Nevada Test Site (NTS) Transuranic (TRU) Waste Project Lessons Learned – 10324

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ABSTRACT

This paper describes the lessons learned during completion of the Nevada Test Site (NTS) transuranic (TRU) waste project. NTS was the first site to ship its inventory of stored TRU waste to the Idaho National Laboratory (INL) consolidation site for final characterization prior to shipment to the Waste Isolation Pilot Plant (WIPP) for disposal. The NTS TRU waste project included activities for design, construction, startup, readiness and operation of a nuclear facility. The facility was used to repackage decades old waste from multiple Department of Energy (DOE) sites under the DOE-headquarters newly issued *Contact-handled Transuranic Waste Packaging Instructions* [1].

Included in this paper are the issues, events and process developments that occurred or were otherwise noteworthy during the project. These issues, events or process developments represent areas where the project had problems or were otherwise able to overcome some form of difficulty during the preparation and implementation of the project. Best practices noted by assessors or developed during project execution are also included. These items were developed and documented during the different phases of the project. The lessons learned were collected and sorted by functional areas such as design, construction, procurement, nuclear safety, startup, readiness, maintenance, radiological control and operations. The items presented have generic implication to allow others to benefit from the NTS innovations and to avoid similar pitfalls.

The sharing NTS TRU project lessons learned is intended to provide the information to other sites with similar facility construction and TRU waste processing activities. This is designed to help prevent repeating adverse events/trends and to share good practices to promote excellence across the DOE complex. The most beneficial lessons learned at NTS involved radiological control of the significant contamination encountered during repackaging operations, facility ventilation, and waste packaging and certification issues associated with the first time use of the *Contact-handled Transuranic Waste Packaging Instructions.*

INTRODUCTION

The NTS, located in southern Nevada approximately 105 km (65 mi) northwest of Las Vegas, served as the nation's primary site for the development and safe testing of nuclear weapons and experiments from 1951 to 1992. Existing site facilities and infrastructures enable the execution of operations and experiments in support of the nation's Stockpile Stewardship Program. There is also an ongoing Environmental Management mission at the NTS which includes the Area 5 RWMC, a radioactive waste management facility where TRU waste storage, characterization, and shipment preparation activities were conducted and low-level waste (LLW) and mixed low-level waste (MLLW) is safely and permanently disposed. TRU waste characterization and repackaging was conducted inside the Visual Examination and Repackaging Building (VERB) at the Area 5 RWMC, located in the northern part of Frenchman Flat in the southeastern part of the NTS.

Historically, the VERB was a Hazard Category 3 (HC-3) Nuclear Facility with a mission to provide for the examination, segregation, characterization, and repackaging of radioactive waste stored in waste drums, along with the certification of the resulting TRU waste packages for disposal at WIPP; activities which began in 1997. Following the completion of 48 shipments of TRU waste (1,860 drums) to WIPP in 2005, NTS TRU operations were reduced and the VERB facility was downgraded to a radiological facility. The VERB mission was renewed in 2008 for the final disposition of the remaining, difficult to process, legacy TRU waste stored at NTS in 58 oversize boxes (OSB) and 136 drums.

In order to complete the sorting and size reduction that was required, the VERB required modifications as well as the need to analyze and properly reflect the operation in the Authorization Basis (AB). A Preliminary Documented Safety Analysis (PDSA) was developed, a design for the modifications completed and implemented, the Documented Safety Analysis (DSA) revised, an Operational Readiness Review (ORR) conducted and the waste processing successfully conducted. Operations were completed in 2009.

BACKGROUND

TRU Waste Processing

The waste included large items that had been received and stored in oversize boxes since the 1980s. The size, complexity and variability of the containers necessitated a manual size reduction approach with craft personnel in supplied breathing air to repackage the waste. Each waste container was its own research project requiring remediation of liquids, foam, sources, gloveboxes, and lathes further complicated by the requirement to videotape each and every item per the TRU waste packaging instructions. The waste was also highly radioactive with the highest removable contamination level of 1 billion disintegrations per minute (dpm) per 100 cm^2 encountered, dose levels of 40 Rem/hour detected and airborne levels of 82,000 derived air concentration (DAC) recorded.

