbreviations

AcqDemo	DoD Civilian Acquisition Workforce Personnel Demonstration Project
ACS	American Community Survey
AFNWC	Air Force Nuclear Weapons Center
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
D&I	diversity and inclusion
FEVS	Federal Employee Viewpoint Survey
FFRDC	federally funded research and development center
FY	fiscal year
FYDP	Future Years Defense Program
GBSD	Ground-Based Strategic Deterrent
HR	human resources
M&O	management and operating
MDAP	major defense acquisition program
MSA	metropolitan statistical area
NASA	National Aeronautics and Space Administration
NNSA	National Nuclear Security Administration
NWC	Nuclear Weapons Council
OPM	U.S. Office of Personnel Management
PR	public relations
RDT&E	research, development, test, and evaluation
SAR	Selected Acquisition Report
SSBN	nuclear ballistic missile submarine
SSP	Strategic Systems Program
STEM	science, technology, engineering, and math
SWOT	strengths, weaknesses, opportunities, and threats
UK	United Kingdom

cized incidents—such as the unauthorized transfer of nuclear assets and a serious breach of security at the nation's principal highly enriched uranium processing facility—in which poor employee performance was judged to be a major contributing factor.[1] Using the recommendations of these reviews, both DoD and NNSA have undertaken significant initiatives to enhance the organization, training, equipping, and funding of the national nuclear enterprise, including its workforce. As a result, the health of the workforce has notably improved over the past decade, with significant gains in hiring, training, development, and morale.

Nevertheless, concerns about the overall health of the national nuclear enterprise workforce remain. One of the most pressing of these concerns is the ability of that workforce to handle the sheer number and scope of activities associated with the nuclear modernization programs being executed in both DoD and NNSA to support all three legs of the nuclear Triad. DoD currently plans to field a new dual-capable bomber, a replacement to the existing nuclear-armed air-launched cruise missile, a new class of nuclear-powered ballistic missile submarines, and a new intercontinental ballistic missile system. For its part, NNSA is engaged in several multibillion-dollar programs to extend the service life of existing nuclear warheads and to replace its Cold War–era infrastructure with up-to-date research, development, and production facilities, including restoring the ability of the United States to manufacture plutonium pits.[2] Successfully carrying out multiple nuclear modernization programs of this magnitude and sustaining existing weapon systems and infrastructure as the new capabilities gradually come online are unique challenges that require a military, federal government civilian, and contractor workforce of sufficient size and with the requisite education, training,

skills, and experience in nuclear operations, weapon system acquisition, program management, and construction of nuclear-related facilities. An issue of particular concern in this regard is the competition among various sectors (both internal and external to federal government) in hiring and retaining individuals with these same attributes.

In light of the continued importance of the national nuclear enterprise workforce in achieving National Defense Strategy objectives, the Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs tasked the RAND Corporation with conducting a quick-turn assessment of the health of the acquisition and scientific, technical, engineering, and math (STEM) personnel within the federal workforce, with an emphasis on the inherent challenges to that workforce of managing the transition from existing nuclear deterrent capabilities to a modernized nuclear force and its associated infrastructure. The primary purpose of this assessment was to familiarize new administration senior officials and the members of the Nuclear Weapons Council (NWC) with the most-critical issues. The secondary goal was to identify a variety of options for promoting workforce health for consideration by leaders and human resources (HR) specialists in the services and NNSA.

The RAND study team carried out its 90-day assessment in early 2021 by pursuing four analytic tasks:

1. A document review was conducted that included congressional testimony; news articles; open-source reports by such organizations as the U.S. Government Accountability Office and the National Academy of Public Administration; and materials provided to RAND researchers by NNSA, the U.S. Air Force, and the U.S. Navy in response to the study team's requests for specific documents and data. The study team also reviewed the progress made on recommendations arising from DoD's 2014 internal and external reviews of the nuclear security enterprise, as reflected in DoD's Nuclear Enterprise Review Tracking Tool.[3]
2. Semistructured interviews were completed with a total of 27 DoD, NNSA, and nongovernment stakeholders. Interviewees included senior leaders, program managers, and HR functional experts.
3. An analysis of workforce supply and demand was performed using (1) U.S. Census Bureau data[4] to understand the available workforce in both the private and public sectors and (2) budget data for major nuclear weapon programs and systems to assess the demand signal both now and in the foreseeable future.
4. A review of open-source literature on comparable workforces, such as the U.S. civil space sector and the United Kingdom (UK)'s defense nuclear enterprise, was carried out to identify promising practices for potential application within the U.S. national nuclear enterprise.

More details about each of these analytic tasks are provided in the appendix. An important limiting factor of the study was its quick-turn nature, which meant, for example, that time was insufficient to obtain the regulatory approvals required to interview large numbers of DoD personnel. Additionally, although NNSA, the U.S. Air Force, and the U.S. Navy were supportive of this study, they were not consistently able to compile and share the information the study team requested (e.g., personnel inventory and authorization levels) in the short time frame available. Finally, the personnel who constitute the nuclear enterprise workforce within DoD are not always clearly defined, which affected the study team's ability to analyze the composition of that workforce (e.g., number of personnel by occupation and breakdown of personnel by years of service).

Although the length and scope of the project were limited, the study team's view of workforce health was not. The team developed a conceptual framework based on the U.S. Office of Personnel Management (OPM)'s human capital model (see Figure 1) to evaluate different aspects of workforce health, including recruitment and hiring, leader development, and morale and retention. In addition, it employed a strengths, weaknesses, opportunities, and threats (SWOT) analysis approach, considering strengths and weaknesses within the nuclear enterprise itself, along with opportunities and threats posed by the external environment. Finally, although the OPM framework was used for demarcating dif-

FIGURE 1

Conceptual Framework for Workforce Health

SOURCE: Authors' adaptation of OPM, "Human Capital Framework Structure: Performance Culture Focus Areas," undated-a; and OPM, "Human Capital Framework Structure: Talent Management Focus Areas," undated-b.

ferent aspects or domains of workforce health, the study team was also mindful of issues that cut across different aspects of workforce health. For example, investment in training and development might also help in attracting new candidates and retaining current personnel.

Another important point regarding the study team's overall approach concerns the elements of the workforce it concentrated on. As Figure 2 depicts, the national nuclear enterprise spans the entire country, with major NNSA, U.S. Air Force, and U.S. Navy facilities situated from coast to coast. The workforce at these locations includes operations and maintenance personnel, security forces, scientists, engineers, technicians, program managers, administrators, and many other occupational specialties.

Given the time constraints under which the study was conducted, and at the request of the study's sponsor, the study team focused its research and analysis efforts almost exclusively on federal (civilian and military) acquisition and STEM personnel but, to the extent feasible, also included federally funded research and development center (FFRDC) staff and other contractors working at DoD and NNSA-owned facilities. It did not examine the health of the workforce doing nuclear-related work in defense industries or at other DOE national laboratories and academic institutions that support NNSA's work. Furthermore, although the study team examined data and conducted interviews with individual DoD and NNSA organizations and programs, its perspective was at the enterprise level. Accordingly, the study team looked for areas of common concern across the enterprise and instances in which one part of the enterprise appeared to be faring well and then offered examples of promising practices for broader use.

Finally, after the preliminary research and analyses phase of the study was completed, the study team identified five challenge areas to guide its assessment and to prepare the final report:

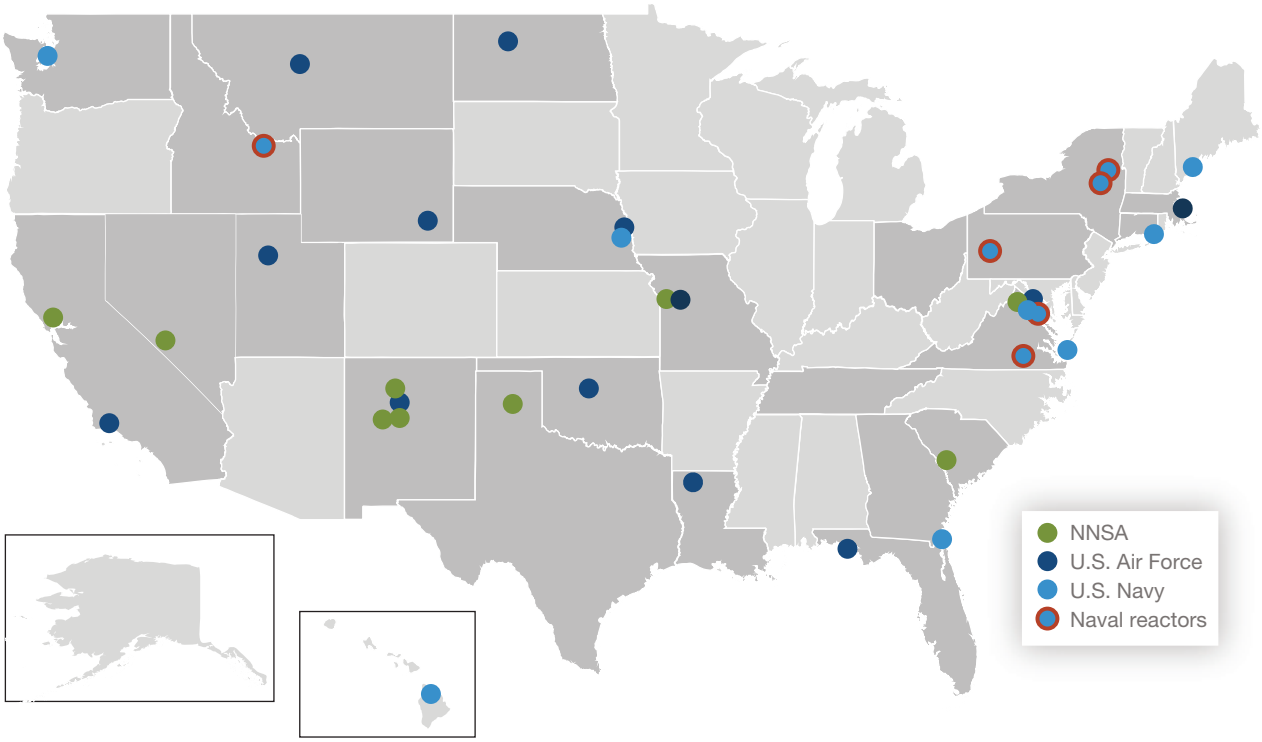
1. addressing workforce health at the enterprise level
2. assessing the demand signal for acquisition and STEM personnel
3. adopting new, innovative approaches to recruitment and hiring
4. developing and retaining the workforce
5. building leaders and succession planning for the long haul.

