



Deactivation and Decommissioning Technology Development Roadmap

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Executive Summary

The Department of Energy (DOE) Office of Environmental Management (EM) tasked the Savannah River National Laboratory (SRNL) to lead a team of subject matter experts (SMEs), i.e. the “D&D Roadmap Team”, collected from NNLEMS, industry, and academia to conduct an evaluation of deactivation and decommissioning (D&D) missions within the DOE Complex. The original target of this evaluation was to collect and assess the technical needs and potential barriers associated with D&D project scopes based upon the direct testimony of those conducting the work. Once done, the D&D Roadmap team attempted to link those needs to research areas, technology development tasks, or available technology to facilitate the development of a D&D Technology Development Roadmap.

To appropriately ascertain a large scale view of technical, D&D related, needs for the DOE Complex and the pathway to utilize their solutions, four objectives were set by the D&D Roadmap Team:

- i. Identify high-priority technical needs and the research areas necessary to meet those needs in support of D&D projects.
- ii. Gather information on how DOE project site teams obtain and communicate D&D related information and technology.
- iii. Identify potential testbed opportunities for the development and deployment of D&D related technology.
- iv. Attempt to pair existing technical needs with available solutions, as possible, during the D&D Roadmap initiative.

Ten active D&D project sites were contacted for interviews to ascertain information and meet these objectives. Four project sites were formally assessed by the D&D Roadmap Team. Summary reports that fully detail specific technical needs, the direct feedback from D&D team members interviewed, and the methodology of the D&D Roadmap assessment are detailed in Summary Reports SRNL-RP-2025-00074, SRNL-RP-2025-00067, and SRNL-RP-2025-00178. These summary reports pertain to the Savannah River Site 235-F facility, Oak Ridge D&D projects at Y-12 and Oak Ridge National Laboratory, and the D&D of gaseous diffusion plants at Portsmouth and Paducah, respectively. Each report is intended to provide a brief historical background of the subject site, the full list of technical needs responses received from each project site, and the assessment of each project site to meet the four objectives of the D&D Technology Development Roadmap.

During the assessment, one challenge to a comprehensive evaluation remained constant; the scale, multiplicity, and intricacy of work that is designated as D&D resists drawing logical conclusions at high levels. This is because a high-level view of D&D work for the DOE contains projects of a wide variety in scope that are typically at very different stages of completion. The DOE complex contains many unique D&D project work scopes that in some cases take years or decades to complete. To capture the technical needs of all active D&D projects at one time provides a snapshot of what is requested by project teams at the current phase of a larger D&D project. In a high-level assessment of project work of such breadth, this snapshot can be considered a single data point in an overall trend that is not visible without continued effort to collect more information over time. The identification of research areas that will benefit the DOE D&D mission the greatest over the coming years requires a continual effort to assess the needs that each

project possesses and compile them for a collective assessment in the context of a more categorized system. In summary, “D&D” can apply to such a variety of project work that a high level outlook is challenged to provide specific, data based, conclusions that apply to future projects. A continued effort to collect technical needs is required to update a D&D Technology Development Roadmap over time.

The complex nature of D&D, and its impact upon all other findings to the D&D Roadmap initiative, lead to several conclusions related to each Roadmap objective:

- i. While technical needs were surveyed, collected, and paired to research areas, the evaluation of technical needs in the totality of the D&D field, with the intent to make recommendations for research areas to meet those needs over time, requires a multiple year effort to fit the scale of the project work conducted. Technical recommendations that may be used for research funding allocation purposes made in this report are based only on data collected from the four project sites interviewed and extrapolations made by the D&D Roadmap Team for the applicability of those recommendations to other similar project sites that exist within the DOE Complex. As with any Technology Development program, priorities and needs evolve as projects initiate and evolve.
- ii. Within the D&D field, there is no unified and streamlined process to disseminate specific technical requests or information. What does exist is a more organic network of related contacts and interests of individuals in the D&D field. The documentation of technical progress may be found in a multitude of sources that include federal databases, site specific technical reports, conference presentations, and a wide variety of journal publications.
- iii. Any single active D&D project site may be suitable for testing of new technology. Though, in nearly all cases, such testing is only feasible if it is applicable to the technical needs of that D&D project mission. Furthermore, new technology typically must be tested in authentic environments before general use (i.e. test the product in the environment for which it will be used). Active D&D project sites may not be suitable for this purpose, and only open to development of new technology as applied to ongoing and site specific technical needs.
- iv. The D&D Roadmap Team was successful, in certain instances, at pairing identified technical needs with solutions in real time. However, a pre-selected team composed of SMEs, such as the D&D Roadmap Team, is relatively unfamiliar with any one project scope or specific technical solution when compared to project site personnel or a specialized researcher. A more efficient form of completing this goal involves project site technical experts directly communicating with a researcher or provider of a potential solution. It is the case that these connections were formed by the D&D Roadmap Team as a method to meet this objective.

Using the technology needs and progress barriers reported by D&D project teams, the D&D Roadmap Team has organized and compiled recommendations for technology development areas for the improvement of the D&D field for the DOE Complex. Final data and recommendations were then assessed for applicability to the broader list of D&D projects known to exist within the DOE Complex.

A system for classifying technical needs was developed by the D&D Roadmap Team to allow for common comparison between unique project sites. Of the technical needs requests provided to the D&D Roadmap team, a variety of trends were noticed upon completing this classification. The most common, high

priority, technical need of the D&D teams that provided sufficient data is improvement to the process of waste preparation. In addition to this, and shown through the data, the use of robotics or remote systems to complete the preparation of waste is found to be closely related to technical needs for waste preparation systems.

The recommendations from the D&D Technology Development Roadmap initiative focus on methods to organize, document, and improve the proliferation of new technology to D&D project teams while performing the same function for the technical needs of project teams. The conduit between research product and field application was found to be reciprocal. A secondary recommendation of the D&D Roadmap is to streamline communication between development and deployment of technology at D&D project sites, while classifying and documenting this communication, in a single place, with a unified system. A model to classify technology and technical needs requests with a common taxonomy was developed to perform this function. If successful, the identification of critical research areas can be done in real time as projects progress and fulfil the D&D Roadmap's original objective in a continued manner. This, or a similar system, could improve DOE capabilities to incorporate new technologies and lessons learned.

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Acronyms and Abbreviations

<u>Acronym</u>	<u>Description</u>
ANL	Argonne National Laboratory
CHBWV	CH2M Hill BWXT West Valley
CPCCco	Central Plateau Cleanup Company
DARA	Disposal Area Remedial Action
D&D	Deactivation and Decommissioning
DOE-EM	Department of Energy – Environmental Management
DOE-LM	Department of Energy – Legacy Management
EPC	Electrostatic Particle Collector
ICP	Idaho Cleanup Project
INL	Idaho National Laboratory
KM-IT	Knowledge Management and Information Tool
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
MSA	Materials Sizing Area
NNLEMS	Network of National Laboratories for Environmental Management and Stewardship
NNSS	Nevada National Security Site
OREM	Oak Ridge Office of Environmental Management
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSTI	Office of Scientific and Technical Information
PGDP	Paducah Gaseous Diffusion Plant
PNNL	Pacific Northwest National Laboratory

<u>Acronym</u>	<u>Description</u>
PORTS	Portsmouth Gaseous Diffusion Plant
PPE	Personal Protective Equipment
PPPO	Portsmouth Paducah Project Office
R&D	Research and Development
SME	Subject Matter Expert
SRNL	Savannah River National Laboratory
SRNS	Savannah River Nuclear Solutions
SRS	Savannah River Site
TDF	Technology Development Center
UCOR	United Cleanup Oak Ridge
WVDP	West Valley Demonstration Project

Introduction

The DOE-EM office has a multitude of facility infrastructure D&D projects ongoing across the United States. Each of these projects operate semi-independently with ad hoc communication to other D&D projects or technical experts outside of their immediate influence provided by DOE leadership and Site Liaisons. Highly technical information is challenging to communicate through these means and these sites are subject to project limitations and technical challenges where solutions may be available, but unknown to the localized team. Similarly, researchers capable of developing those solutions may not be aware of the opportunity presented to apply their expertise. The link between these interests is further complicated by the nature of large and long term D&D project work.

A single project considered to be in a D&D stage may take years or decades to complete, require cutting edge technical solutions drawn from many distinct scientific fields, cost billions of dollars, deal with unique contaminants, and have its proceedings documented in a slew of databases and formal reports unknown to a broader viewership. Commonalities in technical needs do exist between such large scale undertakings, however they may be realized years apart for any one project. At any given time, a legacy facility may be in the process of complete demolition, and another being prepped for the years of inaction of a 'cold and dark' designation, yet both can be considered in the phase of D&D. To truly understand any single technical need contained within such complexity requires intimate knowledge of the specific project objectives and aspects of the task that require a solution. Similarly, a potential technical solution may require highly specialized knowledge of its provider to fully determine its suitability to any specific need. The direct communication between these two pools of knowledge is often an essential step to implementation of a new technology today. Documenting and systematizing such communications and technology utilization for future reference was necessary step for the D&D Roadmap team to complete its objectives, which highlights the importance of this process.

As legacy infrastructure ages and undergoes D&D, new facilities are constructed to continue scientific and national defense progress across the DOE Complex. Achievements gained now in D&D may be critical for the next generation's success. The incorporation of lessons learned during D&D of existing facilities can even inform the design of new ones. Therefore, while improving the availability of technical progress is important to current D&D teams, documentation is also important for the D&D teams to come.

Facilitating the development and deployment of technology through streamlined communication and the efficient documentation of that technical solution's use will help drive more efficient and sustainable D&D progress for the DOE complex while simultaneously reducing the risk to the worker and the environment. The D&D Roadmap Team has concluded this through soliciting technical needs directly from D&D project teams and its own assessment of their responses.

Approach

The mission statement of the D&D Technology Development Roadmap initiative was “to identify high-priority technical needs and the Technology Development (TD) tasks required to meet those needs in support of the ongoing deactivation and decommissioning of Department of Energy infrastructure across the United States” (SRNL-MS-2023-00436). To achieve this goal, ten ongoing D&D projects within the DOE complex were chosen as targets to collect technical needs data directly from the project teams performing the work. A voluntary team of SMEs from across the country was formed consisting of NNLEMS researchers, academia, and private sector contractors experienced in the D&D field to perform the assessment of each technical need. The D&D Roadmap team also consulted with DOE-EM staff to help identify any needs that had been brought to their attention.

To gather the needs, a twelve part questionnaire was provided to D&D project team leadership by the D&D Roadmap Team via the target site’s DOE Site Liaison. This questionnaire is presented in Appendix A-1. The questionnaire covered a range of topics, directly and indirectly, related to technical needs of the target D&D project site. Questionnaires were requested to be completed by a range of project personnel of varying disciplines and positions. Respondents to the questionnaire included, but were not limited to, project managers, engineering leads, industrial hygienists, health and safety specialists, and contractors closely related to the specific D&D projects targeted by the D&D Roadmap Team. The intent behind collecting a wide range of responses from these different levels within a D&D project was multifold:

- i. The questionnaire was designed to solicit as much detail as possible for further assessment, with the goal that the responses gained would include varied information based on the role of the respondent. For example, engineers would have a different perspective than a health and safety specialist.
- ii. The responses would allow the D&D Roadmap Team to proceed with a subsequent interview of the questionnaire responses in a more targeted and efficient manner. By gaining initial information related to a technical need, as reported by the questionnaire responses, an interview could be conducted far more quickly and without heavy emphasis on project background or exposition.
- iii. Written forms of technical needs were collected for reference in the ongoing D&D Technology Development Roadmap effort. Technical needs, expressed in the words of the project site personnel who need them, are used to document the information collected and interpret that same information for comparison to other responses.

Following the collection and evaluation of questionnaire responses, internal D&D Roadmap Team meetings were conducted to prepare for a virtual interview with site project personnel. SMEs external to the D&D Roadmap Team, but of specific relation to technical needs contained within the questionnaire, were invited to participate during the interview process where possible. Including expertise not otherwise contained within the team allowed a more accurate appraisal of technical needs in this phase. Following the interview process, the final analysis of technical needs was performed by the D&D Roadmap Team. Duplicate technology needs’ requests for any single project site were sorted and reduced to a single, example, response to eliminate bias in final data pools created by a varying number of respondents to

each questionnaire or interview who refer to a single topic. Responses that did not involve technical needs were also discounted as outside the purview of the D&D Technology Development Roadmap assessment. Where possible, specific products or available technology were referred by the D&D Roadmap Team to the D&D project personnel.

Following full data collection through the questionnaire and interview process, a taxonomy was created to categorize each technical need for comparison between sites. General themes were seen during technical needs assessments, and categories of D&D related areas were created to organize such a diverse set of information. Six categories were created with three to fifteen criteria within each to create a taxonomical identification number for each technical need. The D&D Roadmap Team of SMEs, used written questionnaire responses, as informed by a subsequent formal interview with questionnaire respondents, fit each technical need into this taxonomical framework to determine the general research areas required to meet those requests. The categories and criteria of this taxonomy is further discussed in the recommendations section of this report and presented in Appendix B-1. The completed assessments and identifications of research areas for each project site response chosen is presented in Appendices B-2, B-3, and B-4 and refer to the Savannah River Site (SRS) 235-F facility, the Oak Ridge Reservation (ORR) Y-12 and Oak Ridge National Laboratory (ORNL), and the Portsmouth-Paducah Gaseous Diffusion Plants, respectively.

The classification of technical needs by the means developed by the D&D Roadmap Team is not only used to meet the first objective of the D&D Technology Development Roadmap, but also to inform recommendations for DOE-EM to further improve the overall DOE mission in the D&D field. Potential solutions for technical needs may also be classified in a similar manner. Meaning, identifying classification numbers can be used to find pairs of D&D needs and D&D solutions. Through doing so, a common form of communication can be established between the most knowledgeable parties required to bring solutions from development to common use.

D&D Roadmap Objectives and Findings

The D&D Roadmap Team set four objectives designed to gather enough information to satisfy its mission statement:

- “To identify high-priority technical needs and the research areas required to meet those needs in support of the ongoing deactivation and decommissioning of Department of Energy infrastructure across the United States”.

These four objectives are presented in the sections below with discussions of their proceedings and specific examples chosen to demonstrate their completion.

Objective 1: Identify high-priority technical needs and the research areas necessary to meet those needs in support of D&D projects.

To fulfil objective 1, the Roadmap team collected technical needs statements from each targeted site through a questionnaire and interview process. This process was designed to target technical needs as reported by a variety of involved D&D project site personnel from a multitude of positions within each

project. To meet the first goal of the D&D Technology Roadmap, it was also necessary to develop a system to evaluate technical requests to only those that apply to the stated purpose of this objective. A stated need must therefore have a priority, apply to a technical issue, must relate to D&D project work, and have an associated research area. Technical requests were evaluated by the D&D Roadmap Team and fit into a taxonomic system for categorization according to set characteristics. The categories and criteria within this system are presented in Appendix B.

