ORNL/SR-2017/91

NUCLEAR SMUGGLING DETECTION AND DETERRENCE

FY 2016

DATA ANALYSIS ANNUAL REPORT

A SUMMARY OF DATA RECEIVED AND ANALYZED BY ORNL

Oak Ridge National Laboratory

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Oak Ridge National Laboratory

Nuclear Smuggling Detection and Deterrence FY 2016 Data Analysis Annual Report

Performance from October 1, 2015, to September 30, 2016

January 2017

Prepared by

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Acronyms

ACR	annual country report
CAS	central alarm station
DART	Desktop Analysis and Reporting Tool
FY	fiscal year
LMP	local maintenance provider
MCAAW	Multi-Channel Analyzer Alignment Wizard
MCR	monthly country report
NORM	naturally occurring radioactive material
NSDD	Nuclear Smuggling Detection and Deterrence
ORNL	Oak Ridge National Laboratory
RPM	radiation portal monitor
RDS	radiation detection system

Contents

Acknowledgments

Chris Pope, Alex Enders, Tyrone Harris, and Jeremy Patterson were crucial to the production of this year's annual report. This would not have been possible without the long-term diligence of Scott Alcala, who among many other things manages the database and drafted most of the queries this report is built upon.

ORNL is also indebted to the National Nuclear Security Administration's Office of Nuclear Smuggling Detection and Deterrence, for whom this work was performed.

EXECUTIVE SUMMARY

The National Nuclear Security Administration's Office of Nuclear Smuggling Detection and Deterrence (NSDD) has facilitated the installation of more than 3,500 radiation portal monitors (RPMs) at 606 sites in 56 countries worldwide. This collection of RPMs represents the world's largest network of radiation detectors and provides one element in the defense-in-depth approach that supports the Global Nuclear Detection Architecture. These systems support NSDD's mission to build partner country capability to deter, detect, and interdict the illicit transport of radiological and fissile material through strategic points of entry and exit at seaports, airports, and border crossings.

NSDD works collaboratively with partner countries and international organizations to optimize the operation of these RPMs. The large amount of data provided by NSDD partner countries highlights the close cooperation and partnerships NSDD has built with 56 countries around the world. Thirty-seven of these countries shared at least some RPM-related data with NSDD in fiscal year 2016. This significant level of data sharing is a key element that distinguishes the NSDD office as unique among nuclear nonproliferation programs and initiatives: NSDD can provide specific, objective, data-driven decisions and support for sustaining the radiation detection systems it helped deploy. This data analysis report summarizes and aggregates the RPM data provided to the NSDD office for analysis and review in fiscal year 2016.

The data can be used to describe RPM performance and characterize the wide diversity of NSDD deployment sites. For example, NSDD deploys detector systems across sites with natural background radiation levels that can vary by a factor of approximately six from site to site. Some lanes have few occupancies, whereas others have approximately 8,000 occupancies per day and the different types of cargo that travel through a site can result in site-wide alarm rates that range from near 0% at some sites to above 3% at others. Based on the data received, the global average uptime for NSDD RPMs was above 96% for fiscal year 2016. NSDD takes all of these factors into account in making recommendations to partner countries on how to most effectively manage and maintain site operations. NSDD utilizes reports and other information products created by data analysts to efficiently allocate the resources needed to detect and ultimately interdict illicit nuclear and radiological material.

FY 2016 Data Highlights

37 Countries

50 Vehicle Crossing Sites

48 Seaport Sites

9 Airports

8 Rail Crossing Sites

1,010 RPM Lanes

0.86% Overall Alarm Rate

88.7 Million Occupancies

241 Thousand Files

522 GB Data Received

Data-Driven Decision Making

Introduction

The National Nuclear Security Administration's Office of Nuclear Smuggling Detection and Deterrence (NSDD) works with partner countries and international organizations to build a global capacity for the deterrence, detection, and interdiction of nuclear and other radioactive materials that are out of regulatory control. NSDD works with partner countries to assist in assuming the operational, maintenance, and management responsibilities for their radiation detection systems, which includes radiation portal monitors (RPMs). The Implementation program partners with the Sustainability program to promote continued operation and performance of the radiation detection system. These programs are implemented in conjunction with Los Alamos National Laboratory, Oak Ridge National Laboratory (ORNL), Pacific Northwest National Laboratory, and Sandia National Laboratories. Each of these national laboratories has a distinct mission related to NSDD. This report focuses on analysis of the collected data, which is ORNL's primary responsibility to NSDD.

ORNL is charged by NSDD with analyzing the data collected by the RPMs. Consistent, quantitative analysis of technical data generated by RPMs significantly contributes to maintaining performance and is important to the long-term operation and sustainability of NSDD systems. This work includes designing the tools and systems facilitating data collection, analyzing the data, creating reports that describe findings and trends about the operation of the RPMs, providing summaries of important issues to NSDD and its partner countries, and developing software to perform these functions. The benefits include

- identifying local operational deficiencies and equipment faults that partner country maintenance providers can remediate,
- optimizing detection efficiency and system responsiveness at the sites,
- identifying areas for improvement in equipment and operation,
- determining real-world requirements for future equipment,
- validating technical policies and assumptions, and
- determining RPM availability and other accountability metrics.

The findings presented in this *Nuclear Smuggling Detection and Deterrence FY 2016 Data Analysis Annual Report* provide a concise summary that supplements these benefits and provides a practical perspective on trends in operational and equipment performance features across the Office of NSDD.

RECEIVE: Data sent to ORNL

NSDD has facilitated the installation of over 3,500 RPMs in over 56 countries around the world. Sites are selected based on a variety of factors, including the amount of traffic expected to be scanned, its relative importance compared to suspected smuggling routes, and other geopolitical considerations. The relative ease of RPM installation and the potential for data sharing with the United States are also considered, though they are not requisite conditions for site selection.

The overwhelming majority of RPMs installed by NSDD are made by one of two manufacturers: ASPECT, a Russian company, and Rapiscan (formerly TSA Systems), a US-based company. ASPECT has provided approximately 56% of RPMs deployed. NSDD, in cooperation with the Federal Customs Service of Russia, has implemented RPMs at all official entry and exit points to Russia, making them one of the largest consumers of RPMs. NSDD does not routinely receive data from ASPECT RPMs, even though they are capable of creating a daily file information (see the "Analyze" section on page 11), just like the Rapiscan/TSA RPMs.