Each of these areas features an interrelated set of findings concerning workforce health, with a look at current and potential challenges, recommendations to address them, and, as applicable, identification of successes and promising practices for greater use. The first two areas—addressing workforce health oversight at the enterprise level and assessing the demand for acquisition and STEM personnel—cut across different aspects of workforce health (see Figure 1). The next three are more domain-specific, pertaining to recruitment and hiring in response to ongoing high demand for acquisition and STEM personnel, developing and retaining those personnel, and finally ensuring that high-quality leaders are in place now and in the decade to come.

The following sections of this report discuss in turn the findings and recommendations related to each of these five focus areas. The report concludes with additional observations about the way ahead for

FIGURE 2

Map of Major Federal Locations of the National Nuclear Enterprise



NOTE: Authors' depiction of the DoD and NNSA nuclear enterprise footprint. Figure does not include (1) locations with a small number of staff (e.g., liaison officer), (2) nongovernment-owned contractor facilities, or (3) DOE national laboratories outside NNSA that support NNSA's work..

sustaining the health of the nuclear enterprise workforce, including priority recommendations. It also suggests a need for members of the NWC, and other participants in the NWC process, to encourage the U.S. Air Force, U.S. Navy, and NNSA to share best practices more effectively and, working together, to develop more-integrated, enterprise-level approaches to managing their respective nuclear workforces.

Challenge Area 1: Addressing Workforce Health at the Enterprise Level

Findings

The phrase *national nuclear enterprise workforce* is an abstraction that does not accurately reflect practical reality. Personnel who perform nuclear weapon–related work come from several different and disparate organizations. Figure 2 gives some sense of the breadth and range of the national nuclear enterprise. It includes U.S. Air Force, U.S. Navy, other DoD, and NNSA organizations and activities populated by civilian federal government, military, FFRDC, and contractor personnel. Each organization manages its respective workforces according to its own, often unique, set of rules, processes, and procedures for hiring, compensation, and other aspects of workforce management.

Moreover, although various offices and groups (such as the NWC) oversee plans and budgets for nuclear-related hardware programs at the enterprise level, no office or organization performs the same function for the nuclear-related workforce. This decentralization affords certain benefits, such as the ability to tailor workforce management practices to the specific mission, tasks, and cultures of the organizations involved. Moreover, as a practical matter, the current division of labor is not likely to change any time soon because the individual departments and services value their statutorily defined roles, responsibilities, and authorities regarding their personnel.

But from a workforce health standpoint, this fragmentation has clear drawbacks. For example, different parts of the enterprise can and often do compete for the same talent at entry-level positions and in later career stages. Moreover, this practice occurs not only between contractors and the federal government but also within the federal government (e.g., NNSA and DoD) and even within individual departments and military services. In some cases, intra-enterprise competition for talent is seen as healthy and a win for the enterprise overall (e.g., NNSA's collaborative approach to recruiting with its management and operating [M&O] contractors, discussed in Challenge Area 3), but some interviewees clearly regarded it as problematic at times. For example, one interviewee reported that U.S. Air Force organizations often compete against each other for the same prospective employees and fail to coordinate their efforts:

> There are so many inefficiencies with the way we do things . . . For example, the University of Puerto Rico was doing some jobs event. We had six people [from the Air Force] going to Puerto Rico to compete with each other . . . . They do things like have a big trailer, which costs a bunch of money. And yet we are all recruiting in the same place . . . . We should centralize Air Force recruiting like a company would, so we aren't competing with ourselves.

In a related vein, several interviewees noted they routinely lose promising employees not just to industry but to other U.S. government agencies where promotion opportunities are perceived to be greater.

Other comments offered by interviewees suggested a more general lack of appreciation for the full enterprise and the need for more systems-level thinking. One senior DoD leader stated, "We don't teach systems of systems thinking, or how programs interface, or how things overlap, or how other people's decisions affect you—or how your decisions affect other people." An earlier RAND study also touched on this issue, noting the value of managing nuclear-specific processes not only from end-to-end but with an enterprise view.[5] The interviews also suggested that crosstalk and coordination within and across government agencies on workforce management best practices are, at best, ad hoc and episodic. Finally, failing to present a united front on areas of common interest or concern, such as developing and funding strategies to grow the future STEM workforce, could affect the overall health of the national nuclear enterprise workforce.

Options and Recommendations to Bolster Workforce Health

Fortunately, there are efforts underway that should help with enterprise-level workforce oversight. As a result of the DoD 2014 internal and external nuclear enterprise reviews, the U.S. Air Force and U.S. Navy were both tasked to review nuclear personnel requirements and address skill gaps. The U.S. Air Force was also supposed to conduct a review of civilian nuclear-related positions. The Nuclear Enterprise Review Tracking Tool indicates that these efforts are ongoing. Once complete, these efforts should help DoD and other parts of the enterprise have greater awareness of the full set of personnel supporting the nuclear mission.

In addition, increasing informal and formal linkages across the enterprise would promote enterprise-level workforce management and ideally limit the number of workforce health gains in one part of the enterprise that occur to the detriment of another part. This could be achieved by increasing efforts already in practice to some degree within the enterprise. For example, personnel rotations across the enterprise are widely viewed as valuable. They could certainly be expanded in number and scope, with appropriate changes to the rules and funding associated with such programs. Efforts to work more closely with contractors on workforce matters—such as NNSA's joint recruiting fairs involving both federal offices and M&O contractors—could also be adopted more extensively across the enterprise. Establishing communities of practice and holding conferences for sharing promising HR practices would provide a valuable basis for establishing linkages, including perhaps ones that persist after events conclude. Another possibility is to establish enterprise-level employee recognition awards modeled on existing department and service-level awards, such as the *Columbia*-class program's employee of the year.

The NWC might also consider establishing an NWC-level working group or task force responsible for monitoring workforce health indicators. This group or task force could help keep the NWC members and participants aware of enterprise-level workforce health issues, further promote synergies across the enterprise, and advocate for workforce policies, authorities, and resources as needed. Perhaps, just as importantly, it also would have important symbolic value by conveying that senior-level leaders regularly assess the overall health of the nuclear enterprise workforce.

Challenge Area 2: Assessing the Demand Signal for Acquisition and STEM Personnel

Findings

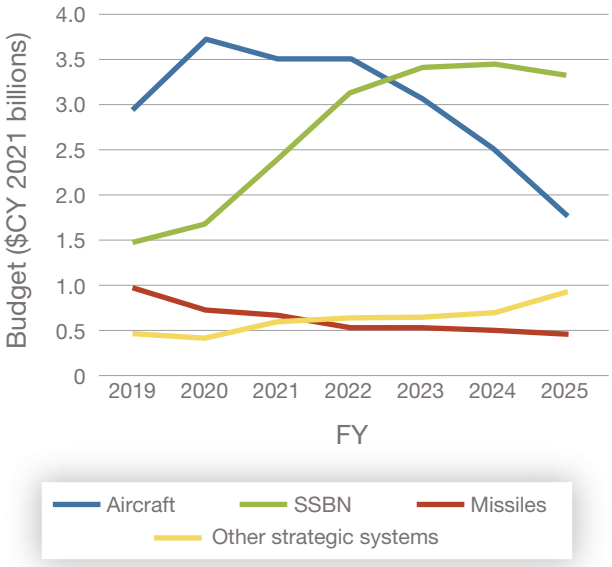
This study was motivated in part by the assumption that the demands of sustaining existing nuclear weapon capabilities, while simultaneously modernizing and transitioning to new nuclear weapon systems and infrastructure, could challenge the health of the nuclear enterprise workforce now and in the future. Given the study's focus on acquisition and STEM personnel, the study team explored this premise by analyzing budget data from the research, development, test, and evaluation (RDT&E) and procurement accounts for major nuclear sustainment and modernization programs. Historical experience suggests that budget data, especially RDT&E costs, can be used to approximate workforce demands, although percentage increases in personnel are generally lower than corresponding increases in the budget.[6] Because several nuclear modernization programs have been underway for several years, significant hiring of STEM and program management personnel has already taken place, particularly by the M&O contractors at NNSA's national laboratories and production facilities. Even so, analysis of the current program data suggests that the demand signal for additional federal and contractor acquisition and STEM employees will likely continue into the near future.

Turning attention first to DoD RDT&E costs, overall RDT&E budgets show only modest growth within the Future Years Defense Program (FYDP): RDT&E spending increases from fiscal year (FY) 2019 to FY 2022 by about 30 percent and, from there, declines gradually. However, the overall picture is somewhat misleading. As shown in Figure 3, breaking down spending by major commodities (the strategic nuclear delivery systems along with the crosscutting strategic systems) shows notable differences. Aircraft RDT&E, driven by the B-21 program, was peaking at the time of this study. RDT&E for *Columbia*-class nuclear ballistic missile submarines (SSBNs) slowly declines as that program enters production. On the other hand, RDT&E for missiles, driven by the Ground-Based Strategic Deterrent (GBSD) program, will nearly triple over the same period. These differences are notable because the workforces are not interchangeable for the most part and cannot follow the demand signal across platforms.