Using this taxonomic system, a set of numbers that apply to each category and criteria was applied to each technology request. This set of numbers is then used as an identifier to quantitatively assess requests made from all project sites that participated in the D&D Technology Development Roadmap Initiative. Tables presented in this section tally the number of times a criteria was designated to a technical response, for each category, for each project site interviewed.

- i. D&D Stage - Three overall stages of D&D were recognized, and while each affect the other, each have different primary goals and require unique consideration. Deactivation, long term storage (otherwise known as 'cold and dark'), and decommissioning are the three separate stages recognized by the D&D Roadmap Team. Each of these stages are identified in DOE guidance documents DOE-G-430.1-2, DOE-G-430.1-3, and DOE-G-430.1-4 as specific stages in the disposition of contaminated, excess, facilities.

Taxonomy Category	Project Site				
<u>D&D Stage</u>	<u>SRS</u>	<u>ORR</u>	<u>PGDP</u>	<u>PORTS</u>	<u>Category Total</u>
Deactivation	3	1	1	3	8
Long Term Storage	0	0	3	3	6
Decommissioning	6	6	9	8	29
Site Total Category Designations	9	7	13	14	

Table 1: Totalized D&D Stages

Of the technical responses assessed, the majority were found to primarily relate to the stage of decommissioning. This is true for all project sites and may reflect technology categories that can be most frequently related to this phase of a D&D project.

- ii. Needs Timeline – Technical needs were collected using a “near current” timeline. Requests assessed by the D&D Roadmap Team were considered valid if their application is currently needed or would have been needed within 5 years of the time of the interview.

Taxonomy Category	Project Site				
NeedsTimeline	SRS	ORR	PGDP	PORTS	Category Total
Near Future	5	6	8	8	27
Current	5	4	9	9	26
Near Past	2	1	3	5	11
Site Total Category Designations	12	11	20	22	

Table 2: Totalized Needs Timelines

The timeline where technical solutions could be applicable to D&D project teams was assessed to be spread, near equally, over a 'current' and 'near future' timeframe. Rational for this trend is not clear, but could indicate a bias in reported technical needs from D&D Project Teams. Essentially, these respondents may only be aware of, or most concerned with, ongoing or upcoming challenges to their project work and thus more likely to reference these challenges in responses to the D&D Roadmap inquiry.

- iii. **Needs Driver** – The impetus for a technical need was included into this classification system to further clarify the intent of a needs requestor. Criteria such as cost, schedule, efficiency, and safety qualify as a 'needs driver' for the D&D Roadmap assessment.

Taxonomy Category	Project Site				
Needs Driver	SRS	ORR	PGDP	PORTS	Category Total
Project Cost	1	0	1	1	3
Project Schedule	2	6	1	3	12
Project Efficiency	4	0	8	3	15
Safety Risk	4	4	4	8	20
Site Total Category Designations	11	10	14	15	

Table 3: Totalized Needs Drivers

Project schedule, project efficiency, and safety risk were identified to represent the majority of responses in the totalized assessment of D&D project team responses. In total numbers 'safety risk' is the most frequent selection. Proportionally to the number of total category selections for each 'needs driver', the selection of 'safety risk' is also the lead at each site with approximately 36% selection at SRS, 40% selection at ORR, 28% selection at the Paducah Gaseous Diffusion Plant (PGDP), and 53% selection at the Portsmouth Gaseous Diffusion Plant (PORTS). A risk to worker safety is a threat to all phases of D&D project work, and may be the reason for this data trend. All entry into contaminated legacy facilities, for any reason and in any phase, often carries inherent risk of toxic or radiological exposure to personnel. In addition, mitigations of safety risks, which typically include high levels of personal protective equipment (PPE) or labor intensive engineering

controls, can impact project schedules and efficiency in turn. 75% of SRS, 100% of ORR, 75% of PGDP, and 37% of PORTS technical responses assessed to be 'safety risk' needs drivers were also designated as either 'schedule' or 'efficiency' needs drivers, which supports a conclusion that worker safety hazards influence overall project schedule and efficiency concerns.

- iv. Project Impact Level – Priority of a needs request directly relates to fully achieving the first objective of the D&D Roadmap. To identify 'high priority' technical needs, they must be separated from those that are of lower priority. Insight gained from the interview process following questionnaire completion was used by the D&D Roadmap Team to rate the impact a technical solution may have to a D&D project team. Impact criteria in this category are designated as 'high', 'medium', and 'low'. These designations were assigned to a technical need by a group vote of D&D experienced SMEs as advised by information gathered from D&D project teams during the interview process. The basis for high, medium, and low priority for a technical needs request are:
- a. High Impact
 - i. Project work may not be completed without this technical solution.
 - ii. Large impact on project cost, schedule, efficiency, or safety was reported by the D&D project team interviewed for a needed technical solution.
 - iii. Alternate methods of D&D may have been available if a technical solution were available.
 - b. Medium Impact
 - i. Project work is able to proceed with impacts to project cost, efficiency, and schedule as reported by the D&D project team interviewed.
 - ii. The technical solution requested is an upgrade to existing D&D methodology or toolsets.
 - c. Low Impact
 - i. Overall and major D&D milestones are achievable at a tolerable impact to project cost, efficiency, and schedule as reported by the D&D project team interviewed.

Taxonomy Category	Project Site				Category Total
	SRS	ORR	PGDP	PORTS	
High	3	2	2	3	10
Medium	3	4	6	4	17
Low	0	0	1	2	3
Site Total Category Designations	6	6	9	9	

Table 4: Totalized Project Impact Levels

Data assessment of project level impacts show a majority of technical needs requested were assessed to be 57% 'medium impact', 33% 'high impact', and 10% 'low impact'. This trend is most likely a result of D&D Roadmap inquiry focusing on ongoing D&D project sites. Active site work is by its nature progressing with whatever available toolset is feasible. Therefore, critical technical

impediments to project progress are less common as they have been overcome with at least a workable solution.

- v. **Challenge Type** – Further clarification of a technical need, by its attachment to what general challenge a technology is meant to address, was found to be useful during the full assessment. For example, worker safety and contaminant control may both require a technical solution in the form of a fixative to secure possibly airborne contaminants. The inclusion of this category and set of criteria allow more detail to be used and communicated by this taxonomy through a general designation of the targeted problem.

Taxonomy Category	Project Site				
Challenge Type	SRS	ORR	PGDP	PORTS	Category Total
Contaminant Type	2	0	0	1	3
Contamination Control	4	4	2	1	11
Security and Maintenance	0	0	0	2	2
Worker Safety	2	4	7	4	17
Waste Processing	1	2	2	3	8
Characterization	2	1	2	2	7
Accessability	2	1	0	1	4
Project Management	0	0	0	1	1
Site Total Category Designations	13	12	13	15	

Table 5: Totalized Challenge Types

The leading challenge type identified during technical request assessment was found to be ‘worker safety’, accounting for 32% of all 53 total response challenge type selections. This is in line with the previously identified primary needs driver of ‘safety risk’, and likely a related data trend. Contaminant control is the second most selected ‘challenge type’ of this category, with 20% of the total 53 responses. Of the technical needs designated as ‘worker safety’ 50% were also designated as ‘contaminant control’ for SRS, 75% at ORR, 29% at PGDP, and 0% for PORTS. It is unclear from the analysis of collected data if this is a potential trend, and a broader data set of technology needs would be required to bring a conclusion.

- vi. **Technology Type** – This category contains the largest set of criteria. Fifteen criteria are defined to distinguish the technology being requested by a D&D project requestor. This is the largest, and final category use for assessment of technical requests. Criteria within this category designate a general technology or research area that apply to a request and include ‘robotics/remote applications’, ‘non-destructive assay’, and ‘interim waste storage’ among others.

Taxonomy Category	Project Site				
Technology Type	SRS	ORR	PGDP	PORTS	Category Total
Modelling	0	0	0	0	0
Non-Destructive Assay	0	1	2	1	4
Samp. Collection and Analysis	1	1	0	0	2
Robotic/Remote Applications	1	2	1	2	6
Fixatives and Coatings	2	1	0	2	5
Decay and Byproduct control	2	0	0	1	3
Grout and Entombment	2	0	0	0	2
Contaminant Collection/Removal	0	2	2	2	6
Personal Protective Equipment	0	1	4	1	6
Exposure Monitoring	0	0	2	1	3
Waste Preparation	1	4	2	2	9
Waste Treatment	0	0	1	0	1
Waste Shipment and Disposal	0	1	1	0	2
Interim Waste Storage	0	0	1	0	1
Artificial Intelligence	0	0	0	1	1
Site Total Category Designations	9	13	16	13	

Table 6: Totalized Technology Types

Of the 15 total technology types available for this taxonomic category, and the 51 total designations performed by the D&D Roadmap Team, 18% were allocated to 'waste preparation'. The deactivation and decommissioning phases of D&D each depend upon the accurate waste segregation techniques for preparation, proper waste stream selection, and disposal pathway selection and may be the driver of this most frequently chosen technology type. Data analysis to totalized results shows a second place split between 'robotic/remote applications' and 'contaminant collection/removal', two categories potentially related to waste preparation techniques.

A complete assessment of specific technical requests related to each interviewed project site are presented in D&D Roadmap Summary Reports SRNL-RP-2025-00074, SRNL-RP-2025-00067, and SRNL-RP-2025-00178, which refer to the SRS 235-F facility, the ORR Y-12 and ORNL, and the Portsmouth-Paducah Gaseous Diffusion Plants, respectively. Unedited responses to the D&D Roadmap questionnaire for each of these sites are also presented in these summary reports. Final tallies graphs of technology requests as applied to the created taxonomy are presented in Appendix B-5.

The evaluation of the categorized technical needs shows the 'waste preparation' technology type contains the most assessed responses. This applies both to the overall pool of categorized technical needs and when considering only those rated as 'high impact' by the D&D Roadmap Team.

Taxonomy Category	Project Site				
<u>Technology Type - High Impact Only</u>	<u>SRS</u>	<u>ORR</u>	<u>PGDP</u>	<u>PORTS</u>	<u>Category Total</u>
Modelling	0	0	0	0	0
Non-Destructive Assay	0	0	1	1	2
Samp. Collection and Analysis	0	0	0	0	0
Robotic/Remote Applications	0	0	1	0	1
Fixatives and Coatings	1	0	0	0	1
Decay and Byproduct control	1	0	0	0	1
Grout and Entombment	1	0	0	0	1
Contaminant Collection/Removal	0	1	0	1	2
Personal Protective Equipment	0	1	0	1	2
Exposure Monitoring	0	0	0	1	1
Waste Preparation	1	1	1	0	3
Waste Treatment	0	0	1	0	1
Waste Shipment and Disposal	0	1	1	0	2
Interim Waste Storage	0	0	0	0	0
Artificial Intelligence	0	0	0	0	0
<u>Site Total Category Designations</u>	4	4	5	4	

Table 7: Totalized, High Impact Only, Technology Types

To provide more resolution the assessment of technical responses was not limited to single classifications. A response was often assessed to apply to multiple technology types by the D&D Roadmap Team. For example, most responses that were assigned 'waste preparation' were also assigned to other technology types.

Further data assessment of 'waste preparation' designated technology needs was performed to determine if a more specific data trend was available to satisfy the first objective of the D&D Roadmap. Of the accompanying technology types co-assigned to 'waste preparation', 'robotics/remote applications' was the most frequent.

Taxonomy Category	Project Site				
<u>Technology Type - Waste Preparation Alternates</u>	<u>SRS</u>	<u>ORR</u>	<u>PGDP</u>	<u>PORTS</u>	<u>Category Total</u>
Modelling	0	0	0	0	0
Non-Destructive Assay	0	0	0	0	0
Samp. Collection and Analysis	0	0	0	0	0
Robotic/Remote Applications	0	2	1	1	4
Fixatives and Coatings	0	1	0	0	1
Decay and Byproduct control	0	0	0	0	0
Grout and Entombment	0	0	0	0	0
Contaminant Collection/Removal	0	1	1	1	3
Personal Protective Equipment	0	0	1	0	1
Exposure Monitoring	0	0	0	0	0
Waste Preparation	--	--	--	--	--
Waste Treatment	0	0	1	0	1
Waste Shipment and Disposal	0	1	1	0	2
Interim Waste Storage	0	0	0	0	0
Artificial Intelligence	0	0	0	0	0
Site Total Category Designations	0	5	5	2	

Table 8: Totalized Waste Preparation Alternate Technology Types

According to the collected data set, using the current taxonomic system, robotics used for preparing waste streams is the most requested technology by the D&D project teams interviewed. A breakdown of data used to formulate this conclusion is also presented in Appendix B-6.

Waste stream management, and more specifically the preparation of waste for correct packaging and disposal, is a critical part of all contaminated facility D&D. The frequency of responses that were designated to the 'waste preparation' technology type is a reflection of this fact. The relationship of 'waste preparation' and 'robotic/remote applications' in the same data set also highlights the research area most requested by D&D teams interviewed. These data sets however, do not specify the overarching purpose of these robotics. Simple logic would state that robotics perform tasks where humans cannot or should not. In the context of legacy DOE facilities with contaminated by hazardous materials, a hypothesis that robotics are needed to prevent human exposure to these substances is apparent. Robotics can also be designed to tirelessly perform a specific function, faster and more efficient than humans. A final round of data analysis was performed to test this simple hypothesis.

Needs drivers for technology requests, that apply only to 'waste preparation', were tallied to determine if the data collected can corroborate either hypothesis for robotic application needs.

Taxonomy Category	Project Site				
<u>Needs Driver – Waste Preparation Only</u>	<u>SRS</u>	<u>ORR</u>	<u>PGDP</u>	<u>PORTS</u>	<u>Category Total</u>
Project Cost	1	0	0	0	1
Project Schedule	0	4	1	2	7
Project Efficiency	1	0	2	1	4
Safety Risk	0	3	1	2	6
<u>Site Total Category Designations</u>	2	7	4	5	

Table 9: Totalized Needs Drivers – Waste Preparation Only

The ‘waste preparation’ filter applied to needs drivers for the collected data support the hypothesis that robotic requests were made to reduce human exposure to contaminants and improve project schedules and efficiency. Response assessment designations are clustered to designations ‘project schedule’ and ‘safety risk’. A response from the ORNL D&D project team is presented in figure 1 as an example of a technical needs request that was filtered from the total response pool through the described means, to meet the first objective of the D&D Roadmap project.

