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The Need for Nuclear Deterrent Fundamentals Training

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SUMMARY

NNSA policy requires that personnel working in the Nuclear Security Enterprise (NSE) receive comprehensive training to be fully capable before they begin their work and that personnel receive ongoing training to maintain their capability and competence.

However, the loss of experienced NSE staff through retirements and the influx of personnel who are inexperienced and untrained in nuclear weapons technology make these training requirements difficult to achieve.

This paper presents an approach for developing and delivering a nuclear deterrent (ND) fundamentals curriculum to respond to these challenges. The training approach leverages existing material already used by Sandia National Laboratories in the ND training arena and proposes to deliver the material in an e-learning format as much as possible. The approach also seeks to maximize the amount of material to be delivered in an unclassified setting.

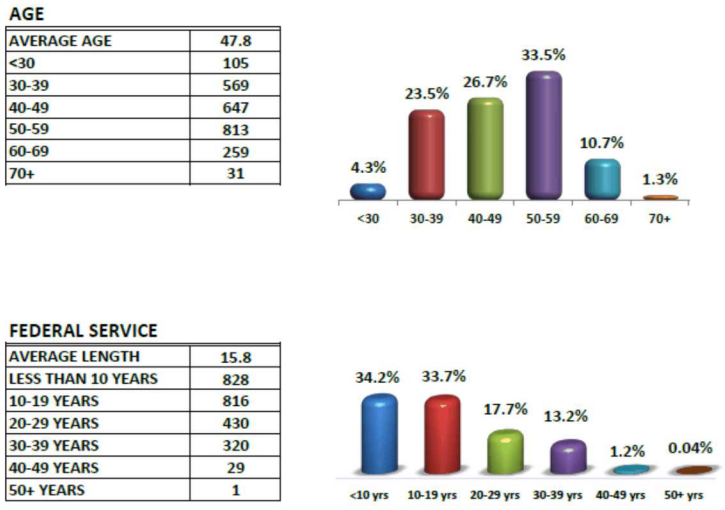
BACKGROUND

NNSA policy (NNSA, 2015) requires that:

- Personnel be trained and/or qualified to be capable and competent before performing their assigned work.
- Personnel receive continuing training to maintain job proficiency.
- Evidence of training, qualification, and/or certification is maintained.
- Qualification is based on a combination of factors including education, training, skills, and experience (NNSA, 2015).

Ensuring that new personnel are quickly and effectively grounded in the NNSA Nuclear Security Enterprise (NSE) mission and acquire a fundamental knowledge of nuclear weapons and the NSE present a significant challenge.

The challenge is aggravated by the departure of experienced personnel and a large influx of personnel into the NSE who have little to no experience with nuclear weapons technologies. As Figure 1 shows, a large portion of the NSE workforce is retirement-eligible and a substantial part of the workforce that has less than 10 years federal service experience (NNSA Office of Civil Rights, 2018).



AGE

AVERAGE AGE	47.8
<30	105
30-39	569
40-49	647
50-59	813
60-69	259
70+	31

FEDERAL SERVICE

AVERAGE LENGTH	15.8
LESS THAN 10 YEARS	828
10-19 YEARS	816
20-29 YEARS	430
30-39 YEARS	320
40-49 YEARS	29
50+ YEARS	1

Figure 1 NNSA Workforce Statistics Report (September 2018).

These challenges exist throughout the NSE. At Sandia National Laboratories, a substantial part of the workforce is retirement-eligible, and approximately 48% of the workforce was hired in the past 5 years (Figure 2) (Nelson, 2017). Similarly, Los Alamos National Laboratory diversity figures report that 32.8% of the Los Alamos National Laboratory workforce are millennials (Los Alamos National Laboratory, 2018).