Figure 4 features comparable analysis of procurement budgets by commodity. Overall, spending will nearly triple within the FYDP. The *Columbia*-class SSBN program starts to increase spending in FY 2021, with the B-21 program following in a couple years.[7] Importantly, this figure does not show the

FIGURE 3

RDT&E Budgets by Commodity

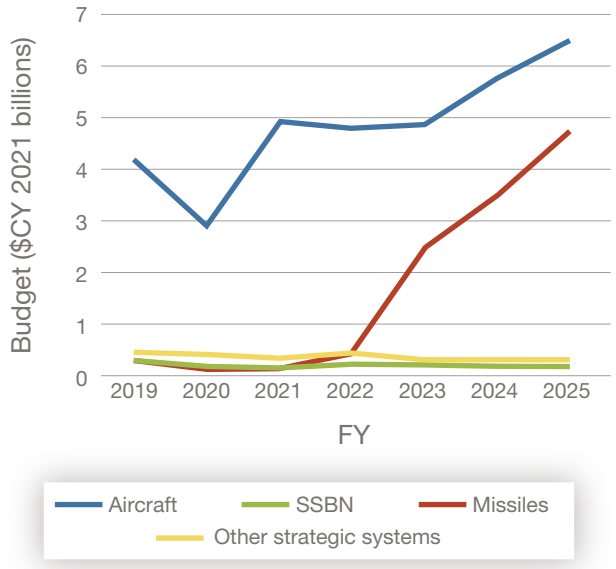


SOURCE: Authors' analysis of component budget exhibits provided by DoD, publicly available data, and news reports.

NOTES: Data do not include costs for reactor components. CY = calendar year.

FIGURE 4

Procurement Budgets by Commodity



SOURCE: Authors' analysis of component budget exhibits provided by DoD, publicly available data, and news reports.

NOTES: Data do not include costs for reactor components. CY = calendar year.

very large increase in the GBSD procurement funding that occurs in FY 2026 (outside the FYDP).

Finally, the team's analysis of weapon system activities within NNSA shows an approximate 60-percent increase in budget over the same time frame, from $10 billion in FY 2019 to almost $16 billion in FY 2025.

Taken together, these spending curves imply more of a direct concern for industry and NNSA's M&O contractors than for the federal workforce beyond those with government oversight responsibilities. On the other hand, it could also mean increased competition for talent already in short supply.

The additional demand for STEM and acquisition employees will be difficult for the nuclear enterprise to meet for several reasons. First, across the enterprise, there is a bimodal distribution of federal personnel (also referred to as an *age bathtub*), with many retirement-eligible personnel expected to leave the workforce soon and with a large number of employees having very limited experience.[8] Additionally, interviewees also noted that after the coronavirus disease 2019 (COVID-19) pandemic subsides, they expect an uptick in retirements.

NNSA, the U.S. Air Force, and the U.S. Navy all recognize the prospect of many experienced employees retiring as a concern and have initiatives in place to promote the transfer of knowledge from retiring personnel to early and midcareer employees. For example, NNSA employs the practice of *double billeting* in some cases to provide overlap between a departing employee and that person's replacement. Both NNSA and U.S. Navy interviewees also reported retaining some retirees with clearances to serve as advisers, especially in addressing issues related to legacy systems. However, many of these activities are small in scale. One interviewee mentioned a need for new efforts to move past a one-to-one knowledge transfer approach:

> Is there a way to do video or training events to create a learning management system to transfer knowledge? It helps to have a knowledge preservation system in place to address the broader need rather than to just transfer to one individual.

The document review and interviews also indicate there are some necessary skill sets that may not be available in sufficient quantities because of atrophy, time to cultivate, limited supply, or competition. These include nuclear-specific capabilities, such as nuclear certification, submarine construction, electromagnetic pulse testing, and plutonium management, and more-general but high-demand skills, such as cyber, contracting, and digital engineering (also referred to as *model-based engineering*). A broader issue is the need for *modernization skills*, which one interviewee explained as follows:

> The problem with modernization is needing employees with two different skill sets. Some people can do both modernization and sustainment, but probably don't want to. Different types of people are attracted to doing modernization and sustainment, as they are very different projects, and there isn't the money to hire two different sets of employees.

A final concern in this area is that workforce planning efforts (e.g., staffing studies) are limited. Portions of the nuclear enterprise, such as the U.S. Navy's Strategic Systems Program (SSP) and the *Columbia*-class program, are engaged in strategic

human capital planning efforts to understand where staffing shortages and skill gaps exist now or are in danger of occurring in the future. However, the study team did not find evidence of this sort of activity happening consistently across the nuclear enterprise, much less at the enterprise level. It is possible that the aforementioned reviews of nuclear personnel requirements and skill gaps that the U.S. Air Force and U.S. Navy have underway in response to the recommendations of the 2014 internal and external reviews will help in this regard.

Options and Recommendations to Bolster Workforce Health

In light of these challenges, ensuring sufficient talent to both sustain and modernize will require innovative thinking. A large expansion of the federal civilian workforce may not be possible or even desirable. Depending on the location and skill set, supply may not be available in the U.S. labor force. In addition, after an intense period of concurrent modernization activities, demand may eventually subside and will certainly evolve. Thus, it is important that ongoing and new workforce planning efforts identify needs that must be met by federal civilian personnel and where other sources of talent may be a better option. For example, the reserve component might be used more as a force multiplier than it currently is. Also, given how parts of the enterprise vary in their reliance on contractor talent (e.g., U.S. Air Force use of Advisory and Assistance Services contractors for nuclear certification; the U.S. Navy bench of contractors in its warfare centers), opportunities might exist to bring in more contract staff to support the surge in demand. These opportunities could include trusted talent, such as FFRDC staff, to help with nuclear-specific or otherwise sensitive tasks.

Finally, as noted earlier, promising practices are available to transfer knowledge from retirement-eligible personnel, but they need to be expanded. NNSA interviewees shared plans to start forums for soon-to-retire personnel to share their knowledge with the workforce. The National Aeronautics and Space Administration (NASA) has a legacy program in which senior employees leave their normal role to work on a special project for two years, providing them with an opportunity to apply and codify their knowledge in a meaningful, memorable way.[9]

Challenge Area 3: Adopting New, Innovative Approaches to Recruitment and Hiring

Findings

The surging demand for STEM and acquisition personnel means it is critical that the nuclear enterprise hires high-quality talent as quickly and efficiently as possible. However, both weaknesses within the enterprise and threats from the environment present talent acquisition challenges. Some interviewees suggested that the nuclear enterprise is not doing a particularly good job in selling itself as an employer of choice. In their view, the attention and resources being devoted to nuclear modernization means that it is an exciting time to be involved in nuclear-related work. However, many prospective candidates, including both college students and those in other industries, are unaware of the career opportunities that the nuclear enterprise has to offer. In addition, certain locations in the nuclear enterprise are perceived to be unattractive in terms of their geographic location, opportunities for spouse employment, other family considerations, and, in some cases, aging infrastructure and data technology.

In addition to these negative perceptions, the private sector can be a fierce source of competition, at times seeking the same people as DoD and NNSA. Interviewees repeatedly brought up the higher compensation that contractors and other private sector companies can pay to attract talent. Moreover, the private sector was also seen as doing a better job with recruiting (e.g., attractive swag at job fairs, ability to hire on the spot) and offering greater opportunities for remote work. Some interviewees recommended more-extensive use of remote work to attract workers to locations considered less attractive.

DoD and NNSA have initiated several programs to help develop the pipeline for talent, including some listed in the box later in this report on promising practices for talent acquisition. The NNSA's Graduate Fellowship Program is a noteworthy example

as one of the largest of such programs. Likewise, several DoD organizations have intern and apprenticeship programs. However, many of the pipeline programs that were regarded by interviewees as successes are small in scale. As one interviewee put it when discussing the U.S. Air Force's internship programs, "We aren't talking hundreds of people, more like dozens." Other interviewees suggested that the bureaucratic and security obstacles to bringing interns on board, giving them meaningful work, and then eventually transitioning them to full-time employment could be a disincentive to both the gaining organization and the prospective intern.

The focus on college internships is indicative of another problem: The nuclear enterprise's targeting of candidates may be suboptimal. The interviews and document review suggest that efforts are overly tilted toward junior staff—college students and even those in high school—but the nuclear enterprise needs people now and in the next few years. Those new to the workforce might not be trained quickly enough to meet the surge in demand. In addition, when the nuclear enterprise does bring midcareer professionals on board, as discussed in Challenge Area 1, midcareer hires seem often to come from other parts of the enterprise.

A final area of concern for acquiring the talent that the nuclear enterprise needs is the federal hiring process. The interviews and documents that the study team reviewed included numerous references to multiple barriers associated with the federal hiring process, such as overly specific job descriptions that might inadvertently deter strong candidates, the confusing process on the USAJOBS federal job listings website, the lengthy amount of time required to complete hiring actions, and the time-consuming security clearance process that some would-be candidates perceive as unduly onerous and intrusive.