Drums of TRU waste, remaining from previous WIPP shipping campaign which removed the easier to repackage and certify containers, were required to be repackaged and shipped. In addition, empty parent waste containers were required to be removed from the processing area by size-reduction and repackaging or intact by wrapping for contamination control and disposal as LLW. TRU payload waste packages, which contain the processed TRU waste from the parent containers, underwent a pre-certification process before shipment to the regional facility for final certification followed by shipment to WIPP for disposal. LLW and MLLW packaged during

VERB activities were disposed on site in the appropriate Area 5 disposal cell in compliance with the NTS waste acceptance criteria [2].

Facility Description

The primary VERB facility modifications implemented to accommodate processing of oversize boxes were: 1) widening of the air-lock doors to 2.4 m (8 ft); 2) installation of three new 0.944 m^3/s (2000 cfm) active ventilation units for radiological control purposes; 3) installation of nine inlet high-efficiency particulate air (HEPA) filters to accommodate the higher ventilation system flow rate, and; 4) installation of a larger backup diesel generator. The as-built configuration of the VERB is shown in Figure 1. Dedicated step-off locations and personnel access/doffing areas were set up to allow personnel to don/doff respiratory protection and anti-contamination (anti-C) clothing.

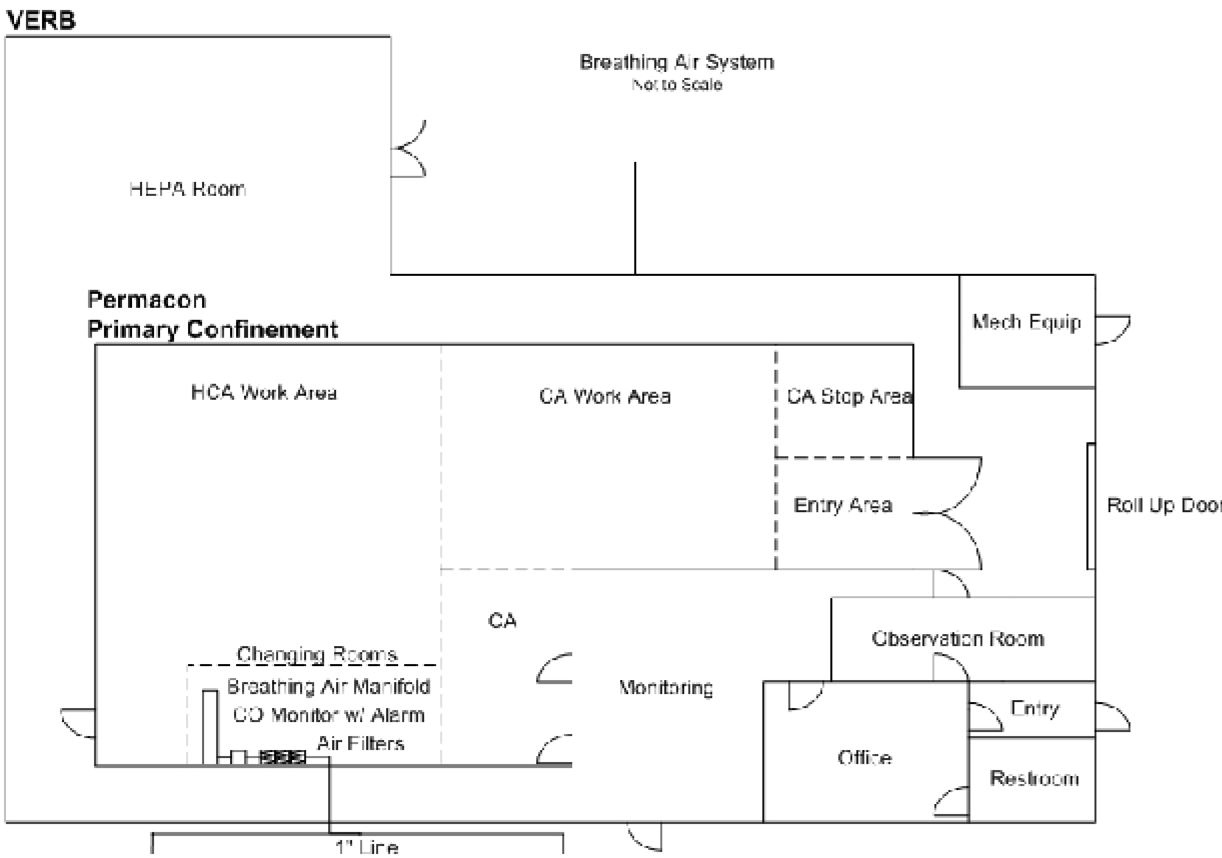

Fig. 1. VERB Floor Plan

Operations

All TRU waste containers were transferred into the VERB, and then opened for waste examination, characterization and removal/remediation of prohibited items. The waste was segregated into three primary waste streams: 1) LLW, such as nonporous metal that was assayed and decontaminated as necessary for disposal; 2) MLLW, such as combustibles, sludge, and other waste that assayed less than 3700 Bq/g (100 nCi/g) by non-destructive assay, or; 3) mixed

TRU waste debris or other waste that assayed at greater than 3700 Bq/g (100 nCi/g). LLW was primarily packaged into cargo containers for disposal on site at the Area 5 RWMC. The MLLW was packaged and treated using a macroencapsulation process for on-site disposal in the Mixed Waste Disposal Unit at the Area 5 RWMC. Mixed TRU waste was size-reduced for packaging in standard waste boxes (SWBs) for transfer to the regional TRU waste certification facility at the Advanced Mixed Waste Treatment Project (AMWTP) at the Idaho National Laboratory (INL). TRU/mixed TRU waste was generated in accordance with DOE Order 435.1, *Radioactive Waste Management* [3] and the associated *Contact-Handled Transuranic Waste Packaging Instruction* that was issued mid-way through the repackaging effort.

LESSONS LEARNED

Ventilation System

A conservatively designed ventilation system provided an environment that promoted worker safety and provided the ability to complete the resizing and repackaging of the TRU waste with no personnel contamination or significant radiological incidents.
Aspects of that design that were components to that success:

- The system was designed with two times the air flow of what was operationally identified. The high contamination area was eventually measured to have approximately 45 air turnovers in an hour.