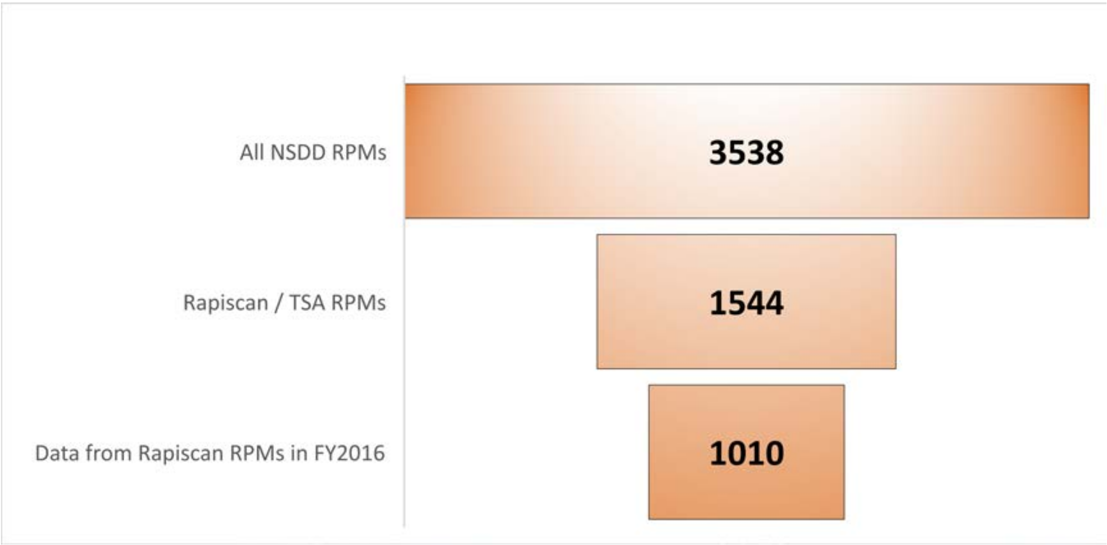

Figure 1. NSDD receives data from about two-thirds of the American-made RPMs deployed globally.

Data for two-thirds of the American-made RPMs deployed worldwide was voluntarily shared with NSDD in fiscal year (FY) 2016 (Figure 1). This high level of voluntary data sharing attests to the utility and value of the data: the analysis results meaningfully improve operations and assist maintenance.

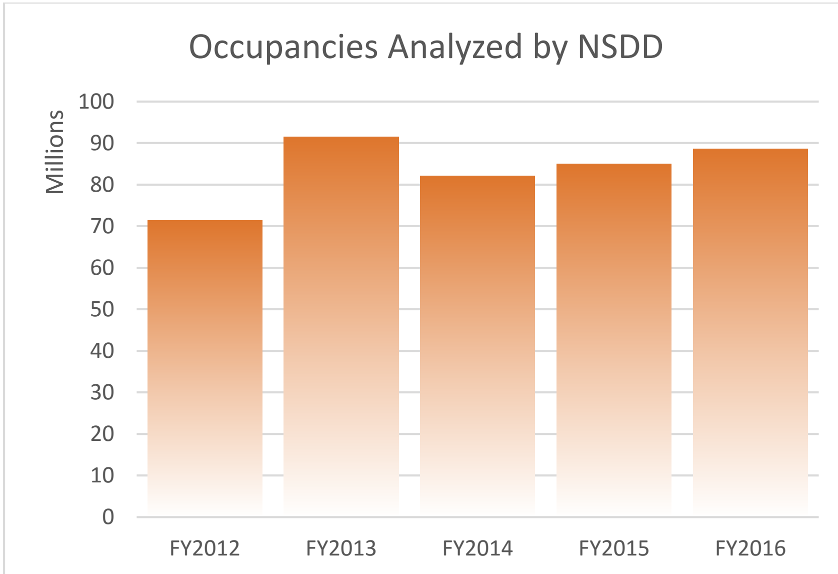

Figure 2. NSDD continues to receive and analyze over 70 million occupancies each year.

Figure 2 shows the consistency that NSDD has received information over the past 5 years. At least 70 million—and usually more than 80 million occupancies—are analyzed each year. In June 2016, ORNL received its 500 millionth occupancy since the inception of NSDD. This wealth of data gives an unparalleled baseline from which to draw inferences about the stream of commerce and the pace of operations at sites. For example, occupancy rates, alarm rates, and typical alarm profiles can be determined to help plan staffing and equipment needs. Detailed examples of how NSDD draws from this data to improve operations and maintenance are provided later.

RPMs scan a variety of traffic, including vehicles, cargo trucks, trains, pedestrians, and luggage or conveyor RPMs. Different types of RPMs are used depending on the application. Vehicle RPMs are the primary means of radiation detection for border crossings and seaports, and they are even deployed at a few airports. Pedestrian RPMs are most commonly found at airports to scan passengers and their luggage, but some are at border crossings to scan people as they walk from one country to another. Similarly, conveyor RPMs are most common at airports for scanning luggage. Lastly, rail RPMs—the largest RPMs deployed by NSDD—are used either at land border rail crossings, or occasionally at seaports where site-specific requirements, such as wide lane spacing, dictate the need for larger and more sensitive RPMs. Mobile RPMs are even used for relocatable missions.

Figure 3. NSDD deploys a variety of RPM types, depending on the application.

Figure 3 shows (clockwise, from upper right) a mobile detection system, a pedestrian RPM, vehicle RPMs, and a rail RPM.

NSDD received data from over 1,000 RPMs in FY 2016. Figure 4 shows most of the data analyzed by ORNL are from vehicle RPMs, which are widely deployed at both border crossings and seaports as the primary means of radiation detection. Data from pedestrian RPMs represent the second most commonly received RPM data, typically because of the large number of RPMs installed at airports.

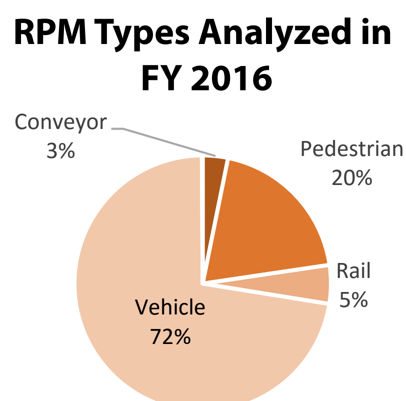

Figure 4. ORNL analyzes data from a variety of different RPM types.