Fortunately, DoD and NNSA have made some headway in addressing these challenges. In addition, parts of the enterprise employ innovative and agile talent acquisition practices that are candidates for broader use. The study team agreed that some of the practices had promise, either because they were regarded as successful by the interviewees or were consistent with successful practices used in another context. The options include creative recruiting strategies, the use of hiring flexibilities to bring personnel onboard faster, and solutions for security delays (see the box on the next page). In addition, different efforts to cultivate the talent pipeline aim to bolster the nuclear enterprise beyond the next decade. NNSA and the services are leveraging relationships with universities, trade schools, local community colleges, professional societies, and state and local governments. For example, NNSA's Educational Partnership Consortium and the Naval Engineering Education Consortium both include dozens of higher education institutions. NNSA, the U.S. Air Force, and the U.S. Navy also have various internships, apprenticeships, and fellowship programs in place, and they engage in targeted outreach to diverse talent, such as by building relationships with historically black colleges and universities and NNSA's Minority Serving Institution Partnership Program.

Options and Recommendations to Bolster Workforce Health

Many talent acquisition initiatives show promise, but additional efforts are needed to sustain the health of the nuclear enterprise over the next decade. Although entry-level talent alone cannot fully meet the enterprise's near-term demands, to the extent feasible, efforts to build the entry-level talent pipeline in place at the time of this study should be expanded to support long-term needs beyond the FYDP. Perhaps more importantly, increased efforts to hire midcareer talent could help address near-term sustainment and modernization demands and avoid a reoccurrence of an age bathtub workforce distribution. For example, the nuclear enterprise might consider strategies to target military veterans, such as by maintaining an active presence in Transition Assistance Program offices in areas with a large nuclear enterprise footprint. There is also a strong need to develop midcareer on-ramps into the enterprise for workers in related occupations outside the industry and rapidly develop their nuclear-specific skills through intensive training.

Investing in such on-ramps could be fruitful because the results of the study team's supply analysis using census data indicate that many industries have an *age hump* workforce distribution rather than an age bathtub, meaning there is a large segment of mid-

BOX

Promising Practices for Talent Acquisition

Within the Defense Nuclear Enterprise

Recruiting

- One NNSA mindset for recruiting: NNSA collaborates with its M&O contractors for recruiting, including monthly recruiting strategy meetings and joint career fairs.
- NNSA Graduate Fellowship Program: More than 80 university partners and more than 40 NNSA program, functional, and field offices participate in this program, in which graduate students spend one year working at NNSA. In the 2019–2020 cohort year, there were 238 applicants and ultimately 47 students were hired. At the time of this study, the program had more than 550 alumni.
- DoD Civilian Acquisition Workforce Personnel Demonstration Project (AcqDemo): This program has such features as starting salary flexibility, pay banding, and the promise of pay for performance to help attract candidates.
- The *Columbia* program: This program recruits individuals who gained experience with the program via Systems Engineering and Technical Assistance contractor internships.
- Other practices: Various examples exist across the enterprise of building different types of partnerships to cultivate the pipeline for talent, such as service on a local college's advisory board, outreach to trade schools, attendance at the Black Engineer of the Year conference, and apprenticeships with high school students for skilled technical work.

Hiring and Onboarding

- SSP is among the fastest in the U.S. Navy in terms of hiring, given its use of direct hiring authorities.
- NNSA has increasingly used excepted service appointments to avoid competing certain jobs and reduce the overall hiring timeline.
- The U.S. Air Force has begun to adopt private sector practices, such as leveraging LinkedIn features and making (tentative) job offers on the spot at job fairs.
- Parts of NNSA have sped up the clearance and qualification process by submitting clearance requests before employee start dates instead of two to three months afterward; using an unclassified training simulator to train people awaiting clearances; and focusing on not giving unnecessary Q clearances (the DOE equivalent of a DoD Top Secret clearance).
- The Air Force Nuclear Weapons Center (AFNWC) created an intern academy adjacent to a secure area and had program offices identify projects that interns can contribute without having a clearance.
- The *Columbia* program accepts summer intern applications starting in December so it can obtain interim clearances for them by the summer.

Used for Analogous Workforces

- NASA and other organizations engage in active campus recruiting, which entails going beyond job fair attendance to a more regular presence on campus and cultivating long-term relationships with faculty and staff.
- Student loan repayment programs are available for those in STEM fields and for underrepresented groups in particular.
- Organizations routinely review and redefine what job qualifications, degrees in particular, are truly necessary (e.g., Google does not require a computer science degree for most of its software engineering or product manager roles).
- UK Nuclear established a dedicated submarine recruitment team and offers a Golden Hello financial incentive for new entrants to the submarine service.

SOURCE: RAND interviews and document reviews.

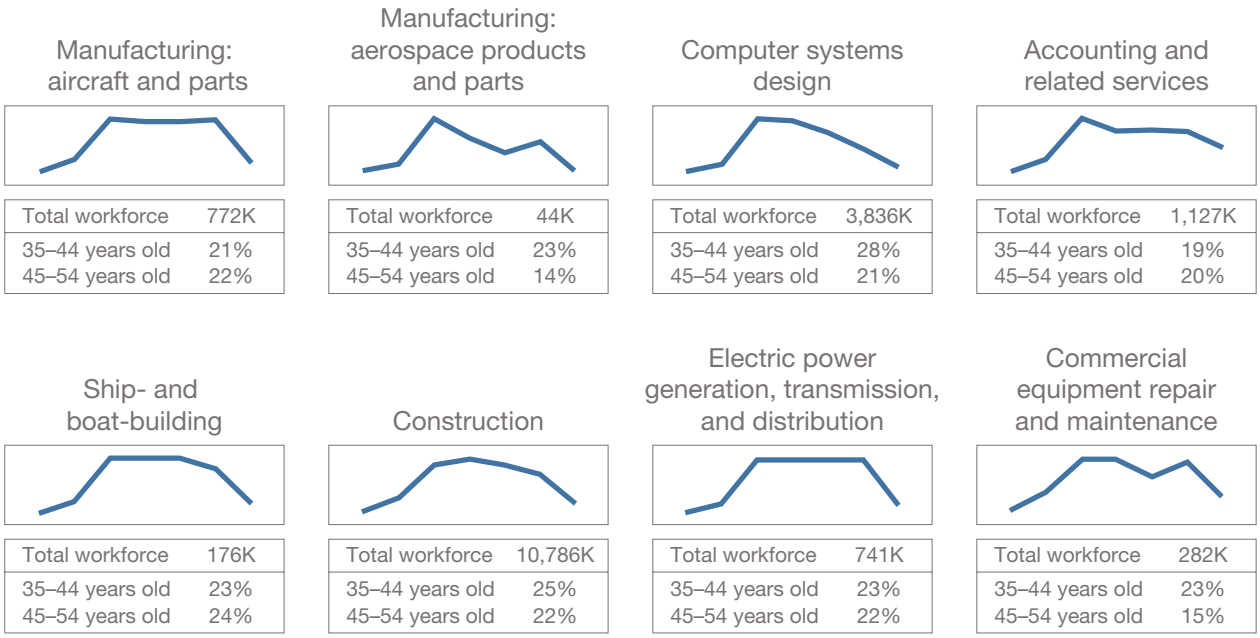
career talent in those industries. Figure 5 includes age humps from some of the industries that could be a source of midcareer talent. They include manufacturing industries—such as aircraft and aerospace, in the top left corner of the figure—as well as industries with workforce skills that can help at different points in a platform or system's life cycle. For example, 47 percent of the ship- and boat-building industry's roughly 176,000 workers are ages 35 to 54, as are 47 percent of the construction industry's 10.8 million workers (bottom left of figure); both may be sources of labor for production. Such industries as electrical power generation, transmission, and distribution and commercial equipment repair and maintenance could also be a source of midcareer talent for sustainment efforts. It is possible that parts of the enterprise already are targeting some of these industries, some of which likely include private sector contractors supporting the nuclear mission (e.g., aircraft and parts, ship- and boat-building), but the study team did not learn of such deliberate efforts in the course of this study.

The census data also suggest other possible sources of midcareer talent that perhaps have not been fully tapped by the enterprise. For example, the study team found that key labor markets for the nuclear enterprise have many *public sector* workers in STEM and non-STEM acquisition occupations, such as contracting, financial analysis, logistics, and program management. This is especially true in the Washington D.C./Northern Virginia and San Francisco Bay metro areas. This workforce may be small compared with the private sector, but these individuals already show a preference for government work and thus may be more interested in supporting a rewarding public service mission versus seeking the highest compensation available in the labor market. Finally, opportunities exist to draw more women into the nuclear enterprise, particularly for non-STEM acquisition jobs in which women are more likely to be found than men. For example, analysis of census data revealed that in some labor markets—such as Ogden, Utah; Albuquerque, New Mexico; Dayton, Ohio; and New London, Connecticut—there are more women than men working in non-STEM acquisition occupations.

Finally, the study team identified other strategies to improve talent acquisition outcomes that would benefit both junior and midcareer hiring.

FIGURE 5

Examples of Industries with an Age Hump as Possible Sources of Midcareer Talent



SOURCE: U.S. Bureau of Labor Statistics, "Labor Statistics from the Current Population Survey: Household Data, Annual Averages, 18b. Employed Persons by Detailed Industry and Age (numbers in thousands)," last updated January 22, 2021. K = thousand.

First, NNSA and DoD could launch an enterprisewide public relations (PR) campaign to promote the attractive aspects of the nuclear mission and of a career in the nuclear enterprise. Interviewees felt that working on a mission of national importance was a key selling point and that the high-tech work associated with modernization was an additional draw. Ways to accomplish this promotion include building communities of interest through social media instead of advertising. LinkedIn and chat bots could be used to contact potential candidates, describe the positive aspects of working within the nuclear enterprise, and help ascertain the kinds of jobs that prospective candidates are interested in, where they want to live, and whether they have family responsibilities, such as child care, to factor into a career decision.