- A filtered specialized point source ventilation capability was installed. This system included the use of two filtered and relocatable (PlymoVent™) ventilation arms, each capable of 1,000 cubic feet/minute flow with a reach of 20 feet. The use of two vents enhanced the workers ability to control the spread of contamination when extremely high levels of contamination were encountered. The PlymoVent™ arms were recognized as a best practice during a DOE VPP Star assessment
- The redundancy of two point source ventilation arms enhanced production by providing the ability to conduct more than one task at a time, thereby utilizing workers time more effectively when in the high contamination area (HCA), and effectively reducing the number of HCA entries required.
- Due to space constraints of the existing structure and the size of the waste containers that required processing, the facility was designed without the benefit of an air lock for processing waste into and out of the contamination areas. Radiological control zones were implemented from areas of no contamination, to low contamination, to high contamination with the appropriate consideration of ventilation air flow. While this design was not optimum, it was effectively implemented without incident and minimal impact on the ability to effectively perform the operation. The wrapping and diapering of the waste containers at various junctures of the operation were effective in minimizing the need for waste container decontamination as containers were removed from the facility.
- For ventilation system designs for radiological contamination, strict application of American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) design recommendations [4] may not be enough. If the VERB had incorporated an air lock, the minimum required air flows would not have been sufficient to achieve the desired operational work environment. Additionally, some standard ventilation design aspects, e.g.,

slotted intakes, are not effective for the purpose of radiological particulate capture. The design eventually incorporated a floor mounted (sidedraft) filter housing instead of the initially identified slotted design called for by ASHRAE.

- Chapter 2 of the DOE Nuclear Air Cleaning handbook, DOE-STD-1169 [5] provides examples of requirements to be applied to ventilation system design. Based on the limitation associated with modifying an existing facility it was necessary that the VERB design be a hybrid of these examples. Therefore the design ended up with the requirements to maintain a 0.76 cm (0.3-inch) water column negative differential pressure that would be expected of a glovebox (even though the area was to be occupied) and the face velocity requirements of a chemical fume hood because there was no airlock. The handbook allows adjustment of these values based on operating requirements and safety analysis, but coordination was not sufficient during the design between nuclear safety and engineering to justify an adjustment.
- ALARA reviews need to be more imposing with respect to the requirements to meet worker safety and radiological protection requirements to reduce the number of events resulting in loss of the Permacon. In the 6 months of operation the Permacon was lost 2 times. This was an extremely low number based on the contamination levels of up to 1 billion dpm per 100 square centimeters which were encountered.
- Radiological Work Permit (RWP) was well written such that it allowed us to enter required actions and recover quickly when suspension limits were exceeded. (10,000DAC.)

