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Nondestructive Assay Technical Infrastructure Program Mission and Vision

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NONDESTRUCTIVE ASSAY TECHNICAL INFRASTRUCTURE PROGRAM MISSION AND VISION

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ABBREVIATIONS

AD&ND	Algorithm Development and Nuclear Data
DM	Data Management
DNFSB	Defense Nuclear Facilities Safety Board
DOE	United States Department of Energy
DQO	data quality objective
HSD	Hardware/Software Development
IPD	Information Preservation and Dissemination
LEU	low-enriched uranium
NCS	nuclear criticality safety
NCSP	Nuclear Criticality Safety Program
NDA	nondestructive assay
NDAP	Nondestructive Assay Program
NM	Nuclear Material
NNSA	United States National Nuclear Security Administration
NSR&D	Nuclear Safety Research and Development
ORNL	Oak Ridge National Laboratory
R&S	Requirements and Standards
SP&T	Staffing, Personnel, and Training
TPE	technical program element
TSG	technical services group
UQ	Uncertainty Quantification

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ABSTRACT

The Nondestructive Assay Program (NDAP) mission and vision is achieved by identifying and accomplishing a set of programmatic goals that correspond with eight broad technical program elements. The NDAP was created as a result of Defense Nuclear Facility Safety Board Recommendation 2007-1, entitled "Safety-Related In Situ Nondestructive Assay of Radioactive Materials," which emphasized the need to improve in situ measurements of radioactive material at US Department of Energy (DOE) defense nuclear facilities. An NDAP five-year plan will define tasks to accomplish specific goals identified in the NDAP mission and vision. This mission and vision is applicable for eight technical program elements:

- Hardware/Software Development
- Algorithm Development and Nuclear Data
- Uncertainty Quantification
- Nuclear Materials
- Staffing, Personnel, And Training
- Data Management
- Requirement and Standards
- Information Preservation and Dissemination

An additional program element is technical support, which provides daily execution management support for the NDAP, site scope, and deliverable tracking via site task managers, along with technical advisement and support from the technical support group. The NDAP mission and vision provides attributes with specific goals for each program element, and some goals benefit multiple program elements. The goals and attributes defined herein are implemented via an NDAP five-year execution plan that defines site work scope, budget, and deliverables, all of which are updated annually. The NDAP is designed to benefit nondestructive assay (NDA) needs to support DOE nuclear criticality safety programs, ensuring that NDA technology is sufficiently capable of guaranteeing the safety of those who handle, store, process, or transport fissionable materials in the complex. Especially important for the NDAP is to maximize capabilities to identify, characterize, and manage in situ fissile material deposits in process equipment to ensure nuclear criticality safety at processing facilities.

1. INTRODUCTION

Nondestructive assay (NDA) is a term applied to a series of measurement techniques that measure radiation emitted spontaneously or induced by nuclear materials in various chemical and physical forms. The goal of the measurement is to relate the intensity of the measured emissions to the amount of nuclear material present. The measurements are nondestructive because the measurement technique does not alter the physical or chemical state of the nuclear material. NDA can be performed on radioactive materials in situ, held within a container, or during fissionable material operations. This is ideal when access to the material is impossible or undesirable, and also when weighing, laboratory analysis, and calorimetry are not viable options.

NDA is used by multiple US Department of Energy (DOE) programs and missions to characterize nuclear materials to ensure safety, security, and compliance with regulatory requirements and consensus standards. The end users are from various areas of specialization, such as nuclear criticality safety (NCS), facility safety basis, nuclear material safeguards, decommissioning, waste management, radiation control, and material control and accountability. Even though each end user has unique objectives and will use measurement results and associated uncertainties differently, the overall goal of the NDA program is the same: to provide consistent and defensible measurements with estimates of uncertainty that meet the needs of the end users. Because NDA plays such a prominent role in multiple diverse areas across the DOE complex, it is beneficial and cost effective for DOE to ensure that the elements of a strong and reliable NDA program are in place and functioning correctly and that needs are identified and addressed with appropriate actions in a reasonable time frame; these are the tasks of the Nondestructive Assay Program (NDAP) mission and vision. Each year, a task plan will be generated to summarize the scope, budget, milestones, and work authorizations for sites supporting the NDAP. DOE's National Nuclear Security Administration (NNSA) Nuclear Criticality Safety Program (NCSP) is currently the program sponsor for the NDAP and has a federal project manager to assist with selecting and authorizing proposals for funding in the NDA program task plan.