Next, sustaining and expanding remote work opportunities would help level the playing field with the private sector and also may open up new pools of talent if geographic proximity is not required. The COVID-19 pandemic compelled the nuclear enterprise to find ways to make remote work viable, even in a classified environment, and now it stands to potentially gain from the lessons learned during this period.

The nuclear enterprise also could be more like the private sector with recruiting strategies, making greater use of online résumé repositories, engaging universities more than once a year for a job fair (i.e., active campus recruiting), and making on-the-spot offers at job fairs. Another possible job fair innovation would be to take the One NNSA idea further: Not only conduct job fairs with M&O contractors but also plan enterprise-level job fairs that include DoD, NNSA, and contractors. This concept could possibly be pilot-tested in such areas as Albuquerque, New Mexico, or Washington, D.C.

Although some progress has been made on reducing obstacles presented by the federal hiring process, more could and should be done, including making more-expansive use of special hiring authorities and excepted service appointments[10] and addressing security clearance issues, such as process length and possible misperceptions by job candidates about what the process entails. With respect to overly specific job descriptions, NNSA and DoD should consider redefining their definition of a *qualified candidate*. For example, at Google, *qualified* does not always mean having a college degree; rather, it means having the specific skills necessary to do the job.[11] In a related vein, the nuclear enterprise should consider ways to vet candidates that do not rely on education (e.g., a *hackathon* event or other tests of aptitude and passion are often used for cyber positions).

Finally, the nuclear enterprise likely cannot and should not strive to match private sector compensation. That said, some targeted use of financial incentives, such as UK Nuclear's Golden Hello bonus and student loan repayment (see the box on p. 11) and increased locality pay for critical or hard-to-obtain skill sets may be helpful.

Challenge Area 4: Developing and Retaining the Workforce

Findings

The nuclear enterprise has made some improvements with respect to career development, morale, and retention since the 2014 DoD internal and external reviews. Moreover, parts of the enterprise have adopted innovative approaches to developing and retaining personnel that are good options for broader use.

The study team's document review and interviews highlighted many training and development activities with DoD and NNSA that have been specifically developed for the nuclear enterprise context. In some cases, these activities are relatively brief—days or even hours long—and the intent seems to provide flexible options for continuous learning. The approach is consistent with what one interviewee recommended:

> We have an opportunity coming up with the new "back to basics" structure to build more training. We need to build small pockets of training, credentials. There can be training for business systems in Montgomery, Alabama, and a different one at Eglin for LRSO [Long Range Stand Off Weapon], or at Hill for GBSD. Skills for those missions are different, so there needs to be trainings for each.

Increased use of virtual offerings (e.g., online courses; virtual brown bag sessions) has also made

Morale is also much improved since 2014. Interviewees attributed this positive change to a strong sense of purpose, the importance of the nuclear mission at this time, and increased opportunities to do "cool work."

professional development activities more accessible to the nuclear enterprise workforce.

Other nuclear-specific development opportunities include rotations within the nuclear enterprise and bringing in outside experts to teach the workforce. For example, the *Columbia*-class program invited Electric Boat to lead a three-day, "101" course on submarine design and systems. The U.S. Air Force uses a mobile training team for instruction on model-based engineering.

Across the enterprise, interviewees from both DoD and NNSA cited university programs and partnerships as means to provide personnel with the necessary education, ranging from short courses to degree programs. According to the interviews, NNSA seems to have taken this practice the furthest in terms of the range of schools and depth of university investment. The services also have developed custom content, such as the Air Force Institute of Technology's "Nuclear 200" and "Nuclear 300" courses.

Another strength related to career development is NNSA's career planning efforts. These include the creation and publication of career paths, competency models, and competency gap assessments. This effort is ongoing but is perceived as helpful thus far. One NNSA interviewee described career paths as follows:

> We have developed a system to ensure key positions within the organization have career paths associated with them. Career paths are something many organizations claim they want to do but can't seem to execute on. Not only have the ones we've established been successful, but we are building more. We have career paths for all types of careers: field office managers, contract specialists, couriers, information technology and budget, and even foreign affairs specialists. We view these as absolutely critical for retention. Employees want to know what opportunities are available to them. They ask, "What is my future?" If you communicate a clear career path to them, and what opportunities are available to them, it really impacts retention. Another benefit is that is also makes us lay out a clear development path that we need to establish. We have employees in three career stages: early, middle, and late. Those people can simply look at a career path and see what they need to do to move up. I can't say enough about it. I'm so excited about it.

NNSA's efforts in this regard seem consistent with UK Nuclear, which has developed a Nuclear Skills Passport and Integrated Competency framework. The passport and framework are part of the UK's efforts to create common nuclear skill sets.[12]

Morale is also much improved since 2014. The annual Federal Employee Viewpoint Survey (FEVS) scores were cited as the primary basis for gauging improvements in morale. Interviewees also described the use of other methods to assess employee attitudes, such as internal climate surveys and leader observations of employee town hall meetings. Interviewees attributed this positive change to a strong sense of purpose, the importance of the nuclear mission at this time, and increased opportunities to do "cool work."

Another positive development since 2014 has been the movement of more nuclear enterprise employees into alternative personnel systems rather than the General Schedule personnel system. NNSA federal government employees are managed under

an alternative personnel system, and a portion of the defense nuclear enterprise is part of AcqDemo or the Defense Performance Management and Appraisal Program. The benefits of these alternative personnel systems include a greater emphasis on ongoing feedback than what is traditionally provided under the General Schedule system and pay for performance. Interviewees felt that both features help with performance management, and previous research about AcqDemo has documented a link between pay for performance, higher retention of strong performers, and higher attrition of low performers.[13]

Finally, parts of the enterprise, within the U.S. Navy in particular, have internal recognition programs perceived as helping with morale and retention. One interviewee described these programs as follows:

> There are Navy-wide awards and SSP-specific ones. We have two tiers: the Poseidon award given at each location (field and headquarters), which are people nominated by their peers, then selected by board of directors; and the Trident award given annually, which is not peer-nominated, but is given to someone who already won a Poseidon. . . . The award is recognition. Sometimes there are other perks, but they always come with recognition of some sort, like a medal. People who are not selected still get personalized notes from leadership on being nominated, even if not selected.

Despite these advances and strengths, significant problems with career development and retention still exist across the enterprise. Many of the training and development activities of perceived value have very limited capacity, which is particularly problematic in light of surging demand. In addition, the interviews suggested that, within the U.S. Air Force and U.S. Navy, a lack of structured, nuclear-specific career development is affecting retention and possibly productivity.

Both services, however, have made new efforts at career management, including nuclear-specific occupational competencies within the U.S. Air Force, skill gaps assessments within SSP, a vision for deliberate career broadening (a potential career pyramid for the AFNWC), a tentative career map for *Columbia*-class personnel, and U.S. Navy SSP's dedicated subject-matter expert track. Yet there is some tension, at least within the U.S. Air Force, about the desire to keep acquisition and STEM personnel within the nuclear enterprise for multiple assignments to gain deep familiarity with the nuclear context and the need to bring in new skill sets and perspectives from the outside. These development concerns were perceived as negatively affecting retention.

Several interviewees, particularly in NNSA, explained that promising early and midcareer personnel are leaving their organization for what they believe to be better opportunities for upward mobility. As one interviewee put it,

> The biggest challenge for us on the federal side is that there is a structural problem in early and midcareer where your best opportunity for promotion every few years is generally to move onto somewhere else. If you're looking to climb in the federal workforce then you need to be looking for other organizations where promotion opportunities are occurring more frequently.

Interviewees also shared that early career personnel leave due to slow onboarding and restrictions on the use of personal electronic devices in the workplace.

Another factor threatening morale and retention across the nuclear enterprise is poor working

Many training and development activities of perceived value [for career development and retention] have very limited capacity, which is particularly problematic in light of surging demand.

conditions. Employee dissatisfaction with facilities and information technology was not only repeatedly mentioned in interviews but also comes up in surveys. Other issues that emerged from the document review as hindering retention are a demanding workload (and the burnout that ensues), the need to work overtime, and difficulties balancing competing tasks.

In addition, the document review and interviews suggest that women and racial/ethnic minorities may not be well supported and that diversity and inclusion (D&I) efforts are lacking. For example, within SSP, female employees were less likely to feel that their skills were being used or that they were given ample opportunities to improve their skills. They also indicated in the Defense Equal Opportunity Climate Survey that they were not discriminated against but did experience microaggressions. Survey results also indicated that minority employees were less likely to have favorable views of programs and policies intended to support diversity; and, in a final example, for Naval Reactors, the FEVS question about programs and policies to promote diversity is one of the lowest-scoring items for the organization.

Options and Recommendations to Bolster Workforce Health

Resolving these problems would benefit workforce health in multiple ways. Ramping up development opportunities, for instance, would both stem attrition and bring a large number of new hires up to speed. Additional reliance on universities and colleges may be one of the best ways to increase capacity (and then reduce it as demand wanes) for continuing education and training. Increasing job rotations within and across the enterprise would also help with development and retention. Given that some civilian personnel are reluctant to relocate for a rotational assignment, organizations should consider offering or pilot-testing job rotations that rely primarily on remote work, which could expand their use and appeal.

In addition, the DoD portions of the enterprise should reconsider identifying nuclear-specific competencies and career paths. This could not only help with retention but also inform the development of training content. The career planning efforts at NNSA and UK Nuclear described earlier in this report offer examples.

Another option is to expand the use of nonfinancial tactics, which could help promote morale and retention across the enterprise. Analysis of analogous workforces suggest that such strategies as increased opportunities for autonomy, flexible work environments, family friendly policies, support for continuing education, and engagement in broader knowledge communities of practice could all be effective, particularly for STEM personnel.