Nondestructive Assay (NDA) Characterization

A processing approach including real-time NDA was implemented that improved efficiency and worker safety. Each parent container to be processed in the VERB was individually mapped using an In Situ Object Counting System (ISOCS), gamma spectroscopy unit. Additionally, most of the waste containers had real time radiography (RTR) information that revealed some details on the objects that would be encountered during the repack. As experience was gained with the completion of each container the workers were able to predict with greater and greater accuracy the specific contents of each new container and the hazards presented. This information was then used by the repack team of ironworkers, laborers, waste handlers, and radiological control technicians (RCTs) to orchestrate their approach to each container. Higher hazard and radiological source areas were approached in the best manner possible to eliminate or reduce the hazard. When appropriate, waste components were surgically removed from the parent containers by cutting holes in the containers sides and extracting waste items that were prohibited or otherwise required removal, such as high-rad items.

Final waste characterization was supported by real time gamma spectroscopy nondestructive assay using ISOCS. These allowed the workers to sort the TRU waste from Low-Level Waste and thus reduced the waste produced and assure that only TRU waste was being made available for shipment to the regional characterization facility. The relatively more expensive TRU waste volume was reduced by over 60% using this sorting process.

Originally, real time characterization of the LLW waste was to be completed using Surface Contaminated Object (SCO) methods. ISOCS was determined to be significantly more effective. Specific aspects of using the real time gamma spec NDA of the waste and waste packages increased efficiency and production:

- Two ISOCS units were used throughout the project: One in the building to sort wastes and the second outside the building for final waste container assay.
- A backup system was also available and was used near the end of the project when one of the primary units needed repair. When the primary unit went down, the backup unit was used to get back up and running within a matter of hours.
- The project used two NDA support personnel: a subject matter expert (SME) and an ISOCS operator. This was the correct resource requirements for the project. When activities slowed near the end of the project a single operator/SME was sufficient.
- An SME on site full time was needed to validate and perform the expert review of the NDA data. This allowed very timely processing and validation of the ISOCS data.
- The Permacon arrangement allowed the ability to negotiate/communicate with the radiological control personnel for the positioning of the equipment and waste. This capability is required to make the real time categorization of the waste effective. Depending on the background dose in the Permacon, the ability to classify the waste was sometimes difficult if not impossible to do. A better design would include a designated area for assaying of the waste that was shielded from the waste processing activities as these activities adversely affect the background and the ability to use the ISOCS. A properly designed arrangement, including shielding would reduce count times, provide for better detection limits, and provide more effective classification of the waste as TRU or LLW. The ISOCS in the Permacon was used in a Contamination Area (CA) and was removed on two occasions. This was facilitated by keeping the CA relatively clean and wrapping the unit. Unrestricted release was achieved at the end of the project, but precautions need to be implemented to ensure this can occur.
- Due to work authorization restrictions, craft were used to maintain nitrogen in the gamma spec detector. This aspect of maintaining the vendor equipment has to be considered when establishing working relationships.
- Due to the space constraints of the VERB, the waste containers were brought in and out the same door. The ISOCS was moved for each evolution which necessitated realignment after each container movement. As space permits, allow for a fixed ISOCS location or consider a second transfer door.
- Integration of ISOCS assay activity with real time support from the prime contractor waste generating services (waste characterization and certification function) streamlined the waste processing and disposal processes for LLW.
- No formal tracking mechanism was initially established to track the daughter waste containers and individual container status. As a lesson learned a visual system of labels or flagged would be appropriate for identifying aspect of the characterization process including the need for an assay or otherwise demonstrate the processing status of an individual package.

Readiness: Team-Building and Mockup Training

The TRU waste project at the NTS was successfully completed in collaboration with the DOE Nevada Site Office (NSO); we were truly a team. The NSO project personnel were particularly noteworthy in support of the readiness effort by helping to schedule resources and helping with the removal of roadblocks during the ORR activities. The NSO support personnel provided the opportunity to achieve readiness on time.