1.1 BACKGROUND

In situ measurements of radioactive materials are performed to monitor and detect the holdup or accumulation of fissile material in process ventilation, piping, and processes over time that could eventually develop into significant NCS concerns and, potentially, a worker safety risk. In situ NDA activities are only a single component of an overall NDAP at a site that relies on NDA techniques and measurements for safety-related activities. For example, NDA measurements are required for material accountability and control (e.g., verifying that nuclear materials are accounted for and that loss, theft, or diversion has not occurred), NCS limit compliance (e.g., complying with fissile material mass limits), and radiation protection requirements. Thus, general NDA techniques are crucial for routine operations and for safeguarding nuclear facilities, and they are inherently part of a site's overall safety management program structure, providing an integral function in support of a site's nuclear criticality safety program.

On April 25, 2007, the Defense Nuclear Facilities Safety Board (DNFSB) issued Recommendation 2007-1, entitled "Safety-Related In Situ Nondestructive Assay of Radioactive Materials," which emphasizes the need to improve in situ measurements of radioactive material at DOE defense nuclear facilities [1]. The DNFSB recommendation cites three specific examples in which errors associated with in situ holdup measurements resulted in the amount of radioactive material being initially underestimated, causing smaller-than-expected safety margins and violations of criticality safety limits. The recommendation also identified three significant technical and regulatory issues with respect to in situ NDA: (1) The lack of standardized requirements for performing measurements in DOE guides and standards; (2) the lack of design requirements for new facilities to facilitate accurate holdup measurement

or to minimize fissile material holdup; and (3) the lack of R&D activities for new instrumentation and/or measurement techniques. DOE accepted the recommendation and corrected numerous deficiencies to close out the recommendation.

To further identify ongoing NDA challenges and programmatic needs, especially those that cut across multiple organizations and missions, the Nuclear Safety Research and Development (NSR&D) Program, managed by the NNSA's Office of the Chief of Defense Nuclear Safety (NA-511) with assistance from Oak Ridge National Laboratory (ORNL), organized the *Workshop on the Technical and Programmatic Needs for a Sustainable NDA Program for the US DOE* held at ORNL on April 10–12, 2018 [2]. Participants representing multiple DOE organizations (including the NNSA, the Office of Environmental Management, several national laboratories, and several contractors overseeing nuclear site operations) provided perspectives on NDA utilization, contributed to identifying current and emerging challenges and technical gaps for NDA within the DOE complex, and confirmed the value of a formal, national NDA technical support program. Improved, coordinated, complex-wide NDA technology has the potential to significantly improve operational efficiency and mitigate safety, security, and operational risk. A second workshop dedicated to improving fissionable material holdup monitoring in the United States was conducted on August 21–22, 2019. Staff from DOE/NNSA, DOE's Office of Environmental Management, national laboratories, the US Nuclear Regulatory Commission, and commercial fuel fabricators participated in the presentation discussions and the four breakout sessions. The workshop started with a review of the *Workshop on the Technical and Programmatic Needs for a Sustainable NDA Program for the US DOE*. Other presentations emphasized holdup challenges, holdup measurement, innovative solutions and emerging technologies, and lessons learned. Breakout sessions were conducted on the following topics [3]:

1. uranium-specific holdup challenges,
2. plutonium-specific holdup challenges,
3. avoiding inadvertent accumulations, and
4. reducing measurement uncertainty, which also provided participants an opportunity to contribute meaningful thoughts and ideas on holdup measurement topics.

These workshops were invaluable for identifying critical needs for the NDA community across the DOE complex and beyond. This DOE NDA program mission and vision will provide attributes and goals to support the identified challenges and critical needs discussed in the workshops. A well-organized holdup program would benefit all end users of NDA technology, such as those in NCS, material control and accountability, and environmental management programs, and it would also benefit US nuclear facility operations [3].

1.2 NONDESTRUCTIVE ASSAY PROGRAM

The combined results from DNFSB Recommendation 2007-1 [1] and the April 2018 NDA workshop form, in part, the basis of the NDAP to support NCS programs in the DOE complex.

The DOE NDAP mission is to provide sustainable expert leadership, direction, and the technical infrastructure necessary to develop, maintain, and disseminate the essential technical tools, training, and data required to support site NDA programs in their tasks of providing measurements with estimates of uncertainty that meet the needs of the end users. To do this, DOE must: (1) help provide training and qualification for essential site NDA personnel; and (2) help ensure that criteria to be met by NDA measurements are well defined and achievable, that NDA program functions are documented in procedures, that a body of subject-matter experts is available to provide advice and technical support to

the sites and to DOE, and that NDA programs are using adequate technology and instrumentation to obtain measurement results.