<u>OR - ORNL - 4: Robotic/Remote Applications</u>		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
ORNL facilities are highly contaminated and possess large source terms of radiological materials. Isotope inventory is varied and the mix of isotopes can present challenges to D&D. Decontamination and demolition solutions that employ robotic or remote handling and/or operation will allow longer stay times in facilities and improve overall completion performance.	Stage	1,3
	Timeline	1,2
	Driver	2,4
	Impact	2
	Challenge	4,7
	Technology	4,11

Figure 1: Technical Needs Response from Oak Ridge - ORNL

Of the requested technology types presented in table 6, two further technology types are most requested by D&D project teams following that of ‘waste preparation’ and ‘robotic/remote applications’. With total tallies of six each, ‘contaminant collection/removal’ and ‘personal protective equipment’ followed as the next most requested technical need. Filtered responses of only ‘high impact’ technical needs also show this data trend, though less conclusively. Here, ‘contaminant collection/removal’ and ‘personal protective equipment’ are tied for second place along with ‘non-destructive assay’ and ‘waste shipment and disposal’ for high impact technical needs requests. Filtering the ‘high impact’ technical needs to show only those requested in conjunction with ‘contaminant collection/removal’, ‘personal protective equipment’, and ‘non-destructive assay’ reduce the available response pool to only four, where again ‘waste preparation’ is the most designated technical criteria. This filtered data does not show a clear conclusion, and the low

number of responses reduces confidence in any that could be made. The filter of 'high impact' was removed to allow more responses to be accounted for.

Taxonomy Category	Project Site				
<u>Technology Type - 2,8,9,13</u> <u>Alternates</u>	<u>SRS</u>	<u>ORR</u>	<u>PGDP</u>	<u>PORTS</u>	<u>Category</u> <u>Total</u>
Modelling	0	0	0	0	0
Non-Destructive Assay	0	0	0	0	--
Samp. Collection and Analysis	0	1	0	0	1
Robotic/Remote Applications	0	1	1	1	3
Fixatives and Coatings	0	0	0	0	0
Decay and Byproduct control	0	0	0	0	0
Grout and Entombment	0	0	0	0	0
Contaminant Collection/Removal	0	0	0	0	--
Personal Protective Equipment	0	0	0	0	--
Exposure Monitoring	0	0	2	1	3
Waste Preparation	0	2	2	1	5
Waste Treatment	0	0	1	0	1
Waste Shipment and Disposal	0	0	0	0	--
Interim Waste Storage	0	0	0	0	0
Artificial Intelligence	0	0	0	0	0
Site Total Category Designations	0	4	6	3	

Table 10: Totalized Technology Types Designated in Tandem with 'Non-destructive Assay', 'Contaminant Collection/Removal', 'Personal Protective Equipment', and 'Waste Shipment and Disposal'.

Using the filter of all assessed responses, to find the technology type requested most in tandem to 'Non-destructive Assay', 'Contaminant Collection/Removal', 'Personal Protective Equipment', and 'Waste Shipment and Disposal' reveals that, again, 'waste preparation' is the most selected. Second to this is a split between the technology type 'Robotic/Remote Applications', which has already been discussed, and 'Exposure Monitoring'. The total assessed responses limited to this filter numbered ten. Technical needs requests that were designated as 'exposure monitoring' total to three, and only from PGDP and PPPO.

It must be noted that only four of the ten petitioned D&D project teams provided responses to the D&D Roadmap Questionnaire. In addition, the form of taxonomic classification itself may produce some bias in drawing conclusive results. As more filters to this current data set are applied, the number of responses is reduced, and whatever bias that does exist either from that made during the categorization process by the D&D Roadmap team or inherent to this system itself, is enhanced. However, the conclusions that the technical needs identified to be most impactful based are logical in the context of D&D project work in the DOE Complex. Each project site assessed by the D&D Roadmap Team have highly dangerous contaminants that exist very rarely, such as Pu-238 dust contamination at the SRS 235-F facility, and to

lesser degrees, such as the extent of mercury contamination at the ORR Y-12 facilities, beyond the borders of the DOE Complex. It is not a surprising conclusion that the nature of these relatively unique contaminants drive technical challenges for D&D project teams within the DOE Complex. If any D&D project is to succeed, successfully mitigating the hazards of these contaminants through the reduction of human and environmental exposure to them is paramount. Throughout the investigation and assessment of technical needs provided by D&D project teams, improved forms of detecting, handling, and monitoring exposure to these contaminants during operations was a continual data driven theme. The use of robotics to achieve this, primarily through operations of waste preparation appears the most impactful technology development area to enhance safe and efficient operations for D&D within the DOE Complex as reported by the D&D teams interviewed.

It must also be noted, that in the terms of what is requested by D&D teams, the use of robotics to reduce human exposure and improve waste preparation technique is a reactionary response to current technical needs. Other forms of technology or best practices may achieve the same goals if employed in construction, to prevent a problem in demolition. For instance, a facility or structure could be designed in a way to facilitate its disposal. Pre-coated or metal lined surfaces could reduce contaminant penetration into concrete, and greatly reduce the need for complex disposal procedures seen in the responses to the D&D Roadmap. Large components could be designed to break down into forms conducive to standardized waste packaging and would also improve end-of-life decommissioning workflow.

Further collection of technical needs from more project sites would only improve the conclusions this data analysis could produce. A continued effort to collect, evaluate, and document technical needs based on the direct input of D&D project teams would achieve this over time. Any system of classification must evolve as new data is presented and the D&D taxonomic system it is no different.

Objective 2: Gather information on the procurement and propagation of D&D related information and technology by project teams at DOE sites.

D&D project teams around the United States have completed, and continue to complete, technically challenging work to safely remove or otherwise achieve an end state for legacy DOE nuclear facilities. The development of new methods and technologies to support this effort is not new, and D&D project teams have continually obtained the means to complete their work. The assessment of how this interaction between R&D (research and development) and the deployment of R&D products is closely related to the mission statement of the D&D Technology Development Roadmap. Once research areas are identified, based on the technical needs of project sites, the logical next step is to deliver solutions that meet those needs. In the case of D&D related technology, this is achieved through the targeted R&D from national laboratories and universities, the procurement of commercially available products, and the carryover of expertise accumulated in personnel who perform the work. During the questionnaire and interview process, the means of procuring new technology or knowledge to meet D&D project goals were assessed by the D&D Roadmap Team.

The conduit used by D&D project teams to procure the necessary knowledge or tools needed to complete their mission goals was found to vary depending on the specifics of the project site. These included simple proximity and association between a project site and a national laboratory in the case of the SRS 235-F

facility and the SRNL, D&D experienced personnel bringing their knowledge of gaseous diffusion plant demolition from the Oak Ridge K-25 facility to Portsmouth and Paducah, the Paducah Gaseous Diffusion Plant utilized lessons learned from the Portsmouth Gaseous Diffusion Plant D&D based on the similarity of work scopes, and even more opportunistic methods such as Oak Ridge Y-12 project teams using the D&D Roadmap Team for inquiry. In some cases, these forms of communication or procurement are poorly documented and rely upon the testimony of D&D project teams interviewed. Some, however, are more clearly substantiated through technical reporting. Documented cases include:

- i. Access to R&D Teams: Information regarding new technology deployments at the SRS 235-F facility were known and available to the D&D Roadmap Team prior to the questionnaire or interview. Further participation of the 235-F D&D project team with the D&D Technology Development Roadmap clarified the process of utilizing new technology in a common manner following its R&D. Specifically, the testing and utilization of FireDam™ within the 235-F facility demonstrates one method of a D&D team finding and incorporating new technology into a routine toolset. FireDam™ Spray Red 200 is a commercially available intumescent fixative and product of the 3M Company. SRNL deployed and tested FireDam™ in conjunction with the 235-F D&D project team for the purposes of radioactive contamination control (SRNL-TR-2018-00074). Testing of FireDam™ was successful, and this fixative was incorporated into routine use at the 235-F facility. Project teams involved in testing at the 235-F facility and SRNL benefit from quick access or personal contact due to the proximity of their offices, making a R&D pathway more direct. SRNL is routinely involved with R&D and various other project support for the greater SRS site outside of D&D as well.

Project work at Oak Ridge benefits from the same interrelation between ORNL and the wider Oak Ridge Reservation. ORNL continues to provide support through robotics development, sampling analysis, and other forms of research for D&D projects on their own campus and the Y-12 complex (Office of Environmental Management, 2023). Routine development of technical solutions is conducted at ORNL with targeted applications across the ORR.

- ii. Employee Knowledge Transfer: Examples of D&D knowledge and technology communication were found during information gathering at the Portsmouth and Paducah projects. Each site is home to former gaseous diffusion plants, making D&D missions largely similar. Knowledge transfer carried from one site to another through employee expertise is reported by interviewees to play an important role in D&D progress at each site. This can even be traced to personnel involved in the D&D of the K-25, completed in 2013, bringing their accrued skill to the PORTS and PGDP. The staggered timeline of their work also plays an important role in the progress of these D&D projects. The PORTS D&D mission is roughly ten years ahead of that of the PDGP. Lessons learned at PORTS are freely shared with the PGDP team and are facilitated by the combined Portsmouth Paducah Project Office (PPPO). Dust control, a forefront challenge for the PORTS and PDGP teams and their decommissioning work, has led to the construction of a specialized materials sizing area (MSA) at the PGDP which is continually improving working conditions and efficiency to complete their mission goals (D. Nichols, 2024). Decommissioning of the X-326 and X-333 buildings at PORTS directly influenced the design and use of the MSA at the PDGP.

Technology deployment and knowledge communication at the SRS 235-F facility, Oak Ridge Reservation, and Portsmouth/Paducah are three examples of D&D related communication found within the DOE complex. Databases such as the DOE Office of Scientific and Technical Information (OSTI) and annual conference presentations such as the Waste Management Symposia were also reported to be important sources of technical solutions by D&D project team members. A far broader network of personal contacts, incentives, and research collaborations exist and continue to advance mission objectives nationwide as well. With the limited extent of the D&D Roadmap's data collection in this area, the conclusion that communication of D&D related technologic advancement and usage occurs organically based upon these existing networks and motivations in parallel to other means of more conventional inquiry.

A single system, that tracks the technical challenges to D&D project teams and the requests from those teams for support would be an improvement to the current methods found to be in use by the D&D Roadmap Team. In addition, this same system could be used to catalogue technical solutions that have been deployed successfully in response to a technical need. No such system was found to exist that performs each function. It is the conclusion of the D&D Roadmap Team that a unified repository of technical needs and solutions as applied to the D&D field, that is accessible to be queried by project team level personnel, would improve overall process efficiency and progress by reducing the time needed for effective communication between D&D project teams and researchers or vendors able to provide a technical solution.

Objective 3: Identify potential testbed opportunities for the development and deployment of D&D related technology.

Final product testing is an integral part of the development of new technology. Typically, this involves trials that are within or simulate authentic conditions that will be encountered during routine use of the research product. Legacy facilities within the DOE that require new technology can often have highly hazardous conditions, including radioactive contamination or hazardous materials present and be located within secured facilities with strict entry requirements. R&D personnel may not be able to access an active project testbed and exposure to contaminants within these facilities is tightly controlled and monitored, with human entry further limited to necessary actions to advance the progress of the D&D mission. These challenges can be overcome by developing new tools that have direct application to a D&D project goal and/or to a degree that testing can be performed by D&D project teams. Additionally, testing may be performed by cleared researchers within the DOE, though this is likewise typically limited to research applicable to D&D project goals. The D&D Roadmap Team assessment of the four active D&D project sites confirmed this eventuality.

All project sites at SRS, Oak Ridge, Portsmouth, and Paducah currently or routinely collaborate with external research organizations such as national laboratories and universities to develop and deploy new technology to achieve specific objectives. Specific examples of these include FireDam™ and electrostatic particle collector (EPC) research projects by SRNL at the SRS 235-F facility (SRNL-TR-2018-00074), AF-1000 fixative testing at Oak Ridge in collaboration with Pacific Northwest National Laboratory (PNNL) (PNNL-36559), and robotic crawler deployments for piping inspection at the PGDP (Office of Environmental Management, 2023). These are three commendable examples that show how new technology is

developed and tested at active D&D project sites to meet mission goals at each interviewed project site. There is also a duality in this style of development. Firstly, final field testing is focused on the target issue at hand. While logical, this method necessitates that this last stage of development, field testing, be performed at a project site. Secondly, the complexity of the solution, and evaluation of field testing results may require some time and possibly create delays not anticipated by D&D project teams in early planning. Often complete mockup areas are created to test new tools for eventual use in real-world application, where failure could lead to ever more significant delays and safety hazards. During this evaluation period, the D&D project challenge either remains unsolved or the D&D project team proceeds in a different manner without the developing solution. Two pathways to improve this circumstance were further investigated by the D&D Roadmap Team.

The first option would be a general testing ground for D&D related research ready for field deployment. While a general testbed facility would likely not be a fully authentic environment for complete field testing (i.e. a lack of high level contamination or other uncontained hazardous substances that may be necessary for field testing), such a centralized facility could allow a D&D project team to better assess new options for upcoming problems and potentially select one sooner with more time to plan. There are no currently known central testing grounds for D&D related research to fulfil this role. However, a potential candidate was presented to the D&D Roadmap Team during investigation at the ORR. United Cleanup Oak Ridge (UCOR) and the Oak Ridge Office of Environmental Management (OREM) are considering the formation of a Technology Development Facility (TDF) to act as a testbed facility within the ORR. Located at the former Disposal Area Remedial Action (DARA) site, the TDF is focused upon enabling the development of technology to support mercury cleanup at the ORR. The possibility of wider research application is unknown, however the TDF is at least an example that general testbed facilities are possible and valuable to the advancement of a broad range of R&D.

A second, and more common, option is to develop technology in advance as completely as possible to minimize the impact of field testing and evaluation. Utilizing targeted research in this way lessens the impact to D&D project scheduling and ensures that research is directly related to pathways for field application. This approach does not fully eliminate some form of evaluation period to determine an R&D solution's success once deployed in the field. Additionally, a research team must be aware of upcoming D&D project challenges with enough time to complete development for maximal advantage to be realized. Finally, D&D project objectives may change after R&D is initiated and before completion, resulting in a loss in the core benefit of targeted research and a testing ground for a project team. For instance, the removal of contaminated infrastructure may be a stated goal for a D&D project team in early planning and require new tools to complete. R&D to produce these tools would then begin, only to be rendered itinerant when a decision is made to abandon the targeted infrastructure in place through other means. In such an event, the secure documentation of the R&D product for future use by D&D teams is critical to limiting wasted cost and time incurred by its development.

Following data collection by the D&D Roadmap Team, a combined approach using a general testbed facility to facilitate the selection of targeted R&D solutions for D&D project teams would improve DOE-EM operations. A centralized location to demonstrate mature technology, accompanied by

documentation related to a common testbed would, over time, collectivize data pertaining to available options for D&D teams. Currently, as research produces new technology and it is deployed at project sites, the results are captured in site or institution specific reports and information releases. Today, a compilation of these accomplishments requires a survey of all individual sources.