The production team was required to be assembled from scratch and was formed into a cohesive unit that carried the entire readiness process. Experience with this type of radiological operation was limited at NTS. A Repack Team was assembled of ironworkers, laborers, RCTs and waste handlers. The team was chosen to include a few members who had had similar experience with high hazard waste repackaging and radiological operations. While few, these individuals were the foundation that the team was built upon.

The readiness preparation was enhanced by designing and building a mockup facility for the purpose of selecting an air suit, practicing in doffing the air suits and other high contamination area (HCA) operational activities. This mockup was critical for those personnel who had not had experience in air suit operations and the radiological hazards presented by the impending operations. Proper performance of even simple activities is paramount to the successful completion (without incident) to these high hazard operations. The smattering of experienced personnel, the mockups and associated hands on training to practice provided a basis for the successful completion of the repack campaign. The project completed a 4 month campaign, with two entries per day, 6 days per week, without a recordable injury and no personnel contamination incidents.

Key to this learning process was the use of daily debrief meeting of the repack team. This meeting proved effective for feedback as well as planning the next day's events. Worker involvement was the starting point and prompt action by support organizations and management made for an extremely effective feedback process. The process was used throughout the training and repack campaign.

Management personnel with specific experience in repackaging operations and team building were brought in to ensure readiness preparation success as well as serve as senior supervisory watches for operations. Due to the short duration of preparation these personnel became a key element of the readiness review success. The importance of building an effective team should not be underestimated with mixed crews of labor and support personnel.

Be Sampling

The capability to perform real time beryllium analysis was provided by the Industrial Hygiene (IH) group using a portable fluorescence method for the determination of trace beryllium in the workplace. Field-portable monitoring equipment was located at the VERB and was used to perform an initial screen for safe onsite movement of containers. As the system was not certified, samples had to be sent off site for certified analysis for final container disposition. The beryllium screening methods can be qualified or accredited for local certification, rather than sending the samples offsite to an accredited lab for final analysis. However, due to the small number of samples taken, the cost did not justify the expense in this case. The DOE ORR identified this real-time beryllium screening as a noteworthy practice. Specific areas for improvement include:

- IH and radiological impacts for shipping samples and associated procedures should be planned in advance.

- As with the ISOCS there was an identified need for a sample and container management process for tracking status related to beryllium samples

Radiological Practices

Experience at NTS was limited in the use of air supplied breathing air suits. The approach to breathing zone monitoring and dose assignment required socialization with site organizations and the DOE and eventual revision to the respiratory protection program for implementation. While this approach had been or was in use at other locations in the DOE complex it was new for NTS. The approach employed included the use of air suits, breathing zone air (BZA) monitoring internal to the suits, and the establishment of radiological work permit compensatory actions when external suit derived air concentration (DAC) levels reached the Protection Factor (PF) of the suit and suspension limits at DAC levels greater than 10 times the PF of the suit. Suspension limits for the RWP were reached on 3 occasions. There were no skin or personnel contaminations during the 4 month campaign.

Due to the need to move target SWBs into and out of the HCA, the craft develop a standard plastic cutout for diapering of waste containers. The practice of wrapping empty SWBs prior to introduction into the HCA for waste loading allowed good radiological control and provided the ability to remove the full SWB payload containers from the HCA without incident.

The follow is a list of enhancements and lesson learned related to radiological control:

- Cerium nitrate was not used because of restrictive DSA controls; it works well only on stainless steel and application and removal is not very efficient. Additionally, its use requires a considerable number of fire control measures.
- Simple Green™ and Radiacwash™ were effective for use on decontamination of glove box parts and tack cloth worked well on LLW.

Waste Packaging

NTS was the pilot program for use of *Contact-Handled Transuranic Waste Packaging Instructions* issued in October, 2008. Implementation of this DOE prescribed waste packaging instructions mid-way through processing of the oversize boxes caused waste rejects and resulted in unnecessary rework. First-time procedure use historically requires some revision or clarification, which was not accomplished in this case. This was also a new process for the Carlsbad Field Office (CBFO) and its contractors, which further complicated successful implementation.