The DOE NDAP vision will be a continually improving, adaptable, and transparent program that communicates and collaborates globally to incorporate NDA technology, practices, and programs to ensure that they are responsive to the essential technical needs of those responsible for developing, implementing, and maintaining site NDA programs and the needs of NDA end users to support nuclear safety goals in the DOE complex.

The NDAP mission and vision is achieved by identifying and accomplishing a set of programmatic goals that correspond with eight broad technical program elements. An NDAP five-year plan defines tasks designed to accomplish specific goals identified in the NDAP mission and vision. The eight technical program elements highlighted in the NDA workshops [1, 2] are the following:

- Hardware/Software Development (HSD)
- Algorithm Development and Nuclear Data (AD&ND)
- Uncertainty Quantification (UQ)
- Nuclear Material (NM)
- Staffing, Personnel, and Training (SP&T)
- Data Management (DM)
- Requirements and Standards (R&S)
- Information Preservation and Dissemination (IPD)

An additional program element is technical support, which provides daily execution management support for the NDAP, site scope, and deliverable tracking via site task managers, along with technical advisement and support from the technical support group (TSG).

The NDAP mission and vision provides attributes with specific goals for each program element, and some goals benefit multiple program elements. The goals and attributes defined herein are implemented via an NDAP five-year execution plan that defines site work scope, budget, and deliverables, all of which will be updated annually. Each task in the five-year plan aligns with a specific NDAP mission and vision goal.

1.3 MISSION AND VISION OF THE NDA TECHNICAL INFRASTRUCTURE PROGRAM

The mission and vision for the NDAP provides the programmatic baseline for NDA needs in the DOE complex to augment NCS programs. Available programmatic funding will be used to address attributes and goals identified in this report. Using the mission and vision for the NDAP as a baseline, a task plan will be developed that will define programmatic scope, milestones, deliverables, and budget for prioritized tasks for the eight technical program elements. A task plan will be developed each year. The number of prioritized tasks will be based on the available funding for the program. Proposed tasks will be reviewed by the NDA TSG using the program mission and vision to help prioritize the tasks.

2. TECHNICAL PROGRAM ELEMENTS

The DOE NDAP will be defined around technical program elements (TPEs) to efficiently organize the gaps and needs for NDA programs across the DOE complex. These TPEs are based on two workshops held at ORNL in 2018 and 2019:

1. *Technical and Programmatic Needs for a Sustainable NDA Program for the US DOE* [1], held April 10–12, 2018
2. *Workshop on Improving Holdup Monitoring in the US* [2], held August 21–22, 2019

2.1 HARDWARE/SOFTWARE NEEDS

The HSD program element encompasses the following requirements for consistency in the NDA measurement process: appropriate equipment (hardware, software, electronics) is used for measurements, equipment is properly calibrated, measurement objectives (also known as data quality objectives or DQOs) to be met are agreed upon between NDA staff and end users, and appropriate measurement control activities are implemented.

This element will ensure that a consistent and defensible approach to each NDA measurement is defined, that the customer objectives are achieved, and the standardization and consistency of NDA measurements across the DOE complex are supported.

This element will also address the needs within the NDA community, including improvements in current equipment and/or techniques, and identify emerging needs in hardware, software, and measurement techniques.

This element also encompasses support for the development of a round-robin measurement campaign (between national laboratories) of equipment and/or nuclear materials to promote good practice and communication between measurement teams and stimulate acceptance and trust in the applied methods and results between facilities. The results/benefits of such a campaign are also applicable to other program elements, including AD&ND, UQ, NMs, DM, and SP&T.

The HSD element will provide guidance and direction to NDA programs in these important areas. By doing so, DOE will strengthen and enhance the ability to perform consistent and defensible NDA measurements at sites across the DOE complex. The HSD element will also identify and provide resources, funding, and guidance for hardware and software needs within the NDA community that can only be addressed through R&D activities. This element will utilize input from NDA professionals, the TSG, and periodic reviews of NDA programs.