Objective 4: Attempt to pair existing technical needs with available solutions as possible during the D&D Roadmap initiative.

Where possible, technology recommendations were made to D&D project teams during the Roadmap Initiative. Generally, the success seen in this objective was dependent upon the willingness or ability of the D&D project team to collaborate with the D&D Roadmap Team, the availability of information related to a technical need, and the potential for a technical recommendation to be implemented. Ultimately, the adoption of a new toolset, whether currently available or still being developed, by a D&D project team is rarely an immediate process. The recommendations made to D&D project teams by the D&D Roadmap team and their subsequent proceedings include:

- i. Oak Ridge Reservation – During assessment by the D&D Roadmap Team, a reciprocal dialogue was formed for technical recommendations. Specific to beryllium and mercury contamination within the Y-12 facility, two technical information exchanges were made to assist ORR D&D team decisions.
 - a. Mobile beryllium laboratory and field detection – Primary contaminants within the Y-12 facility at the ORR include significant surface beryllium contamination. Beryllium contamination must be sampled and characterized prior to required waste segregation and disposal procedures. The removal of contaminated debris or equipment is reliant upon the speed these samples can be analyzed. One technical need identified during the D&D Roadmap assessment is the potential for a mobile beryllium laboratory operated solely to accelerate the many thousands of samples being produced at Y-12. SRNL invited ORR staff to tour the operational beryllium laboratory and meet with beryllium SMEs to assist UCOR and OREM in understanding the logistics of this option. Field based characterization conducted by colorimetric testing was also investigated for potential application at Y-12 (Ashley et. al., 2005). Handheld detectors potentially capable of quantitative beryllium contamination measurement are also being developed, and available data has been recommended to the ORR D&D team.
 - b. Mercury vapor sensors – Elemental mercury is known to thoroughly contaminate Y-12 facility structures and their contents, with airborne concentrations continually posing a threat to worker safety. The study of how and when mercury vapor is released throughout these buildings is the subject of ongoing research collaborations between SRNL and UCOR/OREM. Many advanced sensor systems exist that perform vapor analysis functions and as D&D progresses in Y-12, new options are continually considered. During the Roadmap assessment, staff from UCOR and OREM Industrial Hygiene were invited to inspect and assess TEKRAN mercury sensor operations at Savannah River Nuclear Solutions (SRNS) wastewater treatment facilities. The utilization of a similar sensor package for improved D&D operations at Oak Ridge is still under consideration at the ORR.
 - c. Open-air D&D dust control – Several technical solutions related to open-air demolition work were further investigated and referred to the Oak Ridge D&D teams following the

D&D Roadmap Team interview. Particularly for the D&D of contaminated buildings on the ORNL campus, the spread of radioactive particulate and reduction of contaminated waste volume during D&D resulted in the identification of several technical needs. Nitrocision™, a technology successfully deployed during the D&D conducted at the West Valley Demonstration Project (WVDP), uses liquid nitrogen abrasion to remove contaminated concrete surfaces and polymer coatings to a targeted depth within an enclosed, ventilation controlled, system. The WVDP team presented their experience with the Nitrocision™ to aid the ORNL D&D project team in selecting suitable technology for further consideration in upcoming open-air facility D&D.

- d. Concrete decontamination – Following the formal Roadmap questionnaire and interview process, communication channels remained open to the ORR D&D teams to pose further questions regarding available technology. Instances of radionuclide contaminated concrete structures exist within the ORNL and Y-12 facilities. As communicated by ORR D&D team personnel, the removal of contaminants prior to demolition would be preferable due to cost, safety, and logistical concerns. Methods and technology to accomplish this were requested. SuperGel, a polymer based product originally developed at Argonne National Laboratory, designed to absorb radioactive metals and actinides from porous media such as concrete was referred to the ORR for further consideration.
 - e. D&D field team briefing – CH2M Hill, BWXT West Valley, LLC (CHBWV) the primary contractor for the WVDP, also participated by presenting 3-D modeling representations of Main Plant buildings to prepare D&D work teams. The modeling was used at the WVDP to brief D&D teams with visual information showing the location of contamination, electrical hazards, as-built diagrams, piping infrastructure, and other critical information used to complete daily work successfully (Office of Environmental Management, 2025). The ORR D&D project teams are considering its use for their own purposes at the Y-12 complex.
- ii. Savannah River 235-F Facility – Technical needs reported by the 235-F D&D team included the characterization of concrete ducting for eventual disposal. This ductwork is reported to be difficult to reach and must be removed prior to the end state of the overall facility structure. Robotics capable of accessing this ductwork, visually inspecting it's interior, and collecting concrete samples for analytical characterization were specifically noted for this technical request. Following assessment by the D&D Roadmap Team, several institutions were contacted for possible, existing, robotics solutions. Idaho National Laboratory (INL) responded to the D&D Roadmap team detailing their development of sensor packages for similar employment at the Hanford site. A more in depth evaluation of the viability for the use of these sensor packages is an ongoing, pending engagement from the SRS 235-F D&D Team.
 - iii. PORTS and PGDP – Technical needs identified by the PORTS and PGDP project teams focused on the large scale downsizing of process equipment currently being performed at each project site. This work was reported to be difficult to conduct due to the size of equipment needing segmentation and the conditions that employees performing this work face. Large converter cylinders must be cut by plasma torch and segmented into proper waste streams, and this process is performed in the former gaseous diffusion plant building structures, which no longer operate

structure wide climate control. Adverse temperatures that impact non-destructive assay equipment and worker personal protective equipment efficacy are continued challenges to the PORTS and PGDP project teams. In addition, off-gas created from plasma cutting can create hazardous breathing conditions for workers. Technical recommendations that resulted from the D&D Roadmap Team assessment are related to these challenges.

- a. Temperature Controlled PPE – Sweat-through of protective suits used by plasma cutting teams at the PGDP and PORTS sites was reported to hamper stay times for these workers and reduce overall productivity in converter segmentation work. During this interview, representatives from the ORR D&D project teams were invited to attend the D&D Roadmap Interview with the PORTS and PGDP teams to discuss the potential for shared technical solutions that crosscut between project sites. ORR SMEs were able to recommend the use of cooling suits that ORNL has previously helped research for the commercial sector as a potential solution for this technical need (Oak Ridge National Laboratory, 2002).
- b. Fume Control for Plasma Cutting – Nitrous oxide gasses are formed during plasma torch cutting operations and are known eye and skin irritants which can lead to potentially serious health problems. Fume recovery at PGDP and PORTS facilities is an area of potential improvement identified in questionnaire responses collected by the D&D Roadmap Team. Current fume recovery is performed by the specialized materials sizing area ventilation system and accompanying vacuum hosing placed close to torch position during cutting. Researchers at SRNL have proposed a potential improvement that uses 3D printing to attach vacuum intakes to the plasma torch apparatus for more efficient fume recovery. This technology does not yet exist, and research funding to produce prototypes has been requested. Initial proposals for this new technology for use at the PGDP and PORTS sites is ongoing.

Full explanations of technical needs related to each recommendation made by the Roadmap team are contained within the site specific summary reports SRNL-RP-2025-00074, SRNL-RP-2025-00067, and SRNL-RP-2025-00178.

Site Engagement and Communication

Four of the ten targeted D&D project sites fully participated in the D&D Technology Development Roadmap Initiative. Project teams associated with the SRS 235-F facility, ORNL and Y-12 facilities at the ORR, and the gaseous diffusion plants located at Portsmouth and Paducah provided full collaboration to ascertain technical needs relevant to their near current D&D project work. In addition, West Valley D&D SMEs including representatives from CHBWW shared information and lessons learned on specific technology used during D&D projects conducted at the WVDP, and bolstered the data collected by the D&D Roadmap Team. Due to the size and stage of project work at WVDP, a complete assessment was not possible. Questionnaires and inquiries for participation were also delivered to project teams and DOE Site Liaisons at Los Alamos National Laboratory (LANL), the Idaho Cleanup Project (ICP), Nevada National Security Site (NNSS), Lawrence Livermore National Laboratory (LLNL), Hanford Project Site, and the West

Valley Demonstration Project. Full engagement of site D&D teams for these six remaining projects, however, was not achieved.

Throughout the D&D Roadmap, availability to collaborate remained one of the most significant challenges to data collection. The number of technical needs identified, and potential solutions recommended by the D&D Roadmap Team, are partly a function of the ability of a project site to collaborate with this program. For example, project teams at the WVDP are comparatively small, with D&D project work relatively complete when compared to other project sites such as those at Oak Ridge. The WVDP and its contracting representatives were able to participate in a limited, and commendable, capacity regardless of these conditions through sharing lessons learned during their work. ICP, LANL, and LLNL project leadership were engaged with the D&D Roadmap effort, however only initial participation was realized. The D&D Roadmap Team was unable to collaborate with the Hanford Site or NNSS. As with other research collaboration efforts, contractors have defined scope that they must complete and unfunded laboratory requests for information do not always have high priority.

This overall level of engagement is itself a primary finding for the D&D Roadmap. Any external group composed of experienced SMEs in the D&D field, such as the D&D Roadmap Team, are at an immediate disadvantage in specific project knowledge when compared to the local D&D project team. Potentially useful recommendations can be made in such a case and only through a lengthy process of information gathering and background research such as that conducted through the D&D Roadmap questionnaire and interview process.

Final judgement required to implement a new toolset or technology ultimately rests with the D&D project team. In fact, during the formation of recommendations made by the D&D Roadmap Team, it was most often the case that direct contact needed to be made between a technology provider and a knowledgeable representative from a D&D project team to determine a solution's suitability for further evaluation. Beyond data collection and classification, the D&D Roadmap Team often acted as a facilitator of this dialogue. The conclusion drawn from this is that an improved form of this information conduit, to facilitate this communication automatically, would more thoroughly benefit continued progress in D&D for the overall DOE Complex.

Improving communication presents a new challenge, however. The "D&D" moniker applies to large multi-year undertakings that utilize numerous scientific disciplines and unique technologies to complete. The wealth of information available can stifle the identification of a specific solution. Furthermore, when a solution is found and used, its historical details may be recorded in any number of site specific reports, conference presentations, or journals. After the assessment of four project sites, each with unique challenges and goals, this variability of data led the D&D Roadmap Team to develop a novel system of classification simply to compare one technical need to another in a reproducible manner. The D&D Roadmap Team further concludes that such a system could be used to sort available technical solutions by a D&D project team itself. Through doing so, a direct connection can be made between a project site and a technical solution in an efficient and simplified manner in a form that documents this process for easy future reference.

A Recommended Taxonomic System

During the assessment of D&D technical needs, the D&D Roadmap Team developed a form of taxonomy to categorize the influx of technical needs reported by D&D project teams. This was a necessary step to meet the objectives set for success of the Roadmap. No other way was found for such feedback be used to determine a research area requiring more focused attention to produce results for DOE-EM. A research area must be defined, and the technical requests collected must be evaluated to apply to that area in a uniform, reproducible, manner. A similar process of classification is the essence of any system used to arrange large data sets. The D&D Roadmap Team applied this process to the feedback collected from D&D project teams. A full description of the system used, its categories and criteria, and its usage to define each chosen technical need identified for a specific D&D project site are contained in each site specific summary report. The categories and criteria that create this taxonomy are presented in Appendix B-1. Taxonomic codes applied to each individual technical response for all sites are presented in Appendices B-2, B-3, and B-4 and refer to the SRS 235-F facility, the ORR, and the PORTS/PGDP respectively. A complete tally of the accumulated responses and their taxonomic classifications is presented in Appendix B-5.

Any useful system used for classification inherently can be used for the communication of information as well. Using the taxonomy created for the D&D Technology Development Roadmap, a technical D&D solution can be classified using the same process as that of a D&D need. As a result, a common language to reference each side of a dialogue between a need requestor and a solution provider is made. This common method to classify technical requests, R&D projects, and available technology under the scope of deactivation and decommissioning can allow for a requestor to find a provider of a solution far more efficiently and directly.

In addition, once classification is performed, a record is formed. If this system of classification exists in one place, so could its records. Through continued usage of a unified system of classification, and a single database to contain its records, such a system would only improve in utility as data is collected and stored. D&D project management teams can then use the recorded information for tracking and trend analysis to procure much of the same data collected during the D&D Roadmap, in a continuous manner. This would be a direct improvement over existing database systems that only catalogue potentially useful technology such as the D&D KM-IT system developed by Florida International University (FIU).

The D&D Roadmap Team recommends that:

1. The developed taxonomic system, used to assess technical needs, be used as a prototype example to develop a communication system that makes a direct connection between D&D project teams and the providers of D&D related technical solutions.
2. This system be used to continually track and record interactions between these parties and for use in long term assessment of technical needs for the DOE-EM.
3. A web-based site that contains this function, which is accessible to the necessary personnel in the public and private sector, is the recommended method to employ this system.

4. If implemented, this system should be accompanied by a standardized form and process instruction guide to aid obtaining the desired information in a uniform manner, that can be promulgated across the DOE Complex.

An example walkthrough of how this system could be implemented is presented in Appendix B-7.

Conclusions

The D&D Roadmap Team assessed the reported technical needs for four separate D&D projects for the DOE. The SRS 235-F facility team, Oak Ridge teams at Y-12 and ORNL, and teams overseeing the PGDP and PORTS sites were all full participants in the D&D Roadmap project. Other site D&D project teams participated in more limited capacity. Using the data set collected a technical priority can be assigned to improvements in waste handling and preparation via robotics to reduce human exposure to contaminants while performing this work. This technical need is widely applicable to other D&D project sites within the DOE Complex. Notably, this recommendation for DOE Complex wide performance improvement in the D&D field by the D&D Roadmap Team is inherently related to the ability to solicit the required information to achieve this. As a second rank priority for improvement is to develop a system to enhance the communication of technical needs stated by D&D teams, and catalogue the technology used to meet them.

First tier recommendations are formed around the assessed technical requests made by D&D project teams. While robotics were the most requested technology, and for the purposes of reducing human exposure to contaminants during waste preparation, there are other ways that may deliver similar results. Practices such as building new facilities in a manner that facilitates its D&D is a worthwhile consideration. Steel lined or pre-coated surfaces that are planned containment vessels are one such possibility. Many ancillary requests made by D&D teams also revolved around dealing with the contaminated infrastructure in the D&D phases, and preventing this contamination would achieve similar if not better results to reducing the exposure of D&D teams.

Second tier recommendations that can currently be made by the D&D Roadmap Team apply to the structure of communication and documentation related to the D&D field. A venue for expressing technical needs that also compiles their outcomes and chosen technical solutions would be a direct improvement to existing documentation and tracking within the D&D field of the DOE Complex. No central repository for technical solutions specifically applied to D&D projects exists for reference by ongoing or future D&D project teams and provides this dual functionality. Ultimately, D&D project teams are surveyed for their technical needs and do find new technology through several other means. Maximizing the return-on-investment by streamlining access to information and documentation of previous achievements is the most valuable recommendation to the DOE complex that can be made using the experience gained by the D&D Roadmap Team. A potential method to accomplish this was developed and is presented in the taxonomic system used to assess technical needs data collected to provide the dual benefit of improving communication and documentation through the use of one tool.