Finally, more can be done to formalize support for women and racial/ethnic minorities. Other contexts offer examples of ways to accomplish this. For instance, the UK's Atomic Weapons Establishment has established a D&I Strategy Group, and there is a grassroots Women's Network intended to improve workplace culture and cultivate mentorship networks.[14] In 2020, NASA rolled out the Unity Campaign to focus on creating an inclusive environ-

Increasing job rotations within and across the enterprise would also help with development and retention. Organizations should consider offering or pilot-testing job rotations that rely primarily on remote work, which could expand their use and appeal.

ment for all employees. More than 10,000 employees participated in more than 500 facilitated "Diversity Dialogues," which encouraged a safe space for conversations on social issues. The campaign also seeks to ensure equal employment opportunity in the workplace, regularly assess the FEVS Inclusion Quotient Index, increase recruitment diversity in early career hiring programs, and expand mentoring.[15]

Challenge Area 5: Building Leaders and Succession Planning for the Long Haul

Findings

During the course of this study, there was less discussion about—and evidence related to—leader development and succession planning, and that is cause for concern. The document review and interviews suggest that current leader development and succession planning efforts are not sufficient to meet future needs, particularly in light of the age bathtub and impending retirement wave discussed earlier (Challenge Area 2). Investment in a new cohort of leaders was also perceived by interviewees as important, given the need for new skill sets and the time required to cultivate nuclear-specific expertise and experience. However, it appears that succession planning processes and tools are very limited in parts of the enterprise. For example, some interviewees described ad hoc processes to manage a cadre of potential leaders and expressed concerns that leader development efforts were focused only on the top level of leadership.

Of particular note, civilian leader development faces additional obstacles. Although there is a wealth of opportunities for leadership training, the study team heard in interviews that such training is not mandated for civilian leaders. In addition, interviewees claimed that civilian personnel cannot be pre-identified and groomed for positions like the U.S. Air Force and U.S. Navy do for military personnel. Another contrast with military personnel, according to one interviewee, is that civilian leaders tend to be selected only by looking at those who apply for a position rather than looking across all possible candidates

The document review and interviews suggest that current leader development and succession planning efforts are not sufficient to meet future needs, particularly in light of the age bathtub and impending retirement wave.

for the best person and then moving that person to the optimal leadership position.

Another concern related to leader development that emerged is that some interviewees perceive current leaders, particularly in U.S. Air Force acquisition, as lacking deep nuclear-specific knowledge and experience. Interviewees also cited soft skills that nuclear enterprise leaders needed and sometimes lacked, such as motivating contractors, mentoring, managing innovation, fostering equity and inclusion, and communicating well with others. Managing innovation was regarded as important for modernization in particular. One interviewee said:

> A lot of employees say their supervisors encourage innovation, but that the supervisors don't know what to do with an innovation if it's presented. Previously, supervisors have been encouraged to promote innovation, which they are apparently doing but don't take the next step. But this is understandable given that [organization redacted] is still a "high-consequence" environment, and thus risk aversion is built in here. That risk-averse culture makes promoting risk hard.

Options and Recommendations to Bolster Workforce Health

Fortunately, some newer initiatives show promise, but more extensive, formal efforts are needed to prepare the next generation of leaders. Parts of the enterprise have leader development activities that could serve as models for broader use. For example, the U.S. Air Force offers "Nuclear 400: Senior Leader Nuclear Management," a two-day course for approximately 60 civilian and military leaders annually. Sandia National Laboratories' early career leadership program attracted roughly 30 participants in its first year, and the U.S. Navy has several leadership development efforts for its nuclear enterprise leaders, including the subject-matter expert track for experts who prefer not to become supervisors, the Honorary Dolphin Program, Team Submarine, and the Mid-career and Senior Leadership Institutes. Although these initiatives are relatively new and/or have not yet been formally evaluated, interviewees valued them for meeting nuclear program–specific needs, such as inculcating culture, conferring important information about the program, and cultivating specific leadership skills. If these newer programs lay out a defined leadership curriculum for nuclear enterprise leaders and help jumpstart succession planning processes, they should do much to help improve this aspect of workforce health over the next decade.

Another way to develop leaders is to supplement formal education with layers of already-in-use leader development strategies, such as stretch assignments, opportunities to lead working groups, brownbag lunches on leadership topics, coaching, and 360-degree reviews. As one interviewee explained, a benefit of these short activities is they can hold people over while they await a chance to attend a formal leadership course.

Finally, as workforce planning initiatives take shape, those initiatives should incorporate succession planning for mid- and top-level leaders. For example, an NNSA interviewee mentioned a need to do a better job with succession planning "a couple levels down from the top."

Closing Observations

This study was a 90-day quick-turn assessment of the health of the nuclear enterprise workforce, federal personnel in acquisition and STEM occupations in particular, primarily based on existing data sources. This scope meant that the study team was unable to examine thoroughly the contractor workforce that supports the nuclear enterprise. Given both the myriad important roles that contractors serve and the movement of personnel between the government and contractor portions of the nuclear enterprise, a more detailed look at the health of the contractor workforce is an important topic for future study. A greater understanding of not only the health of the contractor workforce but also its size and skill mix could also inform future efforts to estimate federal workforce requirements. Another topic that warrants additional attention is whether any statutes, rules, or regulations impede efforts to support workforce health. The study team learned about challenges related to the federal

Another way to develop leaders is to supplement formal education with layers of already-in-use leader development strategies, such as stretch assignments, opportunities to lead working groups, brownbag lunches on leadership topics, coaching, and 360-degree reviews.

hiring process and security clearance requirements, but it is possible other regulatory barriers exist that were not uncovered in the document review and interviews. Finally, NNSA's efforts for more-deliberate career planning, most notably career paths, were relatively new at the time of this study in early 2021; therefore, a look at how successful the career paths have been for NNSA and the identification of lessons learned, both good and bad, could aid other parts of the enterprise in implementing similar programs.

Overall, the health of the nuclear enterprise workforce has noticeably improved over the past decade. Greater leadership attention to the nuclear-deterrent mission and to its people have resulted in positive outcomes. Personnel levels and hiring authorities have increased; additional funding for training and development programs has been made available; and several projects to improve existing infrastructure and construct new facilities for the workforce have been completed or are underway. Innovative recruiting and retention practices have been adopted across the enterprise. NNSA's alternative personnel system and DoD's AcqDemo have improved hiring, performance, and retention.

Workforce challenges remain, however, both now and for the foreseeable future. The demands of simultaneously sustaining existing weapon systems while developing and fielding new ones are already creating significant stress. Workforce planning efforts to combat those stressors, address the age bathtub, and estimate workforce requirements are limited. Recruiting is hampered because prospective employees have a poor understanding of job opportunities within the nuclear enterprise and also by the onerous federal civilian hiring process. Early and midcareer personnel routinely leave their respective organizations for better career development prospects in other parts of the enterprise, or outside of it, and some of that movement is regarded as detrimental. Finally, despite the facility improvements that have recently been made, substandard infrastructure remains a problem across the enterprise, making it even tougher to compete with private industry to attract and retain talent.

Throughout this report, the study team identified promising practices that are candidates for more-extensive use across the nuclear enterprise and has offered recommendations that the U.S. Air Force, the U.S. Navy, the NNSA, and the study sponsor should consider to address internal weaknesses and external threats. Five of those actions should be addressed first because they will help workforce health in multiple ways (e.g., by positively affecting recruiting and retention outcomes):

Recruiting is hampered because prospective employees have a poor understanding of job opportunities within the nuclear enterprise and also by the onerous federal civilian hiring process.

1. Ramp up workforce planning efforts, particularly those intended to address the age bathtub workforce distribution and to assess the right mix of federal and contractor workforces.
2. Engage in more-deliberate career management (e.g., use of nuclear-specific competency models and career paths, educational activities that build on each other) so that promising personnel and leaders perceive that they have clear development opportunities within the nuclear enterprise.
3. Step up efforts to promote One Enterprise thinking and collaboration in multiple ways, including in recruiting, rotational assignments and other development activities, and sharing of HR-related lessons learned.
4. Invest in physical facility infrastructure improvements, starting with locations in greatest disrepair or with aging infrastruc-

An NWC-level working group on workforce health could also focus on the promotion of One Enterprise thinking for workforce management.

ture that is a stark contrast to local contractor facilities.

5. Embark on a PR campaign to promote broader awareness and appreciation for the nuclear mission and the exciting, leading-edge STEM work it offers.

Some of these changes will take a long time to implement and for organizations to reap their full benefits. Consequently, they should be undertaken as a matter of priority.

Although some efforts to bolster workforce health will take time to yield results, there are also steps that the NWC members and other participants in the NWC process should take in the short term to help bolster the health of the nuclear enterprise workforce:

- Advocate for investment in facilities and personnel. The NWC can advocate for continued investment in facility and infrastructure improvements; additional authorities for financial incentives, such as higher locality pay and signing bonuses; and more authorizations for excepted service appointments and for FFRDC, University Affiliated Research Centers, and other contractor support. Expanding the use of AcqDemo within the DoD portion of the nuclear enterprise would also help with performance management and retention.
- Support initiatives to enhance remote work opportunities. Enhanced remote work opportunities could potentially have a positive impact on hiring and retention within the enterprise. Specific actions might include addressing the administrative and cultural barriers to teleworking, investing in the development of technology for remote collaboration at the classified level, pilot-testing the targeted hiring of full-time remote personnel, and using virtual rotational assignments.
- Establish an NWC-level working group on workforce health—an action with both practical and symbolic value. An NWC-level working group on workforce health could also focus on the promotion of One Enterprise thinking for workforce management. Its initial agenda could include determining enterprisewide metrics for reporting on workforce health to NWC members, establishing ways to share promising practices (e.g., a conference for HR professionals, lessons learned repository), laying the groundwork for a PR campaign to enhance awareness of nuclear mission and career opportunities, and drafting a strategy to promote D&I within the nuclear enterprise.