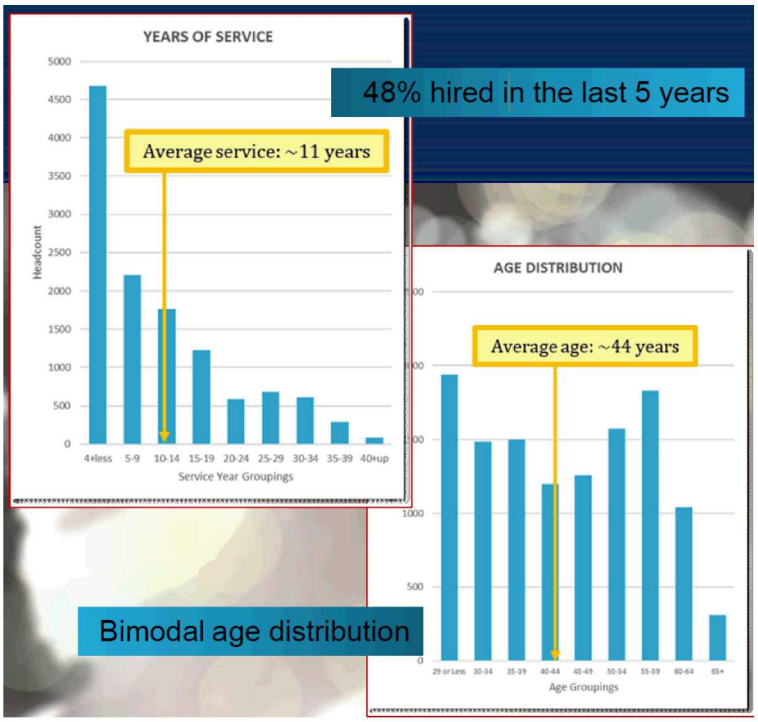


Figure 2 Sandia Workforce Overview (October 2017).

Conversations with other DOE lab personnel also provide anecdotal evidence that experienced personnel exits and retirements and the influx of large numbers of personnel with little or no ND experience is pervasive in the NSE. The NSE is in dire need of a systematic and deliberate effort to capture the knowledge of the exiting experts while providing quick and effective education and training for the incoming generation.

TRAINING THE NEXT GENERATION

The NSE faces a significant challenge in training the many thousands of people entering the ND workforce. Sandia alone expects to hire around 1500 in the next year to bolster its staff due to new programs and expected separations. Los Alamos and Lawrence Livermore National Laboratories and DOE and NNSA are going through similar hiring and training challenges.

Adding to the training and qualification challenge facing the NSE is the length of time required to obtain a "Q" clearance. The current "Q" clearance process takes from nine to eighteen months, making it difficult to train new personnel who have no access to classified information.

To meet the extensive needs and challenges of preparing those entering the ND workforce, this paper proposes five curriculum topic areas, a training approach, and suggestions for implementing nuclear deterrent training for the NSE.

ND Fundamentals Curriculum Topics

The ND fundamental topics are separated in to five broad sections:

1. ND Historical Perspective

2. ND Systems Fundamentals
3. ND Safety and Security
4. NSE and ND Complex Today
5. Sandia ND Operations

Sections 1–4 are not organization-specific and will be used complex-wide to educate and train employees new to the ND mission about the NSE. The fifth section identified is organization-specific. In that section, Sandia National Laboratories is used as an example to illustrate the type of content that is expected in this section. Each entity in the NSE is expected to develop its own organization-specific material for section 5.

This curriculum will be delivered through e-learning as much as possible, complemented by a recommended reading list that the student can use to dive deeper into topics of interest. The Sandia National Laboratories Weapon Engineering Professional Development organization will develop, maintain, and update the curriculum. To make the unclassified material accessible to the entire NSE, it will be available online through a national capability such as the Department of Energy National Training Center web site (Department of Energy, 2018).

The following five sections outline the content for each of the curriculum sections. Whenever possible, existing resources and training are identified to show how existing materials can be leveraged to minimize development time.

ND Historical Perspective

This section provides a historical look at our ND mission. The book *Building the Bombs* (Loeber, 2016) and *The Nuclear Matters Handbook* (Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, 2016) will be leveraged as much as possible to provide an unclassified history of our nuclear deterrent and its evolution over the decades. This section will be broken up into three or four parts and covering the salient points of our ND history. Sandia National Laboratories has an existing training course, History of the Nuclear Weapons Complex, that includes significant video material that can be leveraged to develop the training. In addition to the unclassified portions, a classified portion would cover the details of our legacy stockpile weapons. Sandia's Nuclear Weapon Legacy Hardware Familiarization course would provide a basis for the classified portion.