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Appendices

Appendix A-1: D&D Roadmap Questionnaire

SRNL-L3220-2024-00005, Rev. 0

May 2, 2024

TO: Deactivation and Decommissioning Project Team

FROM: Deactivation and Decommissioning Roadmap Initiative Team

D&D Roadmap: Facility Questionnaire for Technical Needs**Purpose:**

This initiative has been formed to identify high-priority technical needs and the Technology Development (TD) tasks required to meet those needs in support of the ongoing deactivation and decommissioning (D&D) of Department of Energy infrastructure across the United States. This questionnaire is intended to be completed by the personnel involved with current and near-future D&D projects in the DOE Complex. A small team of subject matter experts (SMEs) led by SRNL from the Network of National Laboratories for Environmental Management and Stewardship (NNLEMS) professionals will assess the critical needs, scientific capabilities, and practical technologies identified by this questionnaire and prioritize research and development of TD projects in the D&D focus area to assist ongoing D&D work across the DOE complex. Each D&D project will be asked to complete a questionnaire and participate in a subsequent video interview process to achieve these goals.

This questionnaire is designed to allow interviewers and interviewees to preface a video conference with topics the D&D project team finds of critical importance. By responding to the questions below the formal video conference will be a more focused process. Each interview will be summarized in a corresponding report that will be issued to the D&D project team, DOE TD division, and other participating D&D site teams that are interviewed. All projects will be assessed for opportunities to test key technologies identified by the D&D Roadmap team. A final workshop will be organized and made available for participation and presentation by each entity involved with this D&D Roadmap initiative, including private contractor companies.

Questionnaire Instructions:

The questions and topics below have been selected by the Roadmap SME team to solicit a broad range of information regarding D&D activities at the site. The questionnaire should be completed by personnel involved in the planning, implementation, and assessment of D&D projects that are currently taking place or are slated to take place in the next three to five years. Multiple answers to each question may be necessary. A complete picture of current technological needs and potential problem points is critical to the success of the D&D Roadmap initiative and its ability to provide value to the individual D&D teams. Photographs or related attachments of specific areas of interest are encouraged to be provided in addition to any questions that they may pertain to. Please have three to five employees answer each section of this questionnaire separately:

Respondent Information

Name: _____

Job Title: _____

Contact Information: _____

1. Project Driver

Please describe the primary objective and/or driver of the D&D work taking place that you are currently involved in. This may be timeframe, environmental risk, budgetary concerns, regulatory framework, worker safety, or otherwise.

D&D Project Referenced: _____

Respondent's Position in Relation to D&D Project: _____

2. Project Progress

Are there any specific instances of D&D work being hindered or enhanced by technological improvements or methodology? A specific objective of this project is to propagate useful technology or D&D techniques to other projects in the DOE complex.

D&D Project Referenced: _____

Respondent's Position in Relation to D&D Project: _____

3. Technological Application

Are any technological needs that may improve the results of your D&D project absent or not functioning? This may refer to currently existing, but unobtainable, technology, theoretical application of existing technology, or fully theoretical specialized equipment.

D&D Project Referenced: _____

Respondent's Position in Relation to D&D Project: _____

4. Worker Safety

Are there any barriers or significant risks to D&D worker safety that apply to the current D&D project that have or could impact the performance of this work? This could involve critical safety devices, D&D techniques in hazardous environments, or specific hazard controls related to each project.

D&D Project Referenced: _____

Respondent's Position in Relation to D&D Project: _____

5. Regulatory Framework

What regulatory controls most affect this D&D project? Are there any significant instances of inter-agency priorities that affect this project? This may range from regulatory engagement, regulation clarity, conflicting regulation, or otherwise specified by the project team.

D&D Project Referenced: _____

Respondent's Position in Relation to D&D Project: _____

6. Waste Disposition and Disposal

What issues exist that may affect project outcome that relate to waste processing on this project? This may refer to waste collection, storage, shipment, disposal facility requirements, or otherwise identified by the project team.

D&D Project Referenced: _____

Respondent's Position in Relation to D&D Project: _____

7. Public Engagement

Does the D&D project require specific public engagement or hazard protection required for the successful conduct of this work?

D&D Project Referenced: _____

Respondent's Position in Relation to D&D Project: _____

8. Cost Efficacy

Are there any technological or methodology improvements that could conceptually improve the performance of this D&D project?

D&D Project Referenced: _____

Respondent's Position in Relation to D&D Project: _____

9. Project Lifespan

What is the intended project lifespan and outcome of this D&D work? This may involve eventual public use of the property (with or without environmental restrictions), long term environmental monitoring, reuse of the land by the DOE, or otherwise as identified by the D&D project team.

D&D Project Referenced: _____

Respondent's Position in Relation to D&D Project: _____

10. Research Possibilities

What areas or possibilities are available in this D&D project to deploy emerging technology? Are there any opportunities to test new research and technology related to D&D that may become available in the near future?

D&D Project Referenced: _____

Respondent's Position in Relation to D&D Project: _____

11. Site Specific

What other issues have arisen during the current or previous phases of this D&D project that it is possible to improve? What lessons learned have the project team identified that may be useful to future D&D work on this or other projects?

D&D Project Referenced: _____

Respondent's Position in Relation to D&D Project: _____

12. Open Ended

Please describe any other issues that may relate to D&D project work pertaining to technological or methodological improvements that are, or may be, possible and applicable. This initiative relies upon the expertise and insight of individuals who drive D&D work for the DOE and the expertise of the interview team to recommend or initiate research to aid them.

Respondent's Position in Relation to D&D Project: _____

The D&D Roadmap team appreciates all feedback and answers to this questionnaire. There are no wrong answers, and all input from experienced individuals with experience in D&D work are valuable to the success of this project and related work in the DOE complex. Results of this initiative will be shared freely with D&D project teams with the sole intention of improving the quality of work and life of these teams.

Should there be any questions or comments to this questionnaire, please contact the project leads listed below.

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Appendix B-1: D&D Roadmap Taxonomy Categories and Criteria

D&D Roadmap Assessment Taxonomy Categories and Criteria

Category 1 <u>D&D Stage</u> 1.) Deactivation 2.) Long Term Storage 3.) Decommissioning	Category 4 <u>Project Impact Level</u> 1.) High 2.) Medium 3.) Low	Category 6 <u>Technology Type</u> 1.) Modelling 2.) Non-Destructive Assay 3.) Sample Collection 4.) Robotic/Remote Applications 5.) Fixatives and Coatings 6.) Decay and Byproduct Control 7.) Grout and Entombment 8.) Contaminant Collection/Removal 9.) Personal Protective Equipment 10.) Exposure Monitoring 11.) Waste Preparation 12.) Waste Treatment 13.) Waste Shipment and Disposal 14.) Interim Waste Storage 15.) Artificial Intelligence
Category 2 <u>Needs Timeline</u> 1.) Near Future 2.) Current 3.) Near Past	Category 5 <u>Challenge Type</u> 1.) Contaminant Type 2.) Contaminant Control 3.) Security and Maintenance 4.) Worker Safety 5.) Waste Processing 6.) Characterization 7.) Accessibility 8.) Project Management	
Category 3 <u>Needs Driver</u> 1.) Project Cost 2.) Project Schedule 3.) Project Efficiency 4.) Safety Risk		

Appendix B-2: D&D Roadmap Taxonomy – SRS 235-F Facility Assessment

D&D Roadmap Assessment of SRS Questionnaire Responses

SRS - 235F -1: Field Based Qualitative Characterization		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Definitive, real-time data that will allow for immediate, accurate field decisions in determining appropriate waste streams. This will eliminate the conservative practice of handling/disposing of clean waste as contaminated.	Stage	1,3
	Timeline	1,2,3
	Driver	1,3
	Impact	1
	Challenge	2,5,6
	Technology	11

SRS - 235F -2: Robotic/Remote Applications		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
The current scope of work being performed has no technological needs. Future work like characterizing the interior of the large concrete exhaust duct that is located on the roof of 235-F, this technology should be able to remotely perform Radiological survey, concrete sampling and video feedback at a minimum and be portable enough to be easily mobilized to a roof deployed through small duct opening and perform its work.	Stage	3
	Timeline	1
	Driver	3,4
	Impact	2
	Challenge	1,6,7
	Technology	3,4

SRS - 235F- 3: Contaminant Fixation		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
If adequate lock down/capture/fixative technology existed, it may have driven the alternative selection process (EECA) in a different direction i.e. removal of the building process equipment and building structure. If developed it could provide additional options for D&D of other facilities.	Stage	1,3
	Timeline	2
	Driver	2,3
	Impact	1
	Challenge	2
	Technology	5

SRS - 235F - 4: Hydrogen Generation During In-situ Decommissioning		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Tech Improvement Enhancement: we have and will use specialty grout mixes developed with help of researchers in SRNL are useful to the decommissioning projects that rely on InSitu Disposal end states. Tech Needs: approach for prevention/mitigation of hydrogen deflagration (option to recombiners), method for grout placement in process enclosures without losing confinement, specialty grout for particulate Pu-238.	Stage	3
	Timeline	1,2
	Driver	2,4
	Impact	1
	Challenge	2,4
	Technology	6,7

SRS - 235F - 5: Decay and Byproduct Control		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
There is the potential to install PARs (Passive Autocatalytic Recombiners) in 235-F during its future decommissioning. There is Pu-238 inside the gloveboxes in the building that cannot be removed due to ALARA reasons. As it decays, it generates hydrogen over time, which presents an explosion hazard post-decommissioning. We are still working through multiple different methods for decommissioning and installing PARs is one of those potential methods. However, this is a relatively new technology used primarily in nuclear power plants and has never been used in this type of application.	Stage	3
	Timeline	1,2
	Driver	4
	Impact	2
	Challenge	1,2
	Technology	6

<u>SRS - 235F - 6: Fixative Application</u>		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Building 235-F is slated for "in-situ" decommissioning versus complete demolition, primarily so as to avoid worker exposure and the risk of uptake/contamination events [see Comparative Analysis (Table 3) in SRNS-RP-2021-00001]. That said, there is still significant worker exposure/risk associated with the "in-situ decommissioning" alternative because it does involve extensive entry into Building 235-F (an HCA/ARA) for the installation of forms/supports and placement of grout. Additionally, it is anticipated that grout will be placed inside contaminated components such as cells and gloveboxes. Breaching these contaminated components could release contaminants into 235-F and lead to worker exposure. The best method for breaching the contaminated components and introducing grout is TBD.	Stage	1,3
	Timeline	1,2,3
	Driver	3,4
	Impact	2
	Challenge	4,7
	Technology	5,7

Appendix B-3: D&D Roadmap Taxonomy – Oak Ridge Reservation Assessment

OR - Y12 - 1: Mercury Treatment and Control		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
D&D of facilities located at Y-12 have the potential risk of containing trace amounts of mercury contamination embedded in the debris that could be released (condensate) during temperature fluctuations once packaged in metal waste boxes or bulk containers for off-site disposition at NNSS. If enough mercury accumulates within a waste container, it could be detected by real-time radiography (RTR) upon acceptance at the NNSS disposal facility and result in a non-complaint package. This could lead to suspension of UCOR's NNSS certification program, causing delays in project schedule and productivity.	Stage	3
	Timeline	1
	Driver	2
	Impact	1
	Challenge	2,5
	Technology	11,13

OR - Y12 - 2: Mercury Vapor Management		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Any technology related to mitigating mercury vapors would be beneficial. Any technologies related to mercury disposal would be beneficial.	Stage	3
	Timeline	1,2,3
	Driver	2,4
	Impact	1
	Challenge	2,4
	Technology	8,9

OR - Y12 - 3: Remote or Non-Laboratory Characterization		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
The desire of the project is to obtain a handheld solution for initial characterization, i.e., spectroscopy or XRF, to help identify problem areas, minimize unnecessary decontamination efforts, reduce sample costs, and reduce delays while awaiting results.	Stage	3
	Timeline	1,2
	Driver	2
	Impact	2
	Challenge	6
	Technology	2,3

OR - ORNL - 4: Robotic/Remote Applications		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
ORNL facilities are highly contaminated and possess large source terms of radiological materials. Isotope inventory is varied and the mix of isotopes can present challenges to D&D. Decontamination and demolition solutions that employ robotic or remote handling and/or operation will allow longer stay times in facilities and improve overall completion performance.	Stage	1,3
	Timeline	1,2
	Driver	2,4
	Impact	2
	Challenge	4,7
	Technology	4,11

OR - ORNL - 5: Decontamination and Dust Control		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
ORNL facilities are highly contaminated and possess large source terms of radiological materials. Isotope inventory is varied and the mix of isotopes can present challenges to D&D. A particular issue is open-air demolition of highly contaminated facilities, which are located at both ORNL and Y-12. Decontamination and source term removal is performed to the extent practical to prevent contamination spread during demolition. An aggressive/effective decontamination method followed by a highly adherent/dust suppressing fixing agent for contaminants such as radiological, beryllium, etc. would be a benefit for open-air demolition, confined spaces and high elevations.	Stage	3
	Timeline	1
	Driver	2,4
	Impact	2
	Challenge	2,4
	Technology	5,11

OR - ORNL - 6: Portable Hot Cell		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
A single use portable hot cell that can be used for dismantlement and become the final disposal package for these waste is envisioned as a useful technology that can be applied. Robotic or remote application options for the hot cell is also desirable.	Stage	3
	Timeline	1,2
	Driver	2,4
	Impact	2
	Challenge	2,4,5
	Technology	4,8,11

Appendix B-4: D&D Roadmap Taxonomy – Portsmouth and Paducah Assessment

D&D Roadmap Assessment of PPPO Questionnaire Responses

PORTS - X330 - 1: Automated Segmentation of Large Process Equipment		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Automated size reduction of demo debris would reduce risk and improve efficiency.	Stage	3
	Timeline	1,2,3
	Driver	2,3,4
	Impact	2
	Challenge	4,5
	Technology	4,8,11
PGDP - C333 - 2: Cold Cutting for Segmentation and Downsizing		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
A method for cutting steel without producing the heat of plasma cutting, but just as effective and efficient. The cutting produces fumes and dust harmful to workers. It would be greatly beneficial if an alternate method could reduce or eliminate that. PPE technology that incorporates cooling/heating for the worker would help productivity.	Stage	2,3
	Timeline	1,2
	Driver	2,3,4
	Impact	2
	Challenge	4,5
	Technology	8,11
PGDP - C333 - 3: Material Handling Process Improvements		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Material handling – use of old building cranes is a maintenance problem; however, is the only way to move some equipment. We upgraded two main cranes which has helped. Our equipment is on a 2nd floor, so floor loading is a limitation on material handling equipment. We have purchased some new material handling equipment. We are constantly evaluating material handling improvements, whether crane fixtures, mobile cranes, forklifts, pallet jacks, air casters, carts pulled by tuggers, etc. Handling waste and use of waste containers is also important (metal containers, bags, lifting fixtures, etc.).	Stage	3
	Timeline	1,2,3
	Driver	3
	Impact	1
	Challenge	4,5
	Technology	11,12,13
PORTS - Misc. - 4: Asbestos Materials Size Reduction		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Large diameter recirculating cooling water pipes within the footprint of the 5-Unit Excavation and across the Plant site. These pipes consist of asbestos. The off-site disposal of these pipes will be cost prohibitive. Alternatives for management and size reducing of the RCW piping is being evaluated for ultimate disposal into the OSWDF.	Stage	3
	Timeline	1,2,3
	Driver	2,4
	Impact	3
	Challenge	5
	Technology	11