Aside from the different types of RPMs, there are three primary site types that NSDD receives data from: airports, seaports, and vehicle crossings.

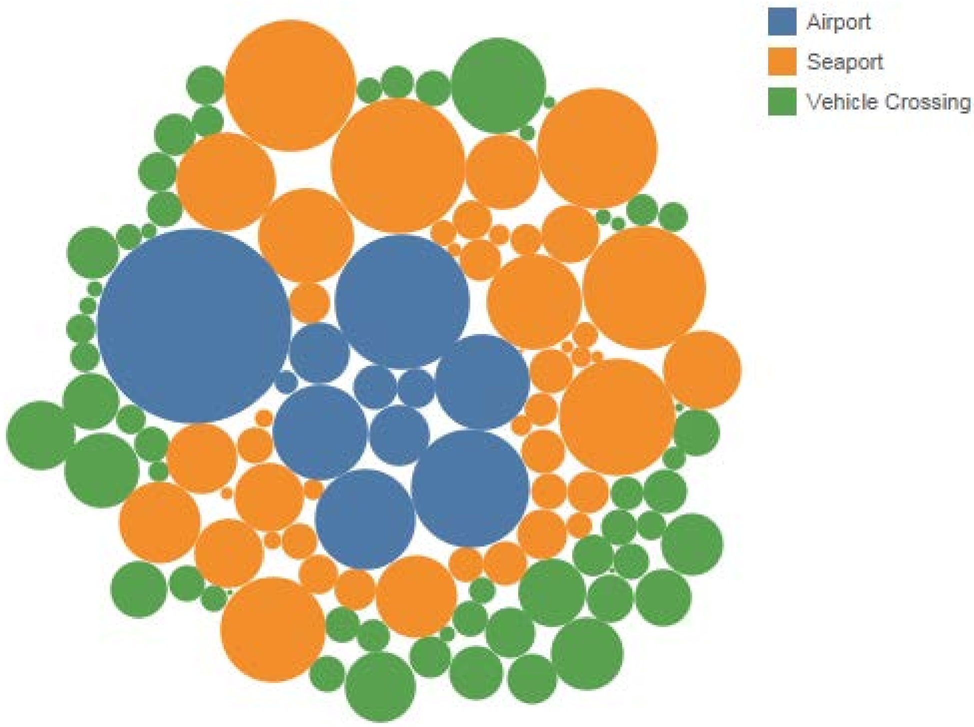

Figure 5. ORNL receives data from a range of sites, with widely varying throughput.

NSDD received data from 122 sites in FY 2016. The size of each bubble in Figure 5 is determined by the average number of occupancies each site records each day. At airports, pedestrians can stream through RPMs, quickly generating a large number of occupancies. Airports are also large installation sites for RPMs. It is not uncommon to have 20–30 pedestrian RPMs in a single airport, leading to thousands or tens of thousands of occupancies each day at a busy airport. Figure 5 also shows the variation in traffic load of different sites within the NSDD program. What is acceptable at some sites, perhaps even normal, is completely unacceptable at other sites because of the scale and size of the operation. NSDD takes these factors into consideration when establishing site-specific criteria for each RPM.

Other site types not included in Figure 5 include rail crossings, training centers, post offices, ferry terminals, and mobile detection systems. In FY 2016, NSDD deployed its 100th mobile detection system. These mobile detection systems enable local law enforcement agencies to scan traffic at a chokepoint along a roadway, or it can be driven next to stationary objects to perform real-time scans for radiological material, providing an advanced means of securing physical facilities such as crowded parking lots.

ANALYZE: Data Analyzed by ORNL

RPMs continuously collect information, which is transferred to a central alarm station (CAS) at the site where the RPMs are installed. The data include alarms created by relatively high radiation levels in traffic going through the portals. These alarms indicate additional inspection may be needed by local operators to determine if the object or person that caused the alarm poses a threat (e.g., the presence of unregulated or unlicensed nuclear or radiological material). Once a day, the CAS assembles the data collected by each RPM into a text file called a daily file (Figure 6). The data included in each file are RPM parameter settings, gamma and neutron radiation measurements taken when the RPM is both unoccupied and occupied, and faults and tamper indications. Partner countries that share data with NSDD provide these files to ORNL. Analysis of the data in these files is subsequently performed by experts at ORNL.

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GS,000035,000044,000026,000033,09-37-13.628
GS,000037,000041,000036,000039,09-37-13.649
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```

Figure 6. Sample contents of an RPM daily file.

Partner countries can each have multiple sites where equipment is deployed, and each site typically has multiple lanes equipped with RPMs. Consequently, the lane is the unit used to count RPM deployments and to organize daily file data for analysis.

Site Traffic

The NSDD office deploys RPMs to a highly diverse set of locations, ranging from major seaports to remote border crossings. This section more closely examines the sites the NSDD office receives data from and discusses how the conditions for radiation detection vary from one site to the next. This information can be helpful in characterizing sites – both existing and planned – against the spectrum of the rest of the NSDD sites.

Figure 7 shows the average number of occupancies per lane and average alarm rate per occupancy, respectively, categorized by fiscal year for airports, seaports, and vehicle crossings. In FY 2016 pedestrian RPMs located at airports again saw the lowest, on average, alarm rates while experiencing one of the highest average occupancy rates, while RPMs located at seaports continued to see the highest alarm rates. In general, seaports tend to see higher gamma alarm rates because of the significant quantity of bulk commodities shipped, including ceramic tile, some types of fertilizer, and many abrasives. Bulk commodities such as these contain naturally occurring radioactive material (NORM) in large enough concentrations to generate alarms at the RPMs.