The following strategy has been developed to direct the HDS element towards achieving its vision. The HDS element will accomplish the following:

- Actively engage NDA personnel to identify their hardware, software, and measurement technique needs through various means of communication and develop and implement capabilities to meet those needs.
- Develop consistent, standardized guidelines for NDA measurement system qualification processes to facilitate acceptance and use of appropriate NDA systems in a cost-effective and timely manner, with input from the TSG and other NDA experts/professionals.

- Improve process for locating and characterizing material holdup in large process equipment and items, with input from the TSG and other NDA experts/professionals.
- Continually identify areas where R&D efforts are needed (hardware, software, and measurement techniques), with input from the TSG and other NDA experts/professionals.
- Identify funding sources for R&D efforts and prioritize those efforts; also identify work being done by other agencies/commercial vendors that could be used within the DOE complex.
- Support and increase access to nuclear facilities that can enable empirical demonstration of new measurement systems under realistic (but known and controlled) conditions.
- Support the development and execution of a round-robin measurement campaign with equipment and/or nuclear materials to promote good practices, communication, testing, and acceptance of various methods, equipment, and materials.
- Support the development of an equipment repository for necessary but seldom-used equipment.
- Support increased access and sharing of equipment/hardware/detection systems that are difficult to obtain/maintain and/or that are necessary but not used as often as other NDA hardware (possible development of an equipment repository).

Table 1. Hardware/software attributes and goals

Attributes	Goals
Standardized NDA measurement system qualification processes	Establish a formalized (and nationally recognized) system qualification process to simplify and unify the qualification of systems already in use and introduce pertinent performance demonstration testing: • Identify measurement controls program requirements by site. • Develop a formalized verification and validation process for algorithms and software to ensure reliable, consistent, and trusted results across the community. • Develop a formalized performance test and validation plan for NDA systems/hardware. • Document and share the performance test and validation reports and evaluations for qualification of NDA systems.
	Perform round-robin measurement campaigns (between national laboratories) to promote good practice and communication between measurement teams and stimulate acceptance and trust in the applied methods and results between facilities.
System or process for locating/characterizing in situ material in large process equipment and items	Document and share current process monitoring methodologies used at DOE sites.
	Support studies on unattended and continuous monitoring capabilities to measure flows and processes, assist in material balance measurements, and provide confidence in facility operations over long periods of time.
	Develop advanced neutron measurement techniques to evaluate thick deposits in heavy equipment.
	Develop analysis techniques capable of measuring volumetric holdup deposits.
Advanced detector development and system integration	Implement a support program to help identify and address emerging incompatibilities between computer systems and measurement software/hardware.
	Survey and document user requirements for field instrumentation.
	Perform a study to outline acceptable communication criteria (based on power levels and frequencies) needed to engineer RF, wireless, or Bluetooth communication technologies acceptable for use by NDA practitioners.
	Support studies utilizing emerging technologies and analyze their impact on detection efficiency and measurement uncertainty.
	Facilitate deployment of smaller and more capable (multidetector support) multichannel analyzers by developing plug and play drivers that are compatible with currently used data acquisition platforms.

Attributes	Goals
	Formalize hardware/software testing at sites and labs prior to field tests. • Establish standardized test plans.
	Invest in infrastructure (e.g., equipment, reference materials) to support R&D testing.
Access to nuclear facilities	Provide resources to sufficiently test NDA systems (equipment, nuclear materials, mock measurements scenarios that correctly mimic attenuation properties, cosmic spallation production) to ensure that deployed systems are well understood and capable of delivering trusted and reliable results.
	Increase support for joint measurement campaigns and field trials such that adequate testing can be performed.

2.2 ALGORITHM DEVELOPMENT AND NUCLEAR DATA (AD&ND)

The AD&ND program element will address needs in the NDA community related to the algorithms (and associated software) for nuclear data used within the NDA community.

The AD&ND element will provide guidance and direction to NDA programs for algorithm use and development. The AD&ND element will also identify and provide resources, funding, and guidance for algorithm and improved nuclear data needs within the NDA community that can only be addressed through R&D activities. This element will utilize input from NDA professionals, the TSG, and periodic reviews of NDA programs.

The following strategy was developed to direct the AD&ND element towards achieving its vision. The AD&ND element will accomplish the following:

- Actively engage NDA personnel to identify their algorithm and nuclear data needs and requirements through various means of communication and develop and implement capabilities to meet those needs.
- Streamline algorithm development by increasing the practicality and utility of algorithms, as well as reduce duplication efforts across the complex in the process, with input from the TSG and other NDA experts/professionals.
- Develop a searchable data archive to support algorithm testing and trend analyses; establish historical archive for NDA datasets.
- Support a controlled mechanism for distributing and sharing algorithms (including associated data and software quality assurance methods) across the DOE complex.
- Adapt algorithms to support the use of neutron generators in place of radioactive sources to reduce cost and source availability issues.
- Identify and support nuclear data needs and experiments to improve algorithm performance, with input from the TSG and other NDA experts/professionals.