PGDP - C333 - 5: Breathing Zone Airborne Contaminant		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
The project has experience issues with real-time monitoring of hydrofluoric acid (Drager 5100 X-am) and combustion gases (Drager 5600 X-am) created during plasma cutting; false alarms have been observed on personal air monitors due to interference sensors on these monitors. A better method for real-time monitoring in the worker's breathing zone would minimize project delays. Improvement in a method to decrease exposure to NOx which decreases the need for additional PPE would have a significant positive impact to future work. the Dust Collector has been very beneficial is being implemented in the next MSA shop in Portsmouth.	Stage	3
	Timeline	1,2
	Driver	4
	Impact	2
	Challenge	4
	Technology	9,10

PGDP - C333 - 6: Environmentally Hardened Sensors		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Due to the building having no environmental controls heat and cold stress require significant attention as well as humidity which impacts instruments needed for monitoring. Majority of our monitoring equipment is restricted to use to within particular parameters i.e. temperature and humidity, and with minimal ability to control those parameters on a large building that is no longer in production we experience delays or require additional mitigations in order to maintain production. Identifying equipment with a broader range in the area of humidity and temperature would be a great benefit to the project. Measuring and testing instruments, such as those used by IH and RADCON, also may be highly sensitive to temperature/humidity. Ideas for improved instrument technology would also be helpful.	Stage	2,3
	Timeline	1,2
	Driver	3,4
	Impact	2
	Challenge	4
	Technology	9,10

PGDP - C333 - 7: Component Recycling and Reuse		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
One of the goals of the C-333 D&D project is to reuse/recycle equipment and materials to the greatest extent possible; however, the effort required to perform radiological surveys required to free release this equipment/material often exceeds the cost for disposal making reuse/recycle cost prohibitive. This project and many others could benefit from a technology that more efficiently identifies the presence of radiological contamination in hard to access areas or on equipment with painted surfaces.	Stage	3
	Timeline	2
	Driver	3
	Impact	2
	Challenge	6
	Technology	2

PORTS - X330 - 8: Large Component NDA		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Non-destructive assay (NDA) for uranium holdup delays characterization and impacts costs.	Stage	3
	Timeline	1,2
	Driver	1,2,3
	Impact	1
	Challenge	6
Improvements in NDA technology could improve schedule and cost.	Technology	2
The sequence of deactivation work has been inefficient. The reluctance to perform proper NDA has delayed schedules and increased costs.		
Future development efforts for better characterization of large valves would benefit the project if completed in time for X-330, and would benefit D&D efforts at the Paducah facilities.		
Large valves are up to 17 feet in length, and pose the same concern. Man-lifts are typically used to position detection instrumentation and personnel for characterization, but improved characterization techniques that do not require access from both the top and bottom of pipe galleys would improve worker safety.		

PGDP - C333 - 9: Robotic Deployment of NDA		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Characterization of the facility has been positively impacted by a qualitative nondestructive assay method through the deployment of a robotic pipe crawler for performing visually-assisted gamma scans. Pairing the detector with a quality camera for visual analysis, and placing the detector and camera on a robotic platform that is remotely operated improves the worker experience, decreases schedule, and helps identify areas in which quantitative NDA methods are required.	Stage	1,3
	Timeline	1,2,3
	Driver	3
	Impact	1
	Challenge	6
	Technology	2,4

PORTS - X330 - 10: Durable Coatings and Hazard Markings		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Early elimination of non-essential systems (Exhaust/Supply Fans, Heating/Cooling) may lead to unanticipated consequences such as moisture/humidity management issues within large facilities. This further leads to contamination control issues resulting from early internal coating and signage/marketing failures.	Stage	1,2
	Timeline	1,2
	Driver	4
	Impact	2
	Challenge	2
	Technology	5

PORTS - Misc. - 11: Degrading Infrastructure Solutions		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Area of Opportunity: There is degrading infrastructure i.e. leaking roofs. There is a need for a short term quick fix.	Stage	1,2,3
	Timeline	1,2,3
	Driver	4
	Impact	2
	Challenge	1,3,7
	Technology	5,6

<u>PORTS - Misc. - 12: Emergency Response</u>		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
The use of drones equipped with radiological and chemical monitoring equipment would be beneficial to our emergency services department.	Stage	3
	Timeline	1,2
	Driver	4
	Impact	2
	Challenge	4,6
	Technology	4

<u>PORTS - X330 - 13: Energized Source Detection</u>		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Unidentified and unexpected energized or pressurized systems during deactivation and excavations on and in the deteriorating facilities.	Stage	3
	Timeline	2,3
	Driver	4
	Impact	1
	Challenge	3,4
	Technology	9,10

<u>PGDP - C333 - 14: Heat Stress PPE</u>		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Improved PPE technology which mitigates or minimizes sweat-out or sweat-thru and incorporates cooling for the worker	Stage	3
	Timeline	1,2,3
	Driver	3,4
	Impact	2
	Challenge	4
	Technology	9

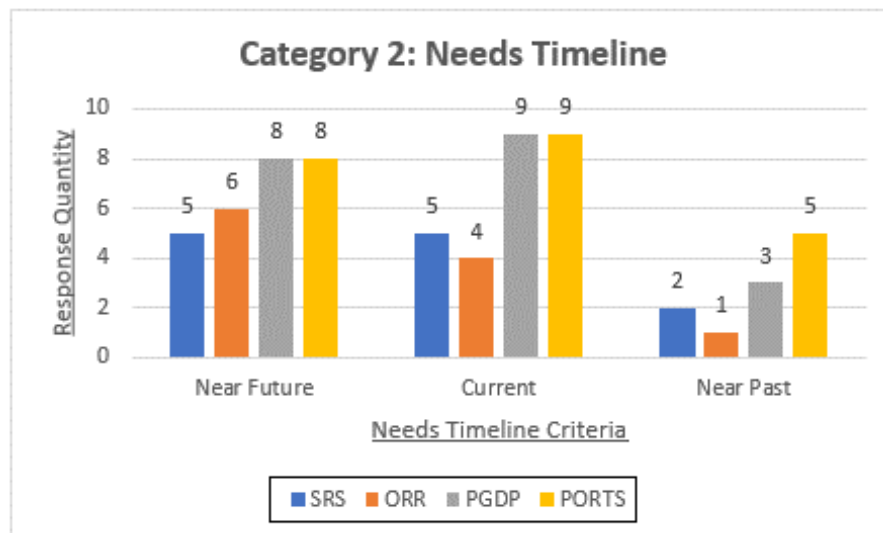
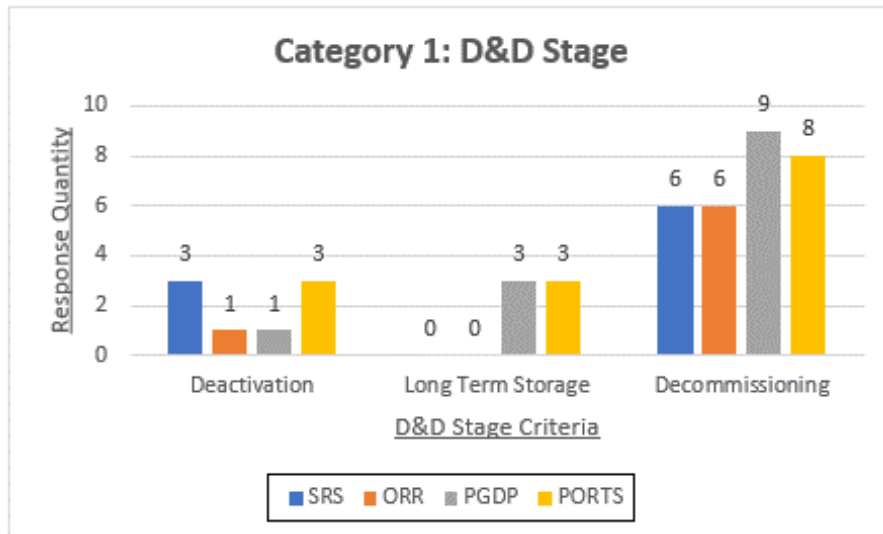
<u>PGDP - C333 -15: Work Zone Air Quality Control</u>		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Ventilation – we must use NAMs, Hepa Vacs, etc, to help with air quality during segmentation. We also installed a dust collection system to remove and filter air from the DEAC processes. These work well, but we continue to work ideas to improve for better air quality and ease on worker. Also, access to HVAC is important for human comfort and will increase productivity.	Stage	2,3
	Timeline	1,2
	Driver	3
	Impact	2
	Challenge	2,4
	Technology	8,9

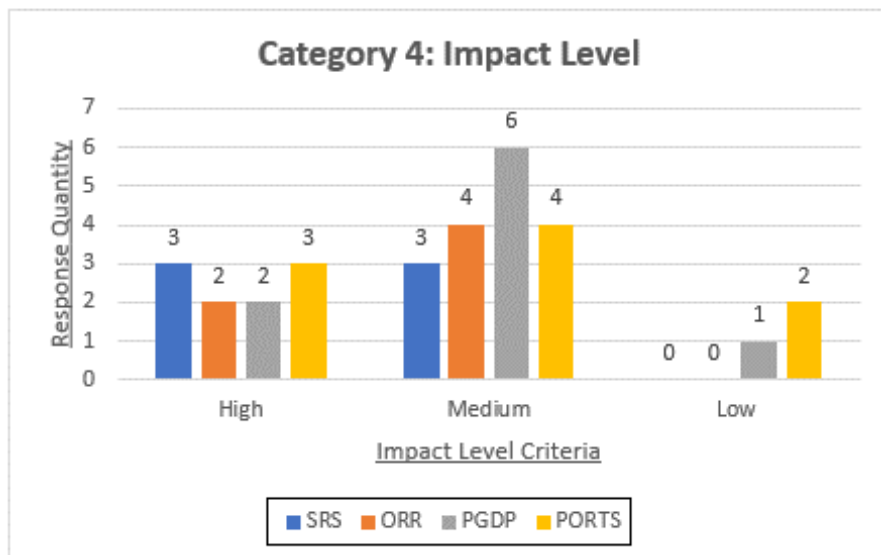
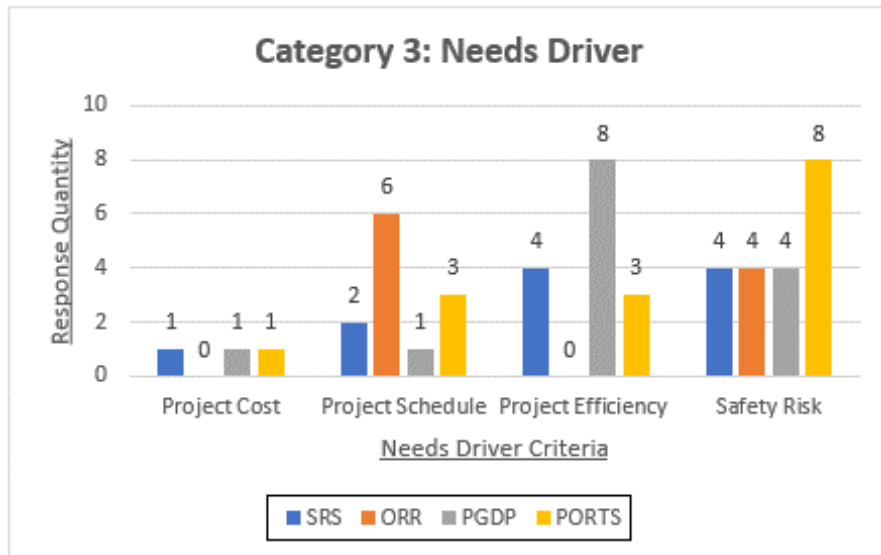
<u>PORTS - X330 - 16: Chlorine Trifluoride Control</u>		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
A second worker safety issue involves lines that were used to provide ClF3 to the plant when it was in operation. The system in X-333 was purged and treated to remove residual gaseous ClF3 with the goal to reduce its concentration to below 1 ppm. A holding tank could not be reduced to this level after multiple treatments, and remains above the immediately dangerous to life and health (IDLH) level. Improved techniques for treating such systems would be beneficial, as the system also fed X-330 at PORTS and a system was also used in	Stage	3
	Timeline	1,2
	Driver	4
	Impact	1
	Challenge	4,5
	Technology	8