Daily Average Occupancies by Site Type

Alarm Rate by Site Type

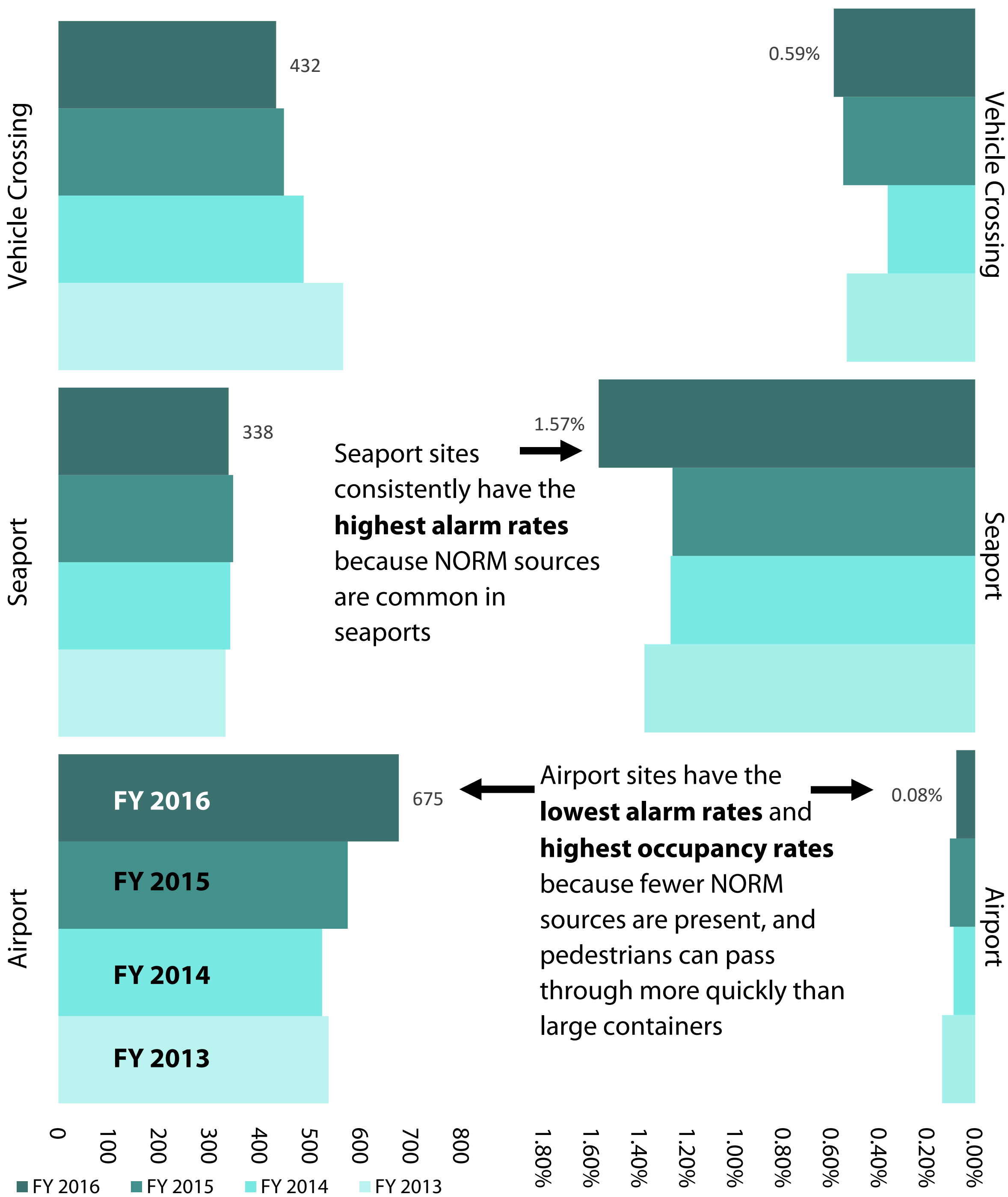


Figure 7. The average occupancies and alarm rates differ by site type.

Airports see lower alarm rates because of the lower amounts of NORM transported through airports. Pedestrians typically do not carry enough NORM-containing material to generate an alarm. However, some medical diagnostic and treatment techniques include radioactive substances, which are easily detected by RPMs. In these cases, a single patient can cause multiple alarms as a result of the RPM's sensitivity. Other sources of alarms include nearby x-ray machines (very common for scanning luggage at an airport), radioactive check sources during RPM maintenance, or malfunctioning detector equipment.

The Office of NSDD uses this wide range of traffic volume information to work with partner countries to ensure sufficient resources and training are available for:

- installing CAS hardware, software, and communications equipment;
- adjudicating alarms; and
- refining secondary inspection procedures.

NSDD tracks gamma and neutron alarm rates, shown in total over the last four years for airports, vehicle crossings, and seaports, in Figure 8. Since there are very few neutron-emitting NORM sources, the rate of neutron alarms tends to be much lower.

Site Background Radiation

Understanding the background radiation level at a site is necessary to determine the smallest amount of radioactive material that can be reliably detected at that site. The higher the background level, the harder it can be to detect a weak radioactive source—like hearing a whisper in a noisy room. Other elements, like vehicle speed and RPM settings, must be considered when determining the overall minimum detectable quantity of radioactive material.

The background level is dependent on the surrounding environment. A location at a high altitude, where the thinner atmosphere allows more cosmic radiation to penetrate, or a location featuring a large amount of exposed granite, which may contain uranium and thorium, will typically have a higher background level than a location at sea level or with sedimentary rock in the vicinity. In addition, the inclusion of NORM in roadway concrete near an RPM can contribute to the measured background. In some cases, collimating the RPMs or repaving the road with less NORM can help reduce the background measured by the RPMs.

Figure 9 shows a histogram of the gamma background count rates for detectors at seaports and vehicle crossings averaged over each site that provided data in FY 2016. The gamma background markedly varies by