The educational objective of this section is to provide the context and background of how and why the nuclear deterrent has changed. This section will also put into context how other countries have pursued nuclear weapons interests and the impact of those endeavors on U.S. nuclear weapons development. The outcome of this training will be that the students will understand the range of historical events that drove the development of the US nuclear weapons.

Table 1 outlines the lectures to be included in the ND Historical Perspective section.

Table 1. Historical Perspective Outline.

Topic	Time	Classification	Source Leveraged
Events Leading to the Manhattan Project	60 min	Unclassified	(Loeber, 2016) (Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, 2016)
The Manhattan project, WWII, and the start of Cold War	60 min	Unclassified	(Loeber, 2016) (Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, 2016)
The Cold War	60 min	Unclassified	(Loeber, 2016) (Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, 2016)
End of the Cold War and today	60 min	Unclassified	(Loeber, 2016) (Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, 2016)
Legacy Stockpile	60 min	Classified	WR867
Global Nuclear Landscape	45 min	Unclassified	(Defense Intelligence Agency, 2018)

ND Systems Fundamentals

The systems fundamentals section, which will be classified, will present the fundamental physics that make a nuclear weapon work and will provide a review of the current stockpile and various subsystems and components. This section will close with an explanation of nuclear weapons effects, based on three Sandia training courses (WR 712, Operation of the Nuclear Security Enterprise; WR713, Engineering Guide to nuclear Weapons Development, Production; and WR708, Stockpile and Survey of Weapons Development and Technology) and Military Liaison training offered at Sandia.

The objective of this section is to provide students with the technical background that has shaped the development of our nuclear weapons. This section will also expose students to our current stockpile and develop an understanding of the devastating power of nuclear weapons. At the end of this training, students will understand the general physics that make a nuclear weapon work, the general makeup of our current stockpile and the various effects created by a nuclear blast.

Table 2 outlines the lectures to be included in the ND Systems Fundamentals section.

Table 2. ND Systems Fundamental Outline.

Topic	Time	Classification	Source Leveraged
NW Physics	120 min	Classified	WR708
Current Stockpile and Subsystems	180 min	Unclassified/ Classified	WR708, WR713, WR712
Weapons Effects	90 min	Unclassified	(Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, 2016)

ND Safety and Security

This section will focus on the safety and security of our nuclear weapons. Sandia WR708, WR713, Accident Response Group (ARG) training, Nuclear Explosive Safety training, and Nuclear Safety Training (NST) materials will be leveraged to generate the lectures for this

section. In addition, this section will include a lecture on Nuclear Enterprise Assurance (NEA). Sandia's NEA 101 course, Understanding Threats and Vulnerabilities, will be used as the basis for the NEA content.

The objective of this section is for student s to understand the drivers for nuclear safety. Students will understand the link between major accidents and significant safety improvements. This section will help students understand the role of various accident response groups. In addition, this section will expose students to nuclear enterprise assurance (NEA) and the potential security risks to our stockpile. After this training, students will understand the drivers for nuclear safety and security and be able to apply nuclear safety and security principals.

Table 3 outlines the ND Safety and Security lectures.

Table 3. ND Safety and Security Outline.

Topic	Time	Classification	Source Leveraged
Nuclear Safety	120 min	Unclassified	WR708, WR713, NST
Nuclear Accidents	60 min	Classified	WR708, WR713, NST
Accident Response	60 min	Classified	ARG, NEST
NEA	180 min	Classified	NEA101

NSE and ND Complex Today

This section will present the drivers associated with the ND mission. In addition, the structure of the ND enterprise and the roles and responsibilities for each of the ND organizations will be presented.