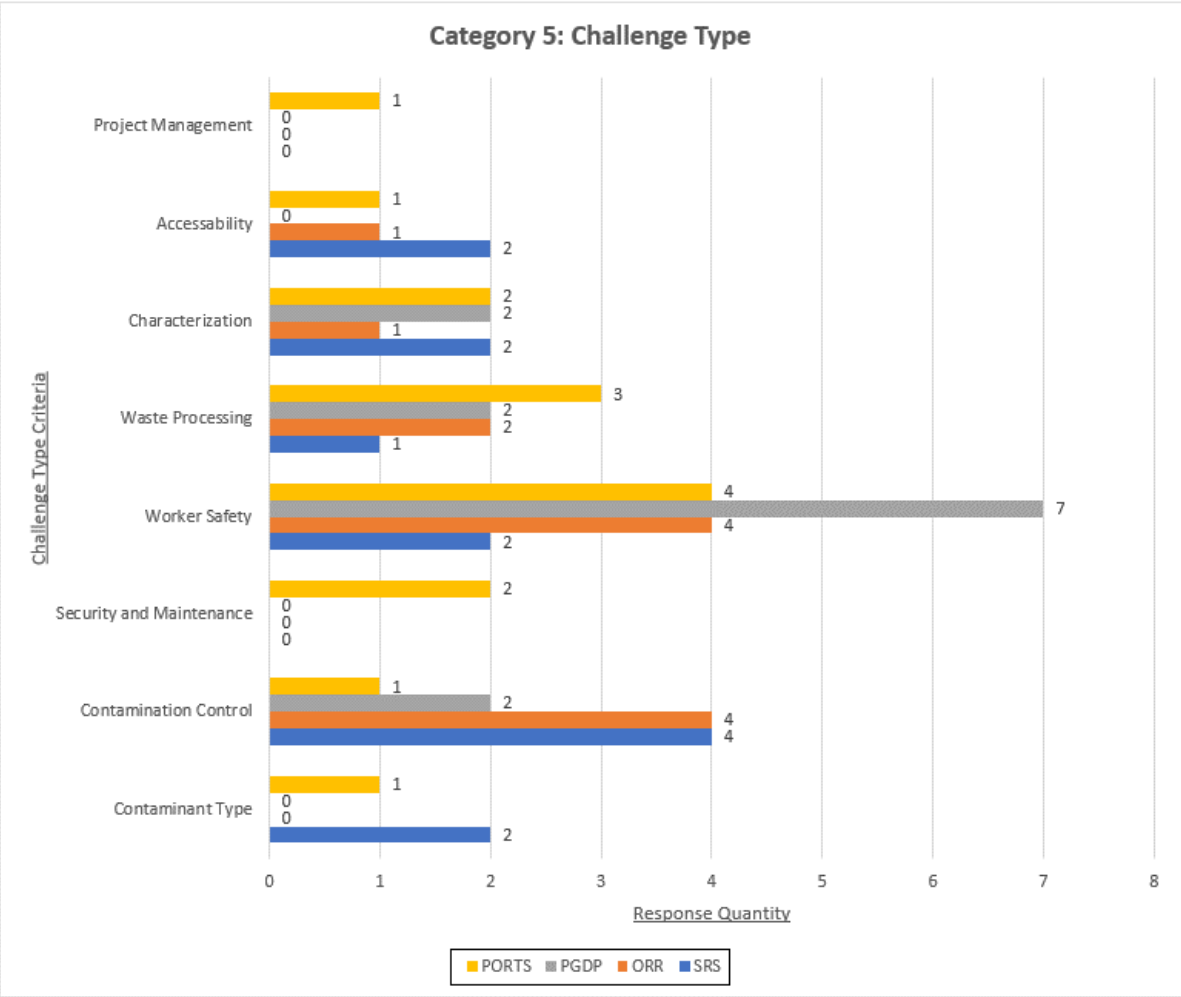
PGDP - C333 - 17: Interim Waste Storage		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Budget confinements has led us to explore options to segmented parts and pieces within the C-333 facility. This saves money in the near term until an on-site waste disposal facility is available; however, with such limited space, storing parts and pieces in this manner creates a potential need to relocate the equipment to complete pre-demo work in the future. The desire is to also build a future on-site waste disposal facility to hold the demolition waste from these projects.	Stage	3
	Timeline	1,2
	Driver	1,3
	Impact	3
	Challenge	2,4
	Technology	14

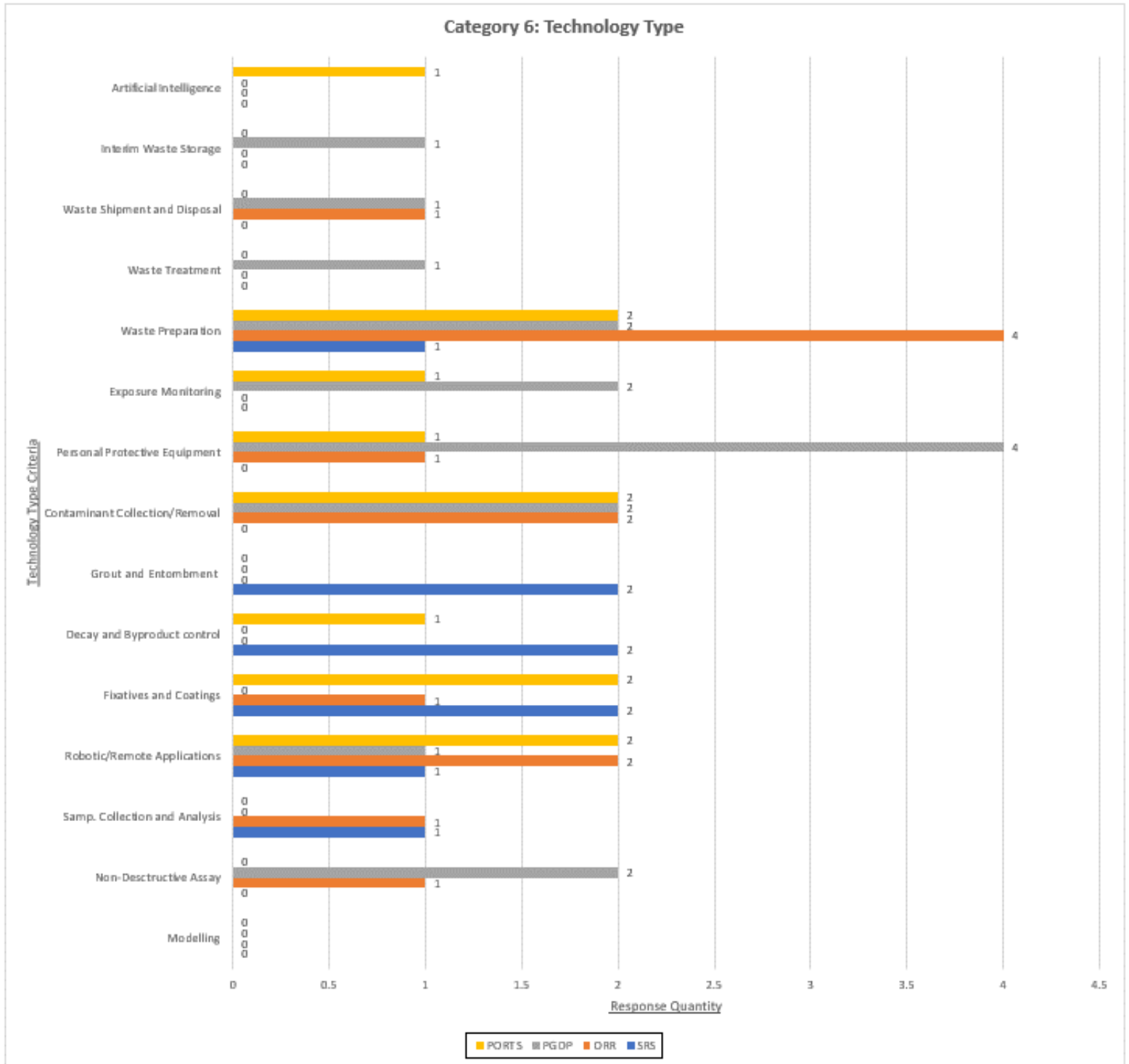
PORTS - X330 - 18: Artificial Intelligence Application		
Chosen Questionnaire Response	Assessment Category	Assessment Criteria
Possible R&D: Incorporation of AI in risk analysis, regulatory documents, and project controls.	Stage	1,2,3
	Timeline	1,2,3
	Driver	3,4
	Impact	3
	Challenge	8
	Technology	15

Appendix B-5: D&D Roadmap Taxonomy – Full Category and Criteria Assessment Totals

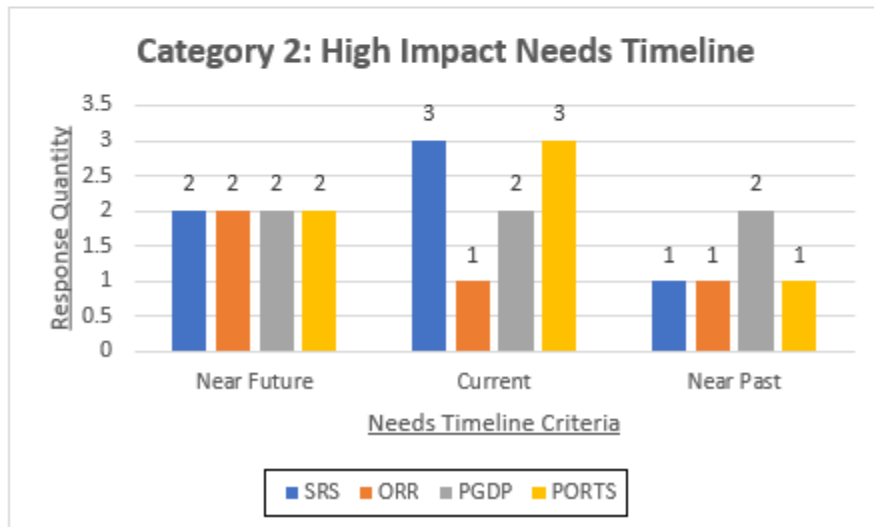
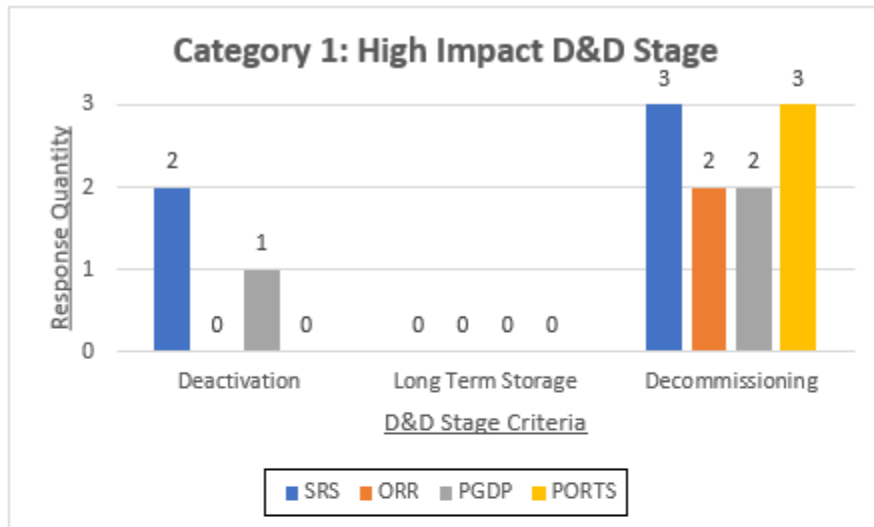