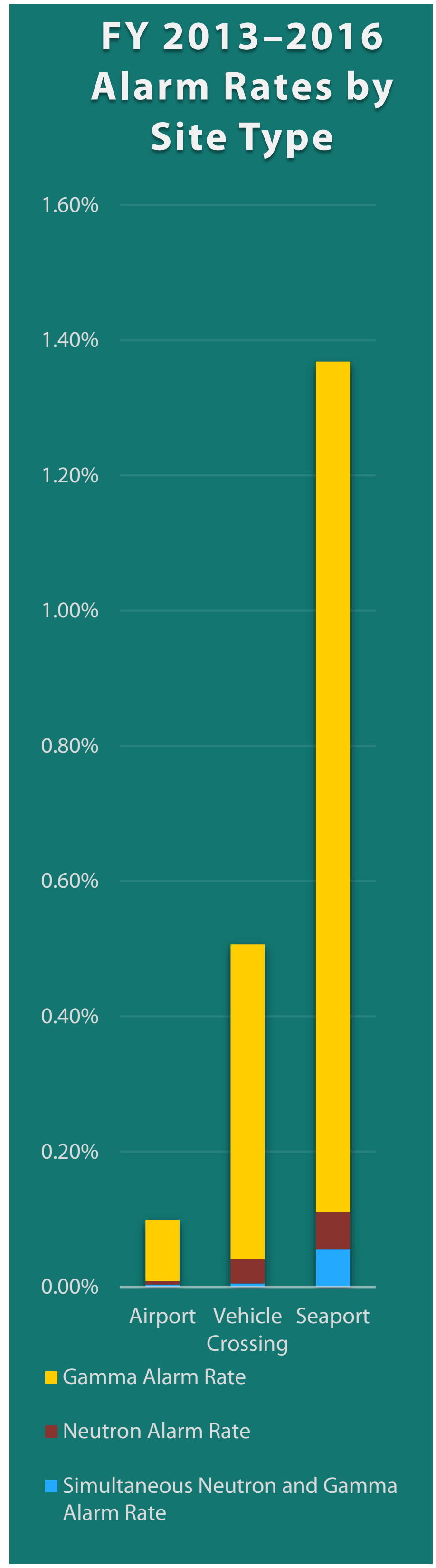


Figure 8. Gamma alarms are the most common type of alarm for all deployment locations.

site. The site with the highest average background is six times higher than the site with the lowest average background.

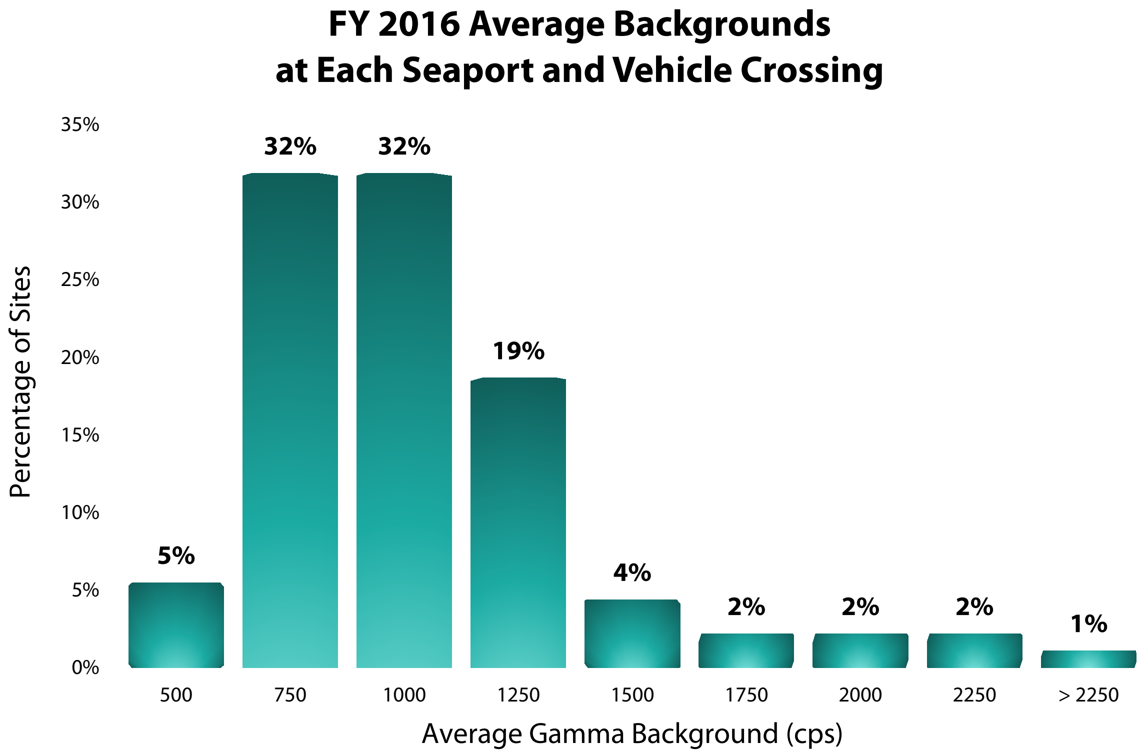


Figure 9. NSDD tracks site gamma background count rates. Lower backgrounds are better for RPM detection.

Lane-Specific Alarm Information

The Office of NSDD monitors and tracks the alarm rates observed at individual lanes, although site- and country-level summaries are useful for management and planning resources, operations occur at the lane level. Each lane is equipped with an RPM and frequently with cameras and other equipment required by the site. The combination of RPMs, cameras, network equipment, secondary inspection equipment, and the CAS, comprise the radiation detection system (RDS) at a site. Figure 10 provides a breakdown of the gamma alarm rates by lane for vehicle RPMs. Over 60% of the lanes show an alarm rate of 1% or less, whereas about 80% of lanes show an alarm rate of 2% or less. The alarm rate each site can manage is highly dependent on available resources, as well as the number of occupancies each lane receives each day. For instance, a 5% alarm rate can be manageable if only 60 vehicles travel through the lane each day, resulting in three alarms per day. A 5% alarm rate can be more difficult to appropriately respond to if 1,000 vehicles travel the lane each day, resulting in 50 alarms per day.

Separate analysis routines can calculate the backlog of alarming vehicles at each site, and NSDD works with partner countries to determine the best path forward to manage alarm rates.