Table 2. Algorithm development and nuclear data

Attributes	Goals
Algorithms and software programs for NDA applications	Support algorithm development and testing in the following areas: • Neutron multiplicity counting, including assay and background characterization • In situ measurements of volumetric sources • Isotopic analyses (enrichment and composition) that build on R&D outside of the traditional nuclear spectroscopy domain • Integration of end effects and lump corrections for segmented gamma scanner analyses • Low-enriched uranium (LEU) analyses methods to address ^{99}Tc interferences (from recycled U) • Analysis techniques for materials (e.g., LEU and new fuel types) where traditional techniques tailored to ^{235}U gamma rays are limited by self-attenuation • Analysis techniques for commercial or research reactor spent nuclear fuel
	Investigate approaches to expand software packages to handle contaminants, interferences, chunks, nonuniformities, and truly unknown items where assumptions are difficult, compared with the traditional routine of developing single-purpose systems.
	Develop flexible software platforms that include trending and archiving capabilities and use a standard interface specification independent of equipment vendor.
Searchable data archive	Develop dataset requirements and survey NDA community for existing and needed datasets.
	Develop and maintain an online database architecture to manage the storage, filtration, and retrieval of measurement data.
	Establish an algorithm sharing mechanism to enable users and sites to obtain and/or distribute new or updated software for testing and use.
Neutron generators as replacements for active neutron sources	Evaluate the potential for portable neutron generators to replace radioactive sources in existing active NDA systems (e.g., AmLi and ^{252}Cf).
	Support updates to measurement software/algorithms to integrate use of neutron generators.
Improved and expanded nuclear data	Survey NDA applications specialists and algorithm developers to identify nuclear data needs.
	Prioritize nuclear data needs based on potential reduction in measurement uncertainties.
	Support nuclear data projects and experiments.

2.3 UNCERTAINTY QUANTIFICATION (UQ)

The UQ program element will address needs in the NDA community related to uncertainty quantification with various NDA methods. This element will include considerations regarding the uncertainty in models and methods used, in assumptions made, and in the underlying nuclear data.

The UQ element will provide guidance and direction to NDA programs in uncertainty quantification. The UQ element will also identify and provide resources, funding, and guidance for uncertainty quantification needs within the NDA community that can only be addressed through R&D activities. This element will utilize input from NDA professionals, the TSG, and periodic reviews of NDA programs.

The following strategy was developed to direct the UQ element towards achieving its vision. The UQ element will accomplish the following:

- Actively engage NDA personnel to identify their uncertainty quantification needs and requirements through various means of communication and develop and implement capabilities to meet those needs.
- Develop a consistent methodology for uncertainty quantification, with input from the TSG and other NDA experts/professionals.
- Support development of modeling and simulation techniques in computer codes to improve application models and reduce measurement uncertainties, with input from the TSG and other NDA experts/professionals.

Table 3. Uncertainty quantification

Attributes	Goals
Uncertainty quantification	Identify the current methodologies used across DOE for estimating uncertainty.
	Identify the mechanism(s) by which UQ methodologies are validated.
	Identify data quality objectives (agreements between end users and NDA personnel) for each site across DOE.
	Establish a support group and set of case studies for different techniques.
	Confirm or validate NDA measurements by supporting destructive analysis on measured items.
Advanced inverse modeling techniques	Evaluate the application and use of modeling and simulation to perform sensitivity analyses to better outline measurement uncertainties.
	Investigate the use of Bayesian logic to decide the best solution to various problems.
	Transition to improved application models. A national technical support program should nurture and facilitate expanded use of modern radiation transport codes within measurement systems to correct for attenuation, spatial, and other effects. An effort to enable and provide guidance on incorporation of these modern codes into the measurement systems would, for many cases, substantially improve measurement uncertainties and reduce reliance on incorrect assumptions.

2.4 NUCLEAR MATERIALS (NM)

The NM program element will address needs in the NDA community related to reference nuclear materials used for calibration, testing, and confirmation of various NDA methods. This element encompasses the development and use of new reference materials, the utilization of existing reference nuclear materials, and development and use of current and new calibration methodologies.