The objective of this section is to have students understand and appreciate the policy and political drivers associated with our nuclear weapons. Students will also understand the makeup of the ND complex today and the role of each of the organizations that make up the ND enterprise. After this training, students will be able to identify the policy and drivers that shape out ND mission and the major organizations that form our ND enterprise including their roles and responsibilities.

Table 4 is an outline for the NSA and ND Complex Today Section.

Table 4. NSE and ND Complex Today Outline.

Topic	Time	Classification	Source Leveraged
Policy and Drivers	120 min	Unclassified	(Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, 2016), NPR, WR712
Roles and Responsibilities for the ND Enterprise	180 min	Unclassified	Corey Cruz Presentation, (Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, 2016)

Sandia ND Operations

This section will contain a detailed description of Sandia's role in the NSE. The section will include Sandia's history and organization. The section will also include descriptions of how Sandia operates and how product is developed.

The objective of this training is to familiarize students with Sandia National Laboratories, its role as part of the NSE, the internal Sandia processes governing the ND enterprise, and the role of Sandia's military liaison mission. After the training, students will be able to recognize the various Sandia organizations and their roles and responsibilities in the ND enterprise. The students will also be familiar with all the internal Sandia processes and understand the requirements and implementation of these requirements in Sandia operations.

Table 5 outlines the lectures for section five. This section will leverage WR712 offered at Sandia.

Table 5. Sandia ND Operations Outline.

Topic	Time	Classification	Source Leveraged
SNL role in the NSE SNL Organization	60 min	Unclassified	WR712
SNL Product Realization Framework	60 min	Unclassified	WR712
SNL Process to meet Requirements	60 min	Unclassified	WR712
SNL Surveillance	60 min	Unclassified	WR712
SNL Information Repositories	30 min	Unclassified	WR712
SNL Military Liaison	30 min	Unclassified	WR712

Training Approach

The training challenges facing the ND enterprise, detailed earlier, make it imperative to establish a comprehensive training and curriculum development program. The curriculum must include enough unclassified material that uncleared personnel can be trained in as many areas as possible while waiting for their clearances. The program must also allow new staff to have timely access to the training to become productive as fast as possible.

Traditional in-classroom training does not effectively address the ND enterprise needs. Inadequate numbers of instructors, instructor availability, subject matter expert availability, and classroom size create bottlenecks and force delays in training. Classes end up being offered only a few times per year and, because of classroom size and availability, they can only address a fraction of the demand imposed by the large number of new personnel.

E-learning presents a unique opportunity to deliver agile, on-demand training that can be synchronous as well as asynchronous. Significant research has shown that e-learning is as effective as classroom learning and also provides advantages over traditional classroom training

(Clark & Mayer, 2008) (Nguyen, 2015) (Noesgaard & Ørngreen, 2015) (Singh, 2003) (Thalheimer, 2017).

Thalheimer suggests that the learning modality (e-learning vs. classroom) is NOT what matters for learning effectiveness; the learning methods matter, including such factors as realistic practice, spaced repetitions, real-world contexts, and feedback (Thalheimer, 2017). Effective design of the e-learning material is the key to learning effectiveness. Thalheimer's research also suggests that a rigorous instructional design process is essential to developing an effective program in either e-learning or classroom instruction.

Effective development of an ND fundamentals curriculum demands that the breadth and depth of the ND material to be covered is well defined. The next section of this paper addresses the elements that must be included in an ND fundamentals curriculum and proposes a path forward for the ND enterprise to develop and execute an NSE-wide ND fundamentals training program.

SUGGESTED IMPLEMENTATION STRATEGY

To implement the ND fundamentals training for the NSE, this paper proposes initiating a three FTE, year-long effort at Sandia National Laboratories. The first six months of that effort should concentrate on generating the training materials from existing training resources. As part of this process, a gap analysis will be conducted to identify requirements for generating new material and a robust set of training policies and procedures that are consistent with modern training practices. As soon as training material is available, it should be piloted and refined so that it can be implemented across the NSE.

The second half of the first year should focus on finishing the training material and implementing it across the NSE. After the first year, the effort should enter a maintenance mode with a yearly assessment of the curriculum to address any concerns and a major review every two years to update and refresh the training material.

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