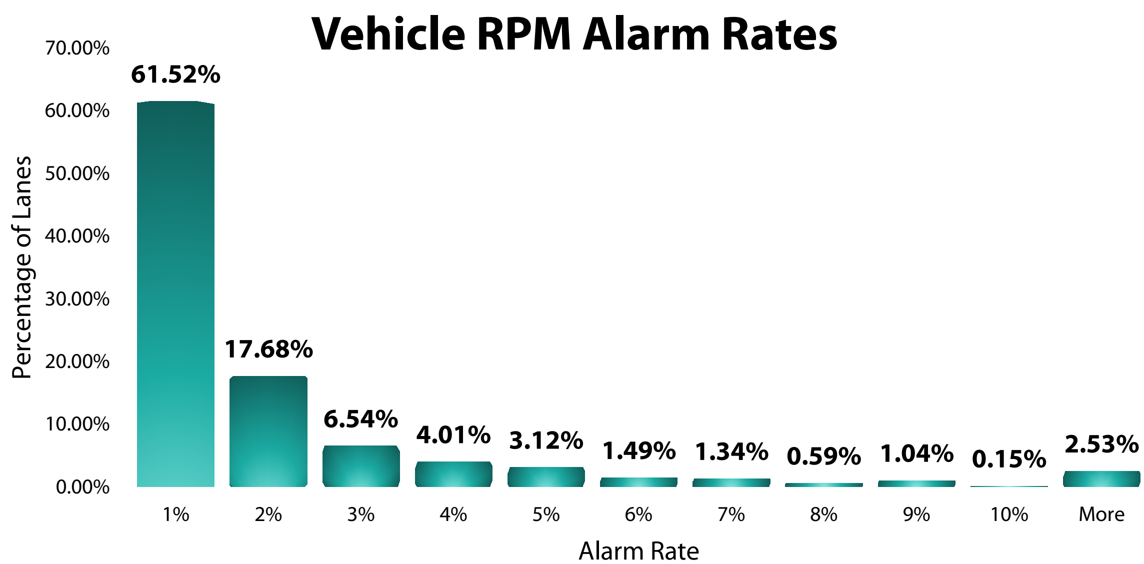


Figure 10. Vehicle alarm rates are generally low, with some exceptions.

Gamma Alarms for Secondary Inspections

Gamma alarms can be generated from a variety of sources, ranging from benign NORM sources, to lost industrial sources or nuclear material. Unfortunately, the strength of the gamma signal is not connected to its severity. For instance, a patient who has recently received a medical radiopharmaceutical treatment can give off orders of magnitude more gamma radiation than some threat sources. When an RPM generates an alarm, a separate piece of equipment (usually a handheld radioactive isotope identifier) is used to resolve the alarm, and that piece of equipment needs to function whether the source of the alarm is very weak or strong. Plots like those in Figure 11 are critical for determining the performance requirements for secondary systems.

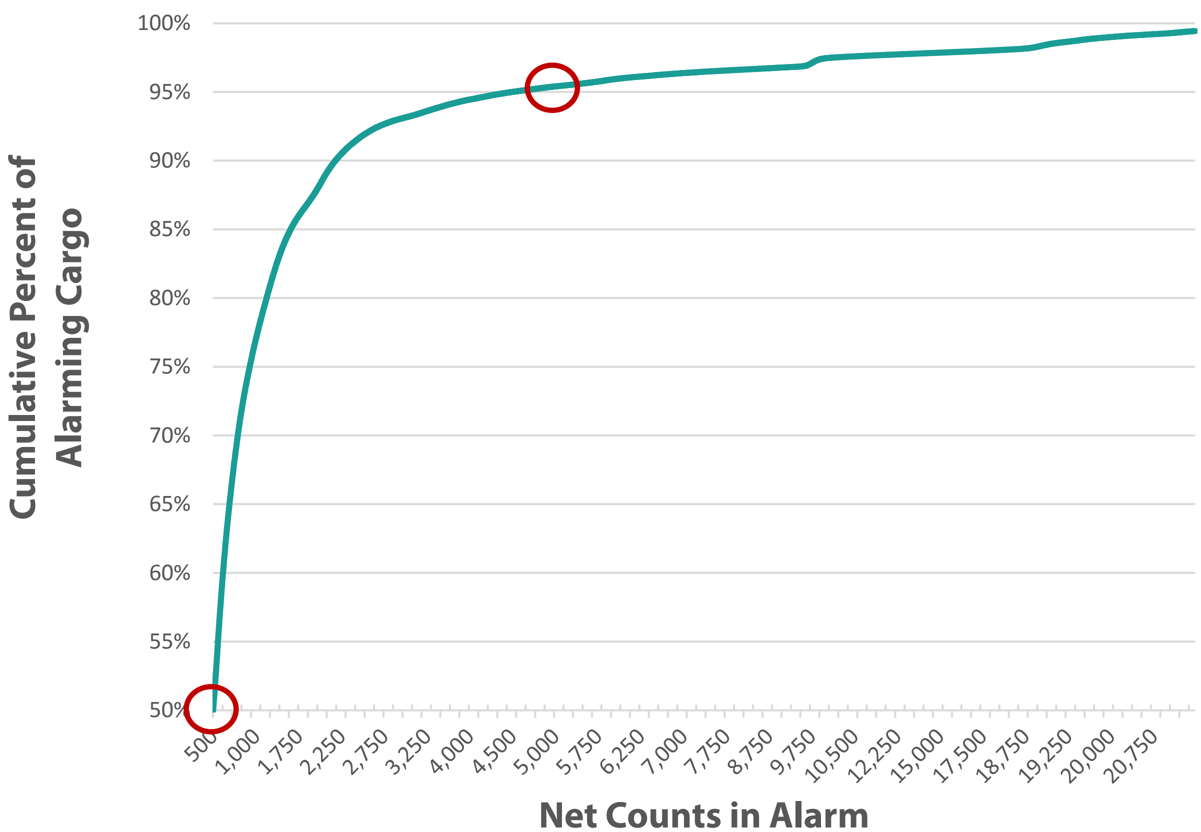


Figure 11. Distribution of net gamma counts for all alarming occupancies from vehicle RPMs in FY 2016.

The two red circles in Figure 11 highlight two sample points. The lower left circle indicates about half of all alarms generate about 500 counts above background ("net counts") or less. The upper right circle shows that 95% of all alarms generate 5,000 net counts or less at the RPM. In other words, about 1 in 20 alarms (5%) generates more than 5,000 net counts. Data points like these can inform requirements for secondary inspection systems and next-generation energy discriminating systems, answering questions like "How 'hot' is the typical NORM source?" and "Can the secondary inspection system still discern threat material inside of a cargo load of NORM?"

ASSESS: Data Analysis Products

Data analysis supports the sustainability of the NSDD detection systems by informing project teams of systematic issues occurring site-, country-, and program-wide. For this purpose, several reports are produced.

Monthly Country Reports

The primary report used by NSDD is the monthly country report (MCR), and one report is produced each month for each country that submitted data. ORNL generated over 280 MCRs in FY2016. These reports summarize operational elements for each RPM: number of occupancies, number of gamma and neutron alarms, and number of faults. Analysis of data over a long period of time (e.g., 1 month) can provide valuable, objective answers to the following questions:

- Is the equipment operating as intended?
- Is the equipment being properly maintained to support its operations?