The NM element will ensure that appropriate nuclear material standards are available for use by NDA programs, and it will support making calibration technologies (including detector response modeling using computer codes) more robust. This element will utilize input from NDA professionals, the TSG, and periodic reviews of NDA programs.

The following strategy was developed to direct the NM element towards achieving its vision. The NM element will accomplish the following:

- Actively engage NDA personnel to identify their nuclear material needs and requirements through various means of communication and develop and implement capabilities to meet those needs.

- Support development of materials and guidelines for difficult-to-measure nuclear material and more complex nuclear material, with input from the TSG and other NDA experts/professionals.
- Support development of representative, traceable standards to support calibration and validation of measurement systems, support hands-on relevant training of NDA personnel, help benchmark computer simulations, validate measurement assumptions, and reduce measurement uncertainties, with input from the TSG and other NDA experts/professionals.
- Support and increase access to existing reference materials to support the development, testing, calibration, and validation of NDA-related technology.
- Support increased access and sharing of nuclear materials that are difficult to obtain and/or that are necessary but not used as often as other common standards (possible development of a nuclear material repository).

Table 4. Nuclear materials

Attributes	Goals
New reference standards	Perform a survey of NDA reference material needs across the DOE complex.
	Support the development and production of new certified reference materials.
Access to existing reference nuclear materials	Perform a survey of existing NDA reference materials within DOE.
	Explore ways to facilitate acquisition and ease the transfer of nuclear materials and equipment between sites (often, it is easier to dispose of excess items than to transfer them).
	Support procurement of adequate nuclear materials to improve and preserve nuclear measurement capabilities.
Standardized and improved data analysis processes	Develop a formalized process to link simulations and calibrations (e.g., published case studies and guidance on reporting).
	Evaluate the use of integrated data (i.e., measurement data from several NDA methods) to confirm agreement between NDA methods and instruments.

2.5 STAFFING, PERSONNEL, AND TRAINING (SP&T)

The SP&T program element will help ensure that sufficient training courses, education, professional development, and qualification opportunities are provided for NDA personnel and personnel who interface significantly with NDA programs. The primary purpose of the SP&T element is to maintain and enhance the technical abilities and knowledge of NDA practitioners and all those who impact the use and quality of NDA measurements. This element also encompasses developing standardized qualification guidelines for NDA personnel.

The SP&T element will identify, develop, provide, and promote practical and excellent technical training and education resources that help ensure the competency of NDA personnel. It will be adaptable and responsive to the needs of those developing and performing NDA methods. This element will utilize input from NDA professionals, the TSG, and periodic reviews of NDA programs.

The following strategy was developed to direct the SP&T element towards achieving its vision. The SP&T element will accomplish the following:

- Continually evaluate qualification and knowledge expectations and communicate identified needs for training and education purposes.
- Actively communicate, promote, and evaluate new and available training and education opportunities.
- Be responsive to identified training and education needs by developing and providing resources that sustain NDA capabilities and adequate oversight and awareness of NDA requirements.

- Provide sustainable, cost-effective, hands-on training of various NDA methods.
- Integrate training and education objectives through sharing of resources and information with national and international partners.
- Develop transparent processes to support efficient application of training and qualification of NDA practitioners within NDA programs.
- Facilitate existing and support development of new professional development opportunities for NDA practitioners.
- Develop qualification requirements for those supporting NDA programs, with considerations for variability of NDA programs across the DOE complex.
- Support development of mentorship programs and succession planning, and foster retention of NDA expertise.

Table 5. Staffing, personnel, and training

Attributes	Goals
Strengthened NDA workforce	Explore and identify potential models, tiers, and progression for nationally accepted NDA training qualifications. • Identify technical competencies for NDA practitioners like the *Criticality Safety Qualification Standard Reference Guide* for criticality safety engineers or develop a foundational curriculum like the DOE radiological control technician training that will help grow and sustain NDA expertise to support the complex. • Develop standardized training modules. • Provide resources (reference materials, measurement equipment, and facilities) to effectively execute training activities. • Institute a multi-lab/site "mobile" NDA training team.
	Establish a mentorship program like the human capital development program (NA-24) to support shadow training, exchanges, and knowledge retention.
	Expand ASTM C1490-14, *Standard Guide for the Selection, Training, and Qualification of NDA Personnel*, on training of NDA practitioners.
	Create and implement tools to assist analysts in recognizing off-normal conditions.