The NTS TRU project relied upon the exceptional efforts of the Waste Examination Experts (WEEs) who took great care to document the waste packaging activities in compliance with the expectations of the waste packaging instructions. However, a training process for the WEEs by CBFO personnel would have been beneficial and would have reduced the containers that required rework. For future TRU waste packaging at small sites, it is recommended to send CBFO qualified Visual Examination (VE) Expert to support packaging at the outset, or to send site representatives to an operating site for initial training.

Nonconformance Reporting (NCR) Process

A formal nonconformance reporting process was not included for waste generation and characterization conducted under the new TRU waste packaging instructions. The lack of an NCR process unnecessarily complicated communication between CBFO and the site. The guidance received from CBFO upon identification of a nonconformance by remotely located waste certification officials was to repackage the entire container. However, in many cases simple removal or further video documentation of a suspected prohibited item was sufficient to resolve the issue.

Without an NCR process to identify and disposition nonconformances, the exact problem and remedy is not agreed upon prior to rework. This results in unnecessary additional rework, worker exposure, and expense. Implementation of an NCR process is highly recommended for use with the TRU waste packaging instructions to provide specific disposition of the waste container.

Sources

The WIPP definition of sources is not clear and not linked to waste criteria. Waste forms that challenge the ability to perform WIPP certified assay at the regional facilities become prohibited or orphaned. Highly radioactive material that does not meet any definition of "source", such as high neutron generating ^{244}Cm and high gamma $^{232/233}$U232 became problematic due to calibration limits of regional characterization facility NDA equipment. These restrictions are not identified in the packaging instructions.

At NTS the high-rad materials were required to be handled beyond the limits of good as low as reasonably achievable (ALARA) practices. A complete list of requirements was not established prior to accessing the high-rad items which resulted in multiple handling. Especially in the case of repackaging decades old legacy waste from another site, the processing facility has great difficulty in obtaining enough information on sources or highly radioactive source like material to provide to the characterization and shipping entities. The ultimate disposition of this material will require every bit of information that can be provided, including any registry numbers, isotopic break downs, physical construction or makeup, pictures, weights, and dimensions. This became a challenge to ALARA as the request for more and more data necessitated repeated handling. It would be beneficial if additional guidance were issued by WIPP regarding acceptable NDA protocols and methods so that generators could tailor their programs appropriately.

Communication

Several attempts were made to make communications among the VERB crew clear, comfortable, reliable and easy to use while in supplied air suits. While communications were effective and the teams adapted to the systems provided, this was an area identified by the workers where improvements could be achieved. The short term nature of the project and the lead times time associated with specialized communication equipment did not make this feasible for the VERB operations. The transfer of containers between the radiological control zones were particularly troublesome as some workers were in air purifying respirators and others with radios were in air suits. For these instances air purifying respirators with devices to assist communications would have enhanced the operation.

WIPP packaging requirements, special material approval processes, and data requirements often work contrary to worker safety and ALARA principles.

- The WIPP packaging instruction requires the use of video and a waste examiner, instead of real time visual examination expert. This process tripled the amount of time required to generate waste containers which is an unfavorable tradeoff for ALARA and worker safety in an extremely hazardous environment.
- There was no real time formal communication process between the generator and WIPP.
- The TRU waste packaging instructions requires written notice followed by written approval to package sources and organics. When these items are identified, a more expedient resolution is required.

Modification of the VERB included recording equipment for the purpose of recording the visual examination of all TRU waste.

- The equipment proved unreliable and failed during visual examination activities. Failures of recordings of a few minutes resulted in rework of several containers. Only industrial grade equipment with numerous levels of redundancy should be installed for these applications.
- There were blind spots in the waste processing high contamination area. The original waste processing flow was modified as experience was gained which would have benefited from additional cameras. When installing the video system, err on the side of extra coverage and redundancy.

CONCLUSION

The TRU waste project at the NTS was successfully completed through the partnering of the Nevada Site Office, NSTec, DOE/Carlsbad Field Office and the associated subcontractors. A remarkable effort was required to design, modify, complete readiness, and operate a nuclear facility fit for purpose to repackage this difficult waste stream. The repackaging operation was safely completed without any significant industrial safety or radiological events. The sharing NTS TRU project lessons learned is intended to provide the information to other sites with similar facility construction and TRU waste processing activities. This is designed to help prevent repeating adverse events/trends and to share good practices to promote excellence across the DOE complex.

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