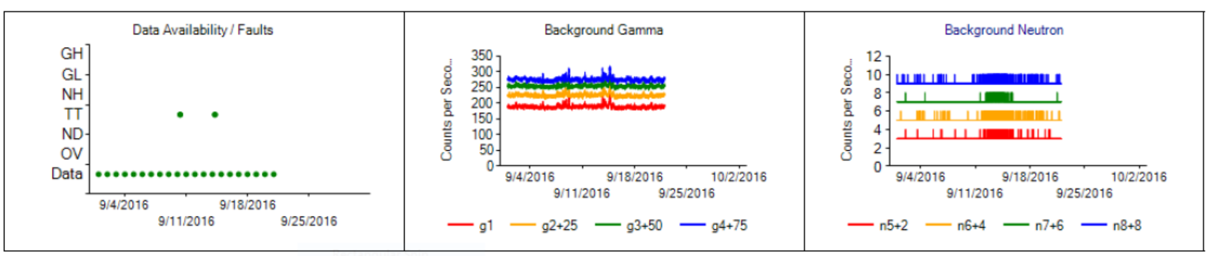
ORNL data analysts review the data from each RPM each month and provide their findings in the MCR (Figure 12). Long-term analysis like this can identify failing components and other problems before they become an operational burden.

Monthly Country Report
Cricket_September 2016
9/1/2016-9/30/2016

Triple - Lane 001 (Vehicle)

Data only available through 9/21.
Both neutron alarms on 9/21 at 10:55am and look like testing.

Data Availability		**Occup Metrics**		**Bkgrd G.Metrics**		**Bkgrd N.Metrics**		**Fault Metrics**	
First (in rpt month):	9/1/2016	Occup Count:	14763	Tot Avg Bg:	795.5	Tot Avg Bg:	7	Gamma High:	0
Last (in rpt month):	9/21/2016	Occ / Day:	703	Avg Bg 1:	189.3	Avg Bg 5:	1.7	Gamma Low:	0
Total Files:	21	G.Alarm Count	1	SDev Bg 1:	5.9	SDev Bg 5:	0.6	Neutron High:	0
Oversize Files:	0	G.Alarm Pct:	0.007	Avg Bg 2:	200.7	Avg Bg 6:	1.8	Tamper Open:	2
Empty Files:	0	G.Alarm / Day:	0.048	SDev Bg 2:	6	SDev Bg 6:	0.6	Tamper Close:	2
Bad Format Files:	0	N.Alarm Count:	2	Avg Bg 3:	205.1	Avg Bg 7:	1.7		
Missing Files:	9	N.Alarm Pct:	0.014	SDev Bg 3:	5.7	SDev Bg 7:	0.6		
		N.Alarm / Day:	0.095	Avg Bg 4:	200.4	Avg Bg 8:	1.8		
		Speed (Mode):	13	SDev Bg 4:	6.2	SDev Bg 8:	0.6		



Gamma Settings

Timestamp	Backgrd High Fault	Backgrd Low Fault	Intervals	Occupancy Hold-In	N.Sigma	Detectors On-Line	Master L.Level Discrim	Master U.Level Discrim	Relay Output	Algorithm	Slave L.Level Discrim	Slave U.Level Discrim	Backgrd Time	Backgrd N.Sigma	Firmware Version
9/21/2016 12:51 AM	630	100	5	10	11.400	1111	0.069	0.455	1	1010	0.069	0.455	20	0.000	1.10.1

Neutron Settings

Timestamp	High N.Fault Alarm	Max Intervals	Alpha Value	zMax Value	Sequence Number	nBkgrd Average Time	Master L.Level Discrim	Master U.Level Discrim	Slave L.Level Discrim	Slave U.Level Discrim
9/21/2016 12:51 AM	50	3	4	1200	1	120	0.504	5.040	0.504	5.040

Figure 12. A fictitious MCR that shows status information for one RPM for 1 month. Items that need attention (missing data, neutron alarms, tamper indications) are highlighted in yellow.

Lane State of Health

The lane state of health is a key element of the MCR; it allows site operators, project teams, and foreign partners to assess the health of a lane quickly and easily based on a comparison of the lane with appropriate criteria. The report highlights lanes as red (immediate attention required), yellow (items to attend to at the next convenient opportunity), or green (no issues with lane operation) as shown in Figure 13.

Light	Files%	Empty%	Oversize%	Speed	gAlign	nAlign	gVar	nVar	gSet	nSet	Faults	Tampers
Green	10	0	0	-1	0.928	0.950	0.781	0.979	0	0	0	0
Yellow	10	0	0	0	0.978	0.956	0.916	0.969	0	0	0	0
Green	10	0	0	843	0.941	0.984	0.874	0.965	0	0	0	0
Yellow	10	0	0	-1	0.945	0.931	0.906	0.720	1	0	1	0
Yellow	10	0	0	-1	0.922	0.926	0.884	0.939	1	0	0	0
Green*	10	0	0	0	0.887	1.000	0.822	1.000	0	0	0	0
Green	10	0	0	549	0.897	0.979	0.898	0.941	0	0	0	0
Green	10	0	0	-1	0.000	0.000	0.000	0.000	0	0	0	0

Figure 13. Lane state of health charts allow quick assessments of individual RPM status. Each row is an RPM, and each column is a different evaluation metric.

LMP Score

The local maintenance provider (LMP) score is one method that NSDD can use to track the performance of its maintenance providers in partner countries. The LMP score is derived from the average lane state of health for all lanes in a country, and the score helps NSDD determine if RPMs are being maintained properly. However, lane state of health is not intended to be the only metric considered for evaluating LMPs. The LMP score is calculated monthly and has a minimum value of 1 and maximum value of 10.

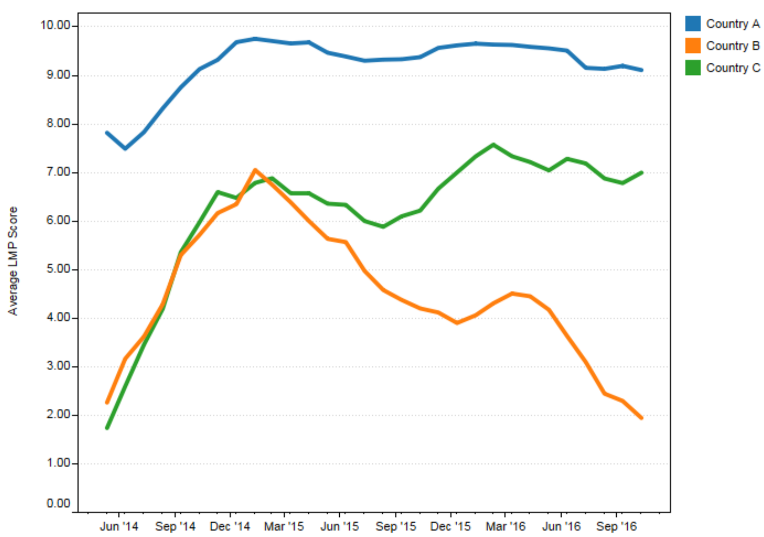


Figure 14. A comparison of LMP scores for three countries. The plot conveys the relative variability of LMP performance in partner countries across NSDD.