2.6 DATA MANAGEMENT (DM)

The DM program element encompasses the use and handling of NDA measurement data. The objective is to address the challenges of inconsistent data handling, inadvertent introduction of human errors, variation in reporting techniques, and handling of measurement uncertainties and end user differences.

The DM element will ensure standardization of NDA measurement data collection, transformations, reporting, use, and archiving. This element will utilize input from NDA professionals, the TSG, and periodic reviews of NDA programs.

The following strategy was developed to direct the DM element toward achieving its vision. The DM element will accomplish the following:

- Actively engage NDA personnel to identify their data management needs and requirements through various means of communication and develop and implement capabilities to meet those needs.

- Develop standardized requirements for data management including information flow, data handling, data transformation, and data reporting, with input from the TSG and other NDA experts/professionals.

Table 6. Data management

Attributes	Goals
Standardized data management processes	Develop standardized requirements for data transformations (e.g., calculations and reporting) to ensure that data integrity is maintained.
	Develop standardized requirements for uncertainty reporting and handling.
	Support automation of data acquisition and reporting mechanisms to reduce data handling errors.

2.7 REQUIREMENTS AND STANDARDS (R&S)

The R&S program element encompasses standardized requirements for NDA programs across the DOE complex and development and integration of NDA-related consensus standards with DOE orders. This element also supports the involvement of NDA practitioners in the development of NDA-related consensus standards.

The R&S element ensures more robust and technically defensible NDA measurement programs by developing and implementing defined, required processes outlining NDA measurement and program expectations. The supported consensus standard development and use of this element ensures the increased consistency, understanding, and communication that comes with a consistent use of standards.

The following strategy was developed to direct the R&S element toward achieving its vision. The R&S element will accomplish the following:

- Actively encourage NDA personnel involvement in requirement and consensus standard development to ensure that requirements and consensus standards are not over-prescriptive and thus result in a loss of needed flexibility but are instead reasonable and achievable.
- Support the development and implementation of requirements and consensus standards to improve the robustness and defensibility of NDA programs across the DOE complex.

Table 7. Requirements and standards

Attributes	Goals
Participation in standard writing committees	Complete the ANSI/ANS-8.28 standard entitled "Administrative Practices for the Use of Non-destructive Assay Measurements for Nuclear Criticality Safety".
	Perform a survey of NDA-related standards and their current status.
	Establish, maintain, and update standards for the following topics as needed: • Process monitoring • Use of modeling for calibrations and measurements • Uncertainty determination for NDA measurements • Selection and qualification of NDA Systems
	Expand ASTM C1490-14, *Standard Guide for the Selection, Training, and Qualification of NDA Personnel*, to include nationally recognized training qualifications for NDA personnel (or at least outline the framework).
	Re-establish ASTM C1592, *Standard Guide for Making Quality NDA Measurements*.
	Develop and maintain an administrative standard for NDA measurements to support NCS programs (ANSI/ANS-8.28 standard).

	Hold and support working group meetings to develop, maintain, and revise standards as needed by the NDA community.
Integration of technical standards into formal requirements	Add NDA-specific chapters to DOE orders.
	Invoke N15.56 standard in directive 420 and perhaps 470 and 474.
	Establish a working group to develop domestic target values by which similar methods applied to similar nuclear materials should achieve similar quality results. Such information would also assist instrument selection when changes are needed or when new facilities need to be measured.
	To better align NDA processes, establish common DQOs for DOE, possibly modeling the Environmental Protection Agency–DQO process.

2.8 INFORMATION PRESERVATION AND DISSEMINATION (IPD)

The IPD program element preserves primary documentation supporting NDA methods and makes this information available for the benefit of the technical community.

The IPD element will identify, preserve, and disseminate selected technical, programmatic, and operational information that enables those responsible for NDA measurements to sustain, enhance, and continually improve performance in support of safe, efficient fissionable material operations. This element will utilize input from NDA professionals, the TSG, and periodic reviews of NDA programs.

The following strategy was developed to direct the IPD element toward achieving its vision. The IPD element will accomplish the following:

- Develop a knowledge management process and associated mechanisms and tools to enable information availability and exchange, with input from the TSG and other NDA experts/professionals.
- Establish a structured approach to using expert groups and individuals who will assist in identifying and selecting existing sources of organized information and other types of technical, programmatic, and operational information for preservation.
- Establish easily accessible repositories that can be sustained to provide for preservation and digital dissemination of the selected information (in conjunction with data archives identified in other program elements and with potential equipment and nuclear material repositories).