As the nuclear enterprise moves forward with its modernization programs, to the greatest extent possible, any implemented workforce changes to meet the current demand surge should also consider what a post-surge world might look like. For example, once the new systems are fielded, a different mix of skill sets may be needed to sustain and continually update the modernized force. A long-range, strategic vision for the nuclear enterprise workforce that accounts for current demand and future requirements should be developed. Finally, whatever actions are undertaken, it will be important to capture lessons learned during this period to better prepare for future surges in the development and deployment of capabilities required for national defense, not only in the nuclear enterprise but in all domains.

APPENDIX

Additional Details on Study Methods

Task 1: Document Review

The study team reviewed relevant documents pertaining to the nuclear enterprise workforce to identify strengths and weaknesses within the enterprise and external opportunities and threats to it. The study team began by conducting a scan of open-source reports, congressional testimonies, and news articles and identified a subset of these documents for closer review and analysis. The study team also reviewed documents sent by NNSA, the U.S. Air Force, and the U.S. Navy in response to a document and data request. Such documents included recent staffing studies and descriptions of ongoing human capital strategic planning efforts, reports describing employee development programs, internal briefings on workforce-related topics, and results from the FEVS and other surveys conducted by portions of the enterprise. Last, the study team reviewed the Nuclear Enterprise Review Tracking Tool to understand whether and where progress has been made toward addressing recommendations from the 2014 reviews of the DoD nuclear enterprise.

In total, the study team reviewed approximately 75 documents, including reports from the U.S. Government Accountability Office, National Academy of Public Administration, Congressional Research Service, and agencies within DoD (both open source and internal). The study team reviewed these documents to extract key insights related to the workforce health domains from OPM's human capital framework: workforce planning, recruitment and hiring, employee engagement and development, leader development, and morale and retention. The study team synthesized the information collected, first by portion of the enterprise (i.e., NNSA, U.S. Air Force, U.S. Navy) and then for each workforce health domain enterprisewide. These summary documents flagged points as signaling SWOT and informed the study team's cross-task SWOT analysis.

Task 2: Stakeholder Interviews

Over a three-week time frame, the study team conducted 27 interviews with DoD, NNSA, and nongovernment stakeholders. DoD and NNSA interviewees included senior leaders, program managers, and HR functional experts. The interview sample was a purposive one; people were selected by virtue of their positions. This means the study team's results are not generalizable beyond this set of interviewees; in many instances, observations shared during interviews were consistent with findings from the team's document review. In addition, some of the individuals the study team had hoped to speak with were unavailable to participate because of their work demands, and interviewing employees was not within the scope of this study.

The study team used a semistructured interview approach, meaning the team had a common set of starting questions for the interviews but also were able to delve into potentially fruitful lines of inquiry based on the response to the initial questions or other observations shared by an interview participant. All the interviews were led by a RAND study team member, and a second team member served as a dedicated notetaker. In some interviews, a third team member also participated in the questioning. In general, the interview topics aligned with the conceptual framework (Figure 1); depending on the interviewee, the study team asked questions about specific workforce health domains (e.g., workforce planning, morale and retention). The study team also posed more-general questions, such as how healthy the nuclear enterprise workforce was overall and what kept the interviewee up at night when thinking about the workforce, and asked about promising practices and suggestions to improve workforce health as needed.

The interviews were subsequently analyzed using a computer-assisted qualitative data analysis procedure referred to as *coding*. Codes are labels used to organize qualitative data by topic and other characteristics,[16] and coding is a common approach to analyzing qualitative data that facilitates data reduction and generation of findings in a way that is transparent and verifiable.[17] The study team coded the interviews via QSR Nvivo, a software package

that permits its users to review, categorize, and analyze qualitative data, such as text, visual images, and audio recordings. After researchers assign codes to passages of text, they can later retrieve passages of similarly coded text within and across source documents, such as interview transcripts. The study team developed a *coding tree*—a set of labels for assigning units of meaning to information compiled during a study, which in turn was the basis for a codebook the team developed to clarify how the codes would be applied.[18] The codebook contained code names, definitions, inclusion and exclusion rules, and examples of interview passages that corresponded to each code.

The study team employed a structural coding approach for this study. Codes were based on the team's study objectives and interview questions and were intended to help identify themes.[19] Several members of the study team worked to develop and apply parent codes (i.e., the highest-level codes) to the full set of interviews. After the parent-level coding was completed, the study team met to develop *child codes*—a set of additional codes intended to parse out parent codes into discrete themes. The codebook was revised to include the new codes, and all study team members then applied the new child codes to the parent codes. In both rounds of coding, a single researcher was responsible for applying a code to all the interviews in close coordination with the study lead, which meant no inter-rater reliability checks were needed.

After the coding was complete, the study team generated coding reports to review all the passages tagged with a specific code together, and those reports were further distilled into summary memos for each of the five workforce health domains. Each memo included a discussion of related themes (e.g., those related to employee engagement and development), a summary of the evidence, and exemplar quotes. The memos were used to share interview findings with the full study team and in preparation of the final study deliverables.

Task 3: Analysis of Workforce Supply and Demand

Supply Analysis

To determine the supply of relevant workers, the study team used U.S. Census Bureau data from the American Community Survey (ACS).[20] The comparable populations were limited to reflect those working in fields comparable with the nuclear enterprise: ACS respondents who earned income, worked full time (more than 35 hours a week) in the private sector (including nonprofits), and worked in select occupations and geographic areas. These respondents were population-weighted using weights from the Census Bureau to reflect the available pool of labor from which the enterprise could hire.

The eight geographic areas in the analysis were based on locations with existing enterprise infrastructure, as shown in Figure 2—for example, the San Francisco Bay Area, which is home to the Lawrence Livermore Labs. The areas typically matched a metropolitan statistical area (MSA), but in some cases two MSAs were combined to reflect a region with shared characteristics. The one-to-one areas with a single MSA were the Boston-Cambridge, Massachusetts, and Newton, New Hampshire area; Norwich-New London, Connecticut; Ogden-Clearfield, Utah; Dayton, Ohio; and Washington-Arlington-Alexandria, D.C.-VA-MD-WV. The combined areas were San Francisco-Oakland-Hayward, California, and San Jose-Sunnyvale-Santa Clara, California. MSAs to form one San Francisco Bay Area group; Albany-Schenectady-Troy, New York, and Pittsburgh, Pennsylvania, to form a Pittsburgh-Upstate New York group; and Albuquerque, New Mexico, and Santa Fe, New Mexico, to form a New Mexico group.

The occupations of interest included were categorized based on prior RAND research of STEM occupations and defense acquisition occupations.[21] The study team created a third group, non-STEM Defense Acquisition, to eliminate the overlap between the two groupings and focus on such occupations as contracting, financial analysis, logistics, and program management. In all cases, these occupation categories were based on occupation codes, a contemporary occupation classification system from the U.S. Census Bureau.

In these geographic areas and across these occupations, the study team analyzed incomes and population sizes by demographics. For incomes, the study team used averages over the 2017–2019 period to ameliorate volatility issues that stem from using a single year (income data are not collected from every respondent so the sample size is lower). Population counts used 2019 alone, because it was the most recent year available. Demographics of interest included race/ethnicity, gender, education level, age, and veteran status.

Demand Analysis

The study team's demand analysis relied on the publicly available budget documents for DoD and DOE. These data provide a reasonably comprehensive view (excluding classified spending) on nuclear deterrent–related acquisition activity across the enterprise. For DoD, the study team extracted and organized the relevant RDT&E and procurement budget data. The study team deliberately did not include military personnel or operations and maintenance budgets. This exclusion was chosen based on discussions with the sponsor to focus on just the STEM and acquisition personnel within the nuclear enterprise. However, the gathered budget data did include the substantial modernization of current nuclear enterprise assets (such as upgrades of nuclear command, control, and communications capabilities). The study team collected similar data from the DOE/NNSA budgets as well. Note that the DOE/NNSA budget exhibits do not divide activity in the same way as DoD (e.g., color of money). For that funding, the study team focused on activities closely aligned to the nuclear enterprise.

One of the limitations of using the budget exhibit for spending projections is that the budgets cover only a limited window of time—seven years. For DoD, this period is known as the FYDP and covers the prior FY, the current one, and five years into the future. Thus, the study team could not use the budget documents to examine long-term trends in funding. To partially offset this limitation, the study team also gathered Selected Acquisition Reports (SARs) for the major DoD programs. These documents project the entire acquisition spending for a DoD program. These data, too, suffer limitations as only major defense acquisition programs (MDAPs) are required to submit SARs, and a corresponding document for NNSA programs does not exist. Therefore, a picture based solely on the SARs would be incomplete. For this analysis, the study team largely relied on the budget exhibits to examine acquisition activity. This view is a short-term picture. The study team used the SARs to get a sense of the longer-term trends for just DoD.

The study team also obtained Acquisition Strategy documents for the major program in DoD. These documents have some projections of program staffing requirements. Again, these data are available only for DoD MDAP programs. The U.S. Air Force and the U.S. Navy also provided some supplementary program information on the program billets (both government and support contractors) for a sample of the nuclear enterprise programs. These data, combined with the budgets, were used to assess the demand signal for STEM and acquisition personnel.