Figure 14 shows the 6 month rolling average of LMP scores for three countries across several years. The RPMs in Country A appear to have been well-maintained over the entire length of the analysis, resulting in many green lane states of health metrics and high LMP scores. Country B had seen some trending improvement in its RPM maintenance but has recently seen a decrease in effective maintenance, and Country C has shown overall improvement in its maintenance capability.

Annual Country Reports

The annual country report (ACR) provides an annual overview of the daily activity for each RPM within a country, such as the number of occupancies and number of daily files submitted. The report also includes a breakdown of the types of RPM faults on each lane and ranks lanes based on the severity of any faults that occurred during the year. When NSDD considers possible maintenance or mitigation efforts and budgets for those efforts, these rankings help prioritize the RPMs that are the most problematic. Finally, ACRs include data on gamma alarms broken down by gamma alarms per day and per occupancy, by lane. Both metrics are valid for analysis, as a high gamma alarm rate at a low traffic site or a high number of gamma alarms per day at any site could indicate environmental or operational problems. Fictitious ACRs are provided as examples of this report (Figures 15–16).

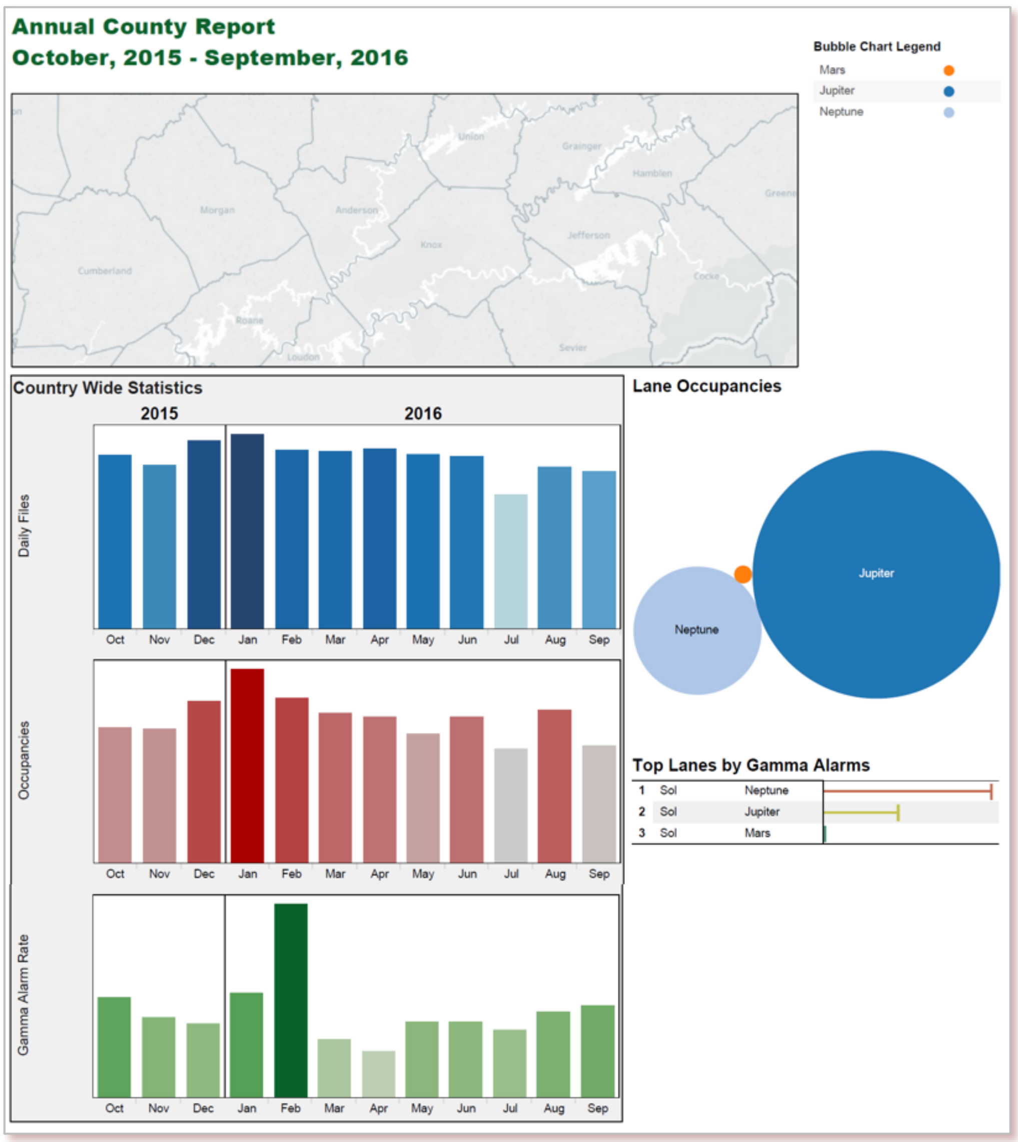


Figure 15. A sample ACR shows site-level statistics at a glance.

Figure 16. Sample analysis from an ACR including (from top to bottom) the ranking of lanes by fault severity, the tracking of gamma alarms per day and gamma alarm rate each month, a month-by-month breakdown of one of the fault types, and the occupancies for each month.

Quarterly Availability Report

On a quarterly basis, ORNL tracks the overall uptime of RPMs from the available data, and publishes the results in a quarterly availability report. A small portion of the availability report is shown in Figure 17. The uptime of all RPMs within a country are calculated and shown in a box-and-whiskers plot. Statistical outliers can be identified (such as the pink star in Figure 17), and ORNL works with project teams to identify and correct long-standing issues. The report also highlights the previous quarter's poor performers and the improvement seen this quarter, which provides a nice synopsis of NSDD's dedication to maintaining and sustaining RPMs.