Table 8. Information preservation and dissemination

Attributes	Goals
Information exchange mechanism	Form and conduct an annual NDA users group meeting.
	Conduct topical technical workshops.
	Develop and support a searchable knowledge management tool (e.g., website or database) that communicates the use and benefit of NDA; shares experiences and lessons learned; provides information about available training opportunities and resources (e.g., measurement equipment, reference nuclear materials, measurement datasets, pertinent documents and references); and captures complex-wide NDA needs and input regarding technology advances and user requirements.
Maintenance/development of repository with important NDA-related data	Implement and maintain periodic call for available material: • Provide processes for evaluating available material for IP&D value. • Archive and disseminate training and operational videos (historical and current). • Preserve topical references.
	Operate and maintain a robust infrastructure to support information dissemination.

	Implement a process to rapidly disseminate information (e.g., operational upsets, emergency response, lessons learned) to NDA practitioners.
	Identify and retain key data important to NDA methods and NDA program implementation.

2.9 PROGRAM MANAGEMENT

The NDA program will be executed by ORNL for the NNSA via the NCSP. The NDA TSG was executing this NDA program via funds from the NA-50 (NSR&D) program until 2020. The TSG membership as of this writing is listed on the NCSP website [4]. It is envisioned that the NDAP will continue to be supported by a group of NDA and NCS experts from the DOE complex. This expert group will provide technical expert advice to the NDA and NCSP program managers, review and rank proposals, investigate events of relevance for the NDA program involving fissionable material holdup, and perform facility walkdowns as directed. The TSG will also review site proposals aligned with the NDAP mission and vision from an annual proposal call to prioritize NDA work for the following fiscal year's budget, a task that is currently being managed from within the NCSP.

3. CONCLUSIONS

NDA is a term applied to a series of measurement techniques that measure spontaneously emitted or induced radiation from nuclear materials in various chemical and physical forms. The goal of NDA measurement is to relate the intensity of the measured emissions to the amount of nuclear material present, which is extremely important to support DOE NCS programs to ensure personnel safety where fissionable materials are handled, stored, transported, and processed. In 2007, the DNFSB 2007-1 recommendation was issued to reflect in situ NDA concerns related to (1) the lack of standardized requirements for performing measurements, (2) the lack of design requirements for new facilities that would facilitate accurate holdup measurement, and (3) the lack of R&D activities for new instrumentation and/or measurement techniques. These concerns are focused on DOE facilities where fissionable material holdup can be a significant criticality safety concern. The use of effective and accurate in situ NDA measurements is necessary to find and remediate fissionable material accumulations before there are significant NCS concerns.

Two workshops held at ORNL determined categories and improvement areas in NDA to support various end users. These improvement areas are certainly applicable to NCS, and they are listed below:

- Hardware/Software Development
- Algorithm Development and Nuclear Data
- Uncertainty Quantification
- Nuclear Materials
- Staffing, Personnel, and Training
- Data Management
- Requirement and Standards
- Information Preservation and Dissemination

The intent of this mission and vision is for the NCSP (current federal sponsor of the NDA program) to provide funding for selected tasks based on the concepts presented in this report. Tasks, funding, milestones, and deliverables will be defined in a separate document, the NDAP five-year plan, that will utilize funding for the NDA program to achieve high-priority NDA needs to support DOE NCS programs.

4. REFERENCES

1. A. Lousteau, C. Parks, and Stephen Croft, *Technical and Programmatic Needs for a Sustainable NDA Program for the US Department of Energy*, Oak Ridge National Laboratory, ORNL/TM-2018/923, Oak Ridge, TN, 2018.

2. A. Lousteau and R. Hunneke, *Workshop on Improving Holdup Monitoring in the US*, Oak Ridge National Laboratory, ORNL/TM-2020/1512, Oak Ridge, TN, 2020.

3. Defense Nuclear Facility Safety Board, "Safety-Related In Situ Nondestructive Assay of Radioactive Materials," 2007, https://www.dnfsb.gov/board-activities/recommendations/safety-related-situ-nondestructive-assay-radioactive-materials, April 25, 2020.

4. DOE/NNSA NCSP Website, "DOE NNSA Nondestructive Assay Program, Technical Support Group membership," https://nda.llnl.gov/tsg.php, April 27, 2021.