Task 4: Lessons from Analogous Workforces

The study team compiled and reviewed a wide variety of open-source documents and data on workforces similar in one or more dimensions to the nuclear enterprise workforce to understand factors affecting their workforce health and to identify opportunities and promising practices that the nuclear enterprise might consider adopting. Dimensions on which the study team sought points of alignment included spanning the public and private sectors with competition from the private sector for talent, needing workers with specialized knowledge and skills, and having a mix of workers with advanced degrees and those with technical credentials. The study team searched for documents related to specific workforces (such as the U.S. space, telecom, and energy workforces and the UK defense nuclear enterprise). Search terms were grounded in the workforce health domains drawn from the study team's conceptual framework and combined the name of the workforce of interest with both broad terms (e.g., workforce issues) and specific terms (e.g., human capital strategic planning, talent acquisition, and performance management). The study team

later broadened the search to include STEM workers overall and cybersecurity workers, having initially uncovered a great deal of industry-specific information but comparatively less of direct relevance to the workforce health domains.

The study team searched principally using Google and Google Scholar, supplementing these resources with searches of government websites, professional associations, consulting firms, and RAND publications. The study team drew insights from academic literature; prior RAND reports; the U.S. Government Accountability Office; the National Academies of Sciences, Engineering, and Medicine; the National Science Board; the National Institute of Standards and Technology; NASA; the Department of Homeland Security; and other federal agencies, various industry trade associations, consulting firms, foreign government agencies, and international organizations. The study team grouped findings into the workforce health domains and synthesized the information into a summary document identifying major themes by domain, highlighting those practices that may merit consideration by the nuclear enterprise.

Notes

[1] See, for example, Chaitra M. Hardison, Carl Rhodes, Jacqueline A. Mauro, Lindsay Daugherty, Erin Gerbec, and Craig Ramsey, *Identifying Key Workplace Stressors Affecting Twentieth Air Force: Analyses Conducted from December 2012 Through February 2013*, Santa Monica, Calif.: RAND Corporation, RR-592-AF, 2014; Office of the Secretary of Defense for Acquisition, Technology, and Logistics, *The Defense Science Board Permanent Task Force on Nuclear Weapons Surety: Report on the Unauthorized Movement of Nuclear Weapons*, Washington, D.C.: U.S. Department of Defense, last updated April 2008; and U.S. Department of Energy, Office of Inspector General, *Special Report: Inquiry into the Security Breach at the National Nuclear Security Administration's Y-12 National Security Complex*, Washington, D.C., August 2012.

[2] Andrew T. Walter, prepared statement presented before the U.S. Senate, Committee on Armed Services, Subcommittee on Strategic Forces hearing to receive testimony on U.S. Nuclear Weapons Policy, Programs, and Strategy in Review of the Defense Authorization Request for Fiscal Year 2022, Washington, D.C., May 12, 2021; and U.S. Department of Energy, National Nuclear Security Administration, *Fiscal Year 2021 Stockpile Stewardship and Management Plan—Biennial Plan Summary, Report to Congress*, Washington, D.C., December 2020.

[3] An unclassified summary of the 2014 DoD internal nuclear enterprise review is available online at U.S. Senate, Committee on Armed Services, "Summary of DoD Internal Nuclear Enterprise Review," Washington, D.C., November 2014; the report of the 2014 external independent review is available at Larry A. Welch and John C. Harvey, Jr., *Independent Review of the Department of Defense Nuclear Enterprise*, Washington, D.C.: U.S. Department of Defense, June 2014.

[4] Drawn from American Community Survey (ACS) and U.S. Census Bureau data hosted by IPUMS, a data repository run by the University of Minnesota (see Steven Ruggles, Sarah Flood, Sophia Foster, Ronald Goeken, Jose Pacas, Megan Schouweiler and Matthew Sobek, *IPUMS USA: Version 11.0 Data Set*, Minneapolis, Minn.: IPUMS, 2021).

[5] Don Snyder, Sherrill Lingel, George Nacouzi, Brian Dolan, Jake McKeon, John Speed Meyers, Kurt Klein, and Thomas Hamilton, *Managing Nuclear Modernization Challenges for the U.S. Air Force: A Mission-Centric Approach*, Santa Monica, Calif.: RAND Corporation, RR-3178-AF, 2019.

[6] The study team considered in several ways the relationship between spending in the FYDP versus the program's (required) billets for those DoD programs for which the team had data. A look at the log-log plots (in which both spending and billets are scaled logarithmically) showed that there appears to be a strong relationship between RDT&E and program size, perhaps reflecting the complexity of the overall program. The relationship is nonlinear, thus an increase in the budget does not correspond to a proportional increase in staffing. Rather, it is roughly a square root relationship.

[7] Note that the B-21 procurement values are based on a news report (see Roxana Tiron and Tony Capaccio, "Pentagon Seeks $10.3 Billion to Buy the Stealthy B-21 Raider," *Bloomberg News*, February 10, 2020). There is no stated procurement spending for B-21 in the currently published budget exhibits.

[8] For example, Section 4.2 of U.S. Department of Energy, National Nuclear Security Administration, 2020; and information provided to RAND by the Air Force Nuclear Weapons Center and Naval Sea Systems Command, March 2021.

[9] Katie Scott, "EXCLUSIVE: NASA Implements Initiatives to Engage Future Workforce," Employee Benefits, February 28, 2018.

[10] Different federal hiring authorities are available for use within the nuclear enterprise. One useful resource published by the Office of the Under Secretary of Defense for Acquisition and Sustainment's Office of Human Capital Initiatives is available online (see Office of the Under Secretary of Defense for Acquisition and Sustainment, Office of Human Capital Initiatives, "Hiring Authorities: DoD Hiring Authority Resources for the Acquisition Workforce," webpage, undated). In addition, DoD's Defense Civilian Personnel Advisory Service has a hiring authorities decision tool available online (see Defense Civilian Personnel Advisory Service, *Direct Hire Authorities: An Interactive Electronic Information Guide to the DoD Direct Hire Authorities*, Washington, D.C.: U.S. Department of Defense, September 2020).

[11] National Science Board, *The Skilled Technical Workforce: Crafting America's Science & Engineering Enterprise*, Alexandria, Va., September 2019, p. 25.

[12] Government of the United Kingdom, Department of Energy & Climate Change, *Sustaining Our Nuclear Skills—Nuclear Sector Skills Strategy: Government and Industry in Partnership*, 2015.

[13] Jennifer Lamping Lewis, Laura Werber, Cameron Wright, Irina Elena Danescu, Jessica Hwang, and Lindsay Daugherty, *2016 Assessment of the Civilian Acquisition Workforce Personnel Demonstration Project: Executive Summary*, Santa Monica, Calif.: RAND Corporation, RR-1783/1-OSD, 2017.

[14] Josie E. Coltman, Dominic Jones, and Paula Rosen, "Diversity and Inclusivity at AWE," *AIP Conference Proceedings*, Vol. 2109, No. 130002, June 2019.

[15] NASA, *Model Equal Employment Opportunity Program Status Report: FY2019*, Washington, D.C., May 2020.

[16] Matthew B. Miles and A. Michael Huberman, *Qualitative Data Analysis: An Expanded Sourcebook*, 2nd ed., Thousand Oaks, Calif.: Sage Publications, 1994.

[17] P. Adu, *A Step-by-Step Guide to Qualitative Data Coding*, Oxford: Routledge, 2019.

[18] J. T. DeCuir-Gunby, P. L. Marshall, and A. W. McCulloch, "Developing and Using a Codebook for the Analysis of Interview Data: An Example from a Professional Development Research Project," *Field Methods*, Vol. 23, No. 2, 2011.

[19] Johnny Saldaña, *The Coding Manual for Qualitative Researchers*, Thousand Oaks, Calif.: Sage Publications, 2016.

[20] Data from the ACS are hosted by IPUMS, a data repository run by the University of Minnesota (see Ruggles et al., 2021).

[21] The STEM occupation grouping came from Kathryn A. Edwards, Maria McCollester, Brian Phillips, Hannah Acheson-Field, Isabel Leamon, Noah Johnson, and Maria C. Lytell, *Compensation and Benefits for Science, Technology, Engineering, and Mathematics (STEM) Workers: A Comparison of the Federal Government and the Private Sector*, Santa Monica, Calif.: RAND Corporation, RR-4267-OSD, 2021. The defense acquisition grouping was adopted from Molly F. McIntosh, Patricia K. Tong, Hannah Acheson-Field, Noah Johnson, Norah Griffin, and Joshua Russell-Fritch, *Monetary and Nonmonetary Compensation for High-Value U.S. Department of Defense Civilian Skill Sets*, Santa Monica, Calif.: RAND Corporation, RR-A385-1, 2020.

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About This Report

This report summarizes the results of a quick-turn, 90-day assessment of the health of the national nuclear enterprise workforce, with a specific focus on federal personnel employed in the acquisition and the science, technology, engineering, and math (STEM) fields. The study team used a mixed methods approach that relied primarily on extant data to consider workforce health in terms of workforce planning, recruiting and hiring, employee engagement and development, leader development, and morale and retention. The report features findings about enterprise strengths, such as promising practices that are candidates for broader use, and factors that challenge workforce health, such as the evolving demand for more and different talent in response to the need to sustain existing nuclear weapon systems while simultaneously developing and transitioning to new and more-modern capabilities. The study team also offers options to bolster the health of the nuclear enterprise workforce, both now and over the next decade. Therefore, this report should be a useful primer for leaders, policymakers, analysts, and others responsible for managing or overseeing the nuclear enterprise in general and its workforce in particular.

The research reported here was completed in October 2021 and underwent security review with the sponsor and the Defense Office of Prepublication and Security Review before public release.

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