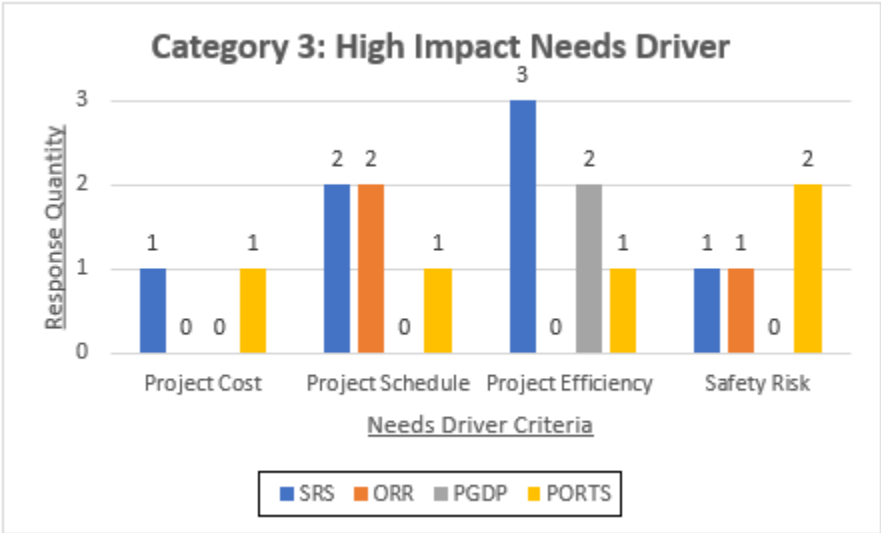


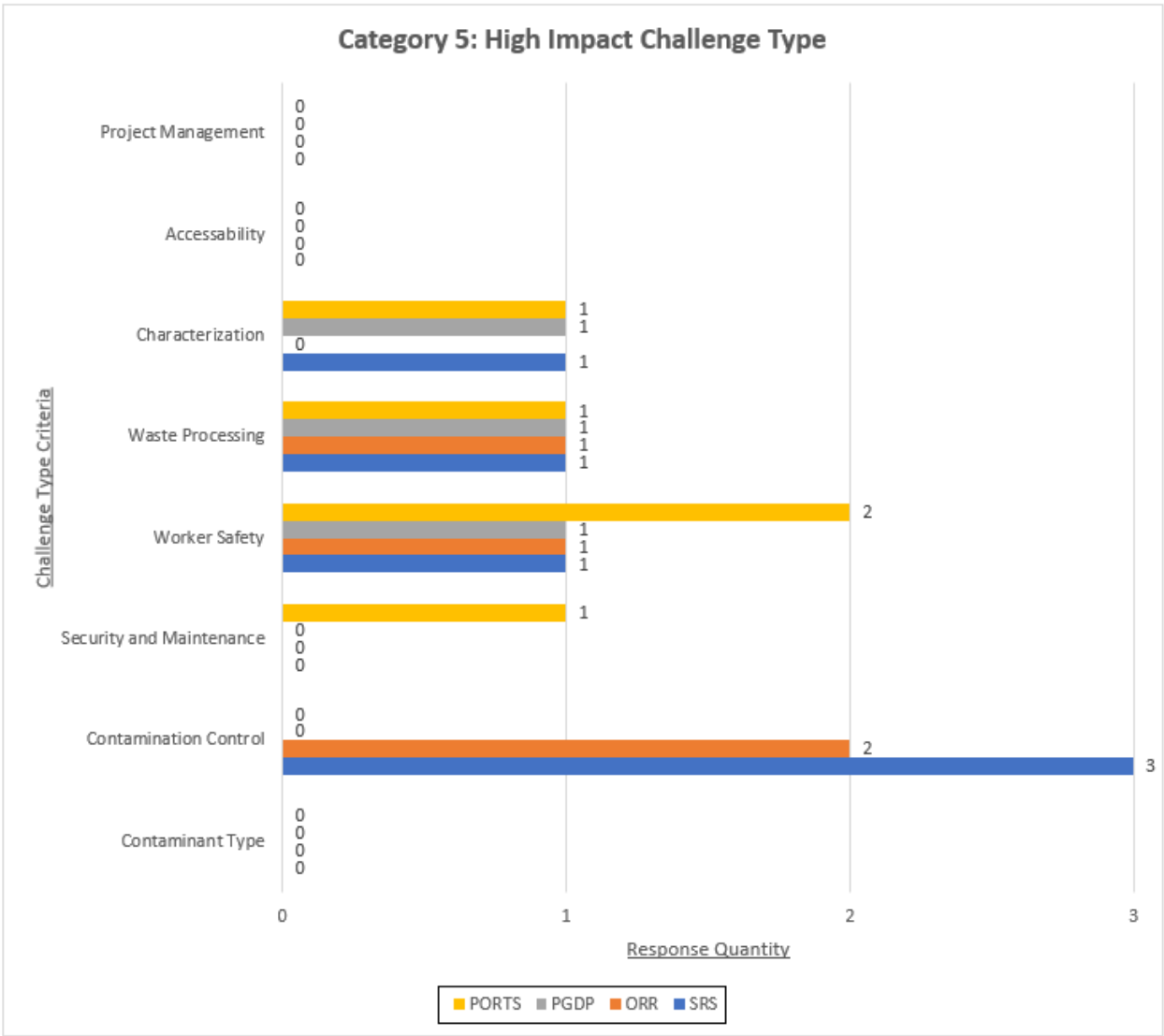


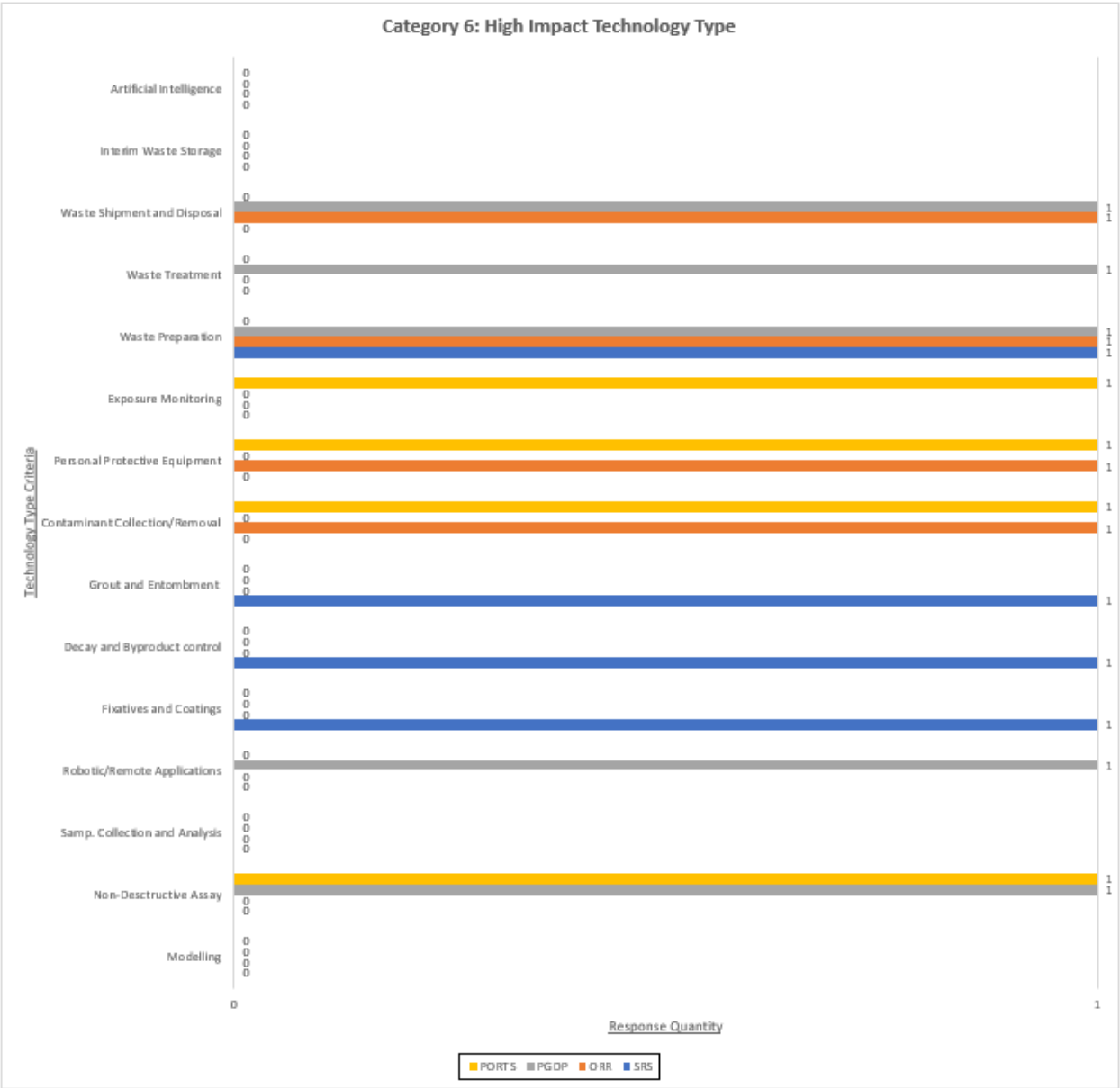


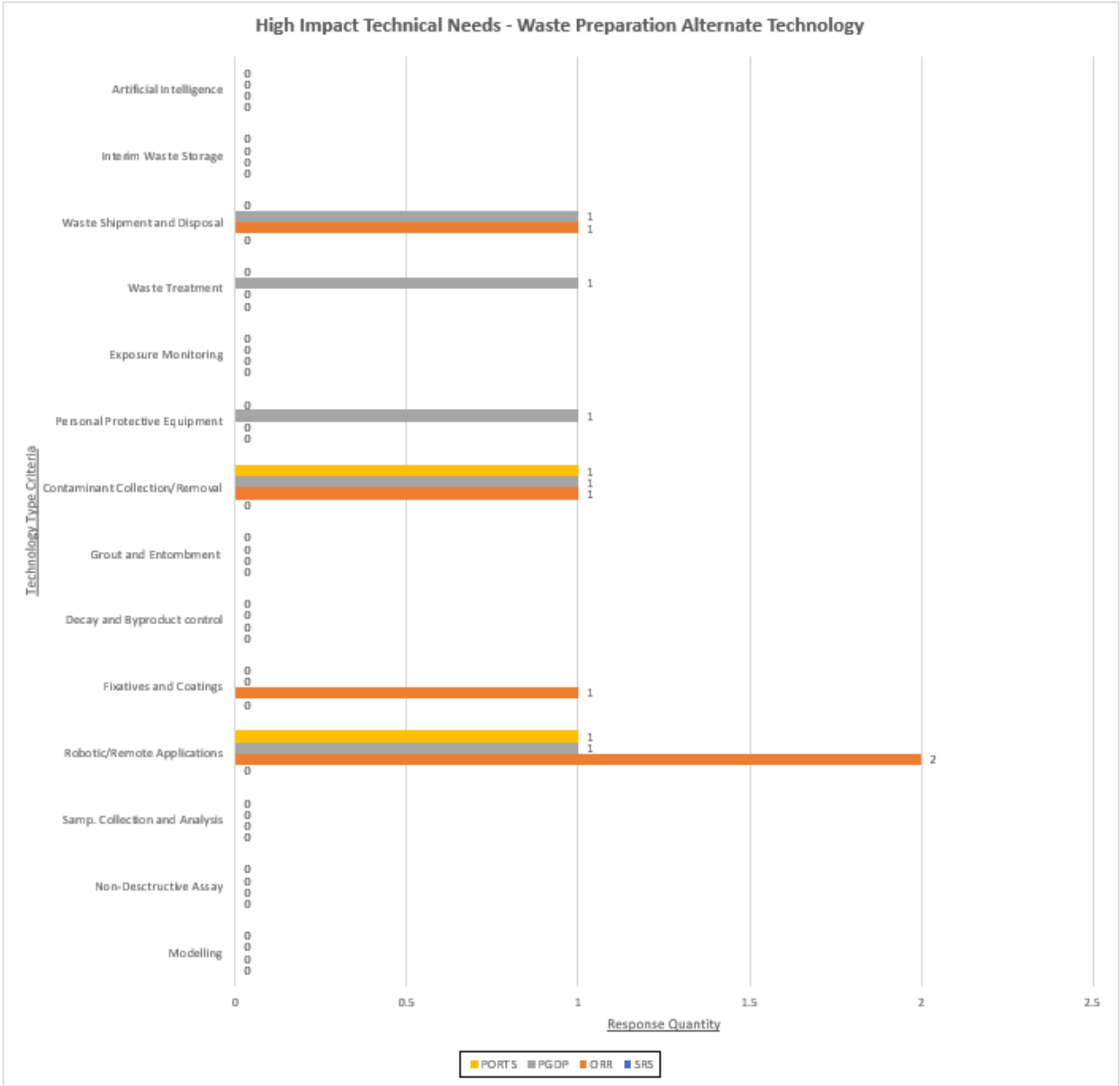
Appendix B-6: D&D Roadmap Taxonomy – High Impact Response Assessments











Appendix B-7: Example Walkthrough of Taxonomic System Usage

Technical Classification Example

Project sites currently and routinely distribute Technology Needs and Opportunity Descriptions at the request of DOE Headquarters to various research organizations and internal DOE personnel. The full extent to which these requests are distributed and all personnel who receive them is not fully known. Regardless, these requests are then utilized by academia and national laboratory researchers that receive them to develop formal proposals and funding requests. The intent of these distributions is to ensure research is directly linked to real world applications. The prototype system developed by the D&D Roadmap Team is intended to improve this function in a form that is more visible and unified, without a significant increase to the time and effort needed for completion by the primary user (i.e. a project team requestor or a technology provider).

A project team member, and primary user example is provided in Figure 1. This technical need request, collected from a SRS 235-F D&D project team member by questionnaire, is used in its entirety and classified with the D&D taxonomy and given a set of identifying numbers. These numbers correspond to the categories and criteria within the taxonomy. Supplementary contact and site specific information is also included to promote direct communication. In a full working system, all information is input by the technology requestor, including the assessment criteria numerical identifiers.

A technical needs requestor and primary user of the developed technical classification system would input all information present in Figure 1. During any input of information, and its classification by a primary user, the Technical Classification numbering system would remain available. In doing so, the knowledge necessary for this classification is input by a D&D project team member, who is most knowledgeable of the project site specifics. The intent is to capture first hand knowledge of a site specific technical need from this primary user and establish

SRS - 235F - 2: Robotic Characterization of Concrete		
Technical Need Request		Technical Classification
The current scope of work being performed has no technological needs. Future work like characterizing the interior of the large concrete exhaust duct that is located on the roof of 235-F, this technology should be able to remotely perform Radiological survey, concrete sampling and video feedback at a minimum and be portable enough to be easily mobilized to a roof deployed through small duct opening and perform its work.	Assessment Category	Assessment Criteria
	Stage	3
	Timeline	1
	Driver	3,4
	Impact	2
	Challenge	1,6,7
Requestor Contact Information		Technology
Request by: Mr. Engineer		3,4
Project Site: SRS - 235F		
Organization: SRNS		
Phone: 555-555-5555		
email: mrengineer@SRS.gov		

Figure 2: Technical needs request received by the D&D Roadmap from the SRS 235-F facility and its assessment using the developed taxonomic system.

the genesis of a dialogue with a potential technical solution provider. Through the assessment of technical requests and the formation of recommendations during the D&D Technology Development Roadmap Initiative, this process was identified as a necessary step for successful resolution to outstanding needs' requests posed by a D&D project team.

Within the same system, a provider or researcher may respond to a technical needs request in kind. Figure 2 contains a reply to the D&D Roadmap during its search for technology recommendations directly related to the technical need presented in the previous example (Figure 1). Assessment criteria numerical identifiers were assigned by the D&D Roadmap Team to this reply to demonstrate the functionality of this system.

In both the request and response, identifying codes are assigned to the communication for later identification and tracking. Each request and proposed solution are classified using categories and criteria that may also be used to identify and record this communication. Search functions utilizing this system of numbers, related keywords, site identifiers, technology deployment history, or any other information included as an input by a primary user is easily employed once this base level interaction is achieved and recorded. Over time, resolved technical needs' cases could be logged and searched for as well to determine further data analytics and the overall success rate of this information system itself. The incorporation of currently available artificial intelligence and machine learning software for greater analysis is also a strong possibility to supplement the search performance of this communication tool.

SRS - 235F - 2: Robotic Characterization of Concrete		
Technical Need Response		Technical Classification
This sounds like the exact type of sensor detection packages INL is building for Hanford could definitely be used here. The package INL develops could be transferred to any robotic platform with ease. Where there is not a need for small size constraints (based on the large ducts shown in the photos) INL could utilize more robust sensors and isotope characterization capabilities. Additionally, INL could serve in an advisory capacity providing types of robotic platforms best suited to the environment, potentially encourage use a dental drill apparatus to a robot for concrete sampling, host a few follow up meetings and provide any additional context needed for scope. A partnership would be ideal, let's make that connection, we'd like to pursue!	Assessment Category	Assessment Criteria
	Stage	1,3
	Timeline	1
	Driver	4
	Impact	1
	Challenge	6,7
	Technology	2,4
Respondent Information		
Response by:	Ms. Researcher	
Project Site:	INL	
Organization:	INL	
Phone:	555-555-5555	
email:	msresearcher@INL.gov	
Deployments	Hanford Site	
Report Links	www.robotics_OSTI.gov	
Usage Guidance	ASTM Standard E10.03 - E3191	

Figure 3: Technical needs response collected from an INL researcher and its assessment using the developed taxonomic system.

Technical Classification Recommendation: Challenges

Noted throughout the D&D Technology Development Roadmap proceedings, communication and engagement will remain a challenge to advancement in the complex network of projects in the D&D field. The critical enabler of success to the proposed system is its widespread and continued usage. If the recommended system proposed by the D&D Roadmap Team is implemented, it is important that the interface be fit-for-purpose and streamlined for primary users. As presented in the prototype examples in this report, minimal additional information is required for entry by these primary users while increasing the functionality for data assessment and documentation.

The continued usage of this system would also be required. A “maturation” phase of this tool would be required to realize its potential benefits. Some amount of encouragement would be necessary to achieve the intended long term result.

Technical Classification Recommendation: Advantages

A formalized classification and information system as described would collect the broad range of information required to produce the data trends completed by the D&D Technology Development Roadmap initiative in 2024. If successful, this would be done over a much longer period of time and without the need for large teams of personnel to make lengthy inquiries to D&D project teams for their needs.

The classification taxonomy, or a more refined form, used for this system is intended to streamline the access to specific information within the very large range of data covered in the field of D&D. Over time, a collected pool of relevant challenges, solutions, and related information would be compiled for use by future D&D teams, researchers, private industry, and DOE personnel.

The recommended form of this technical classification system would also require a minimal increase in detail and effort from a D&D project team or technology provider to complete. Additionally, their efforts would reach a traceably larger volume of viewers.

The advantages of this recommendation can directly address the primary challenges related to complexity and communication within the DOE complex identified during the D&D Technology Development Roadmap Initiative.

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patrick.o'neill@srs.gov
Grady.Friday@srs.gov
Caleb.Kline@pad.pppo.gov
William.Wessel@pppo.gov
jud.lilly@pppo.gov
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richard.mayer@pppo.gov
Gregory.Mcginnis@orcc.doe.gov
Clinton.Mori@orcc.doe.gov
Robert.Alred@orcc.doe.gov
William.York@orcc.doe.gov
Russell.Lum@orcc.doe.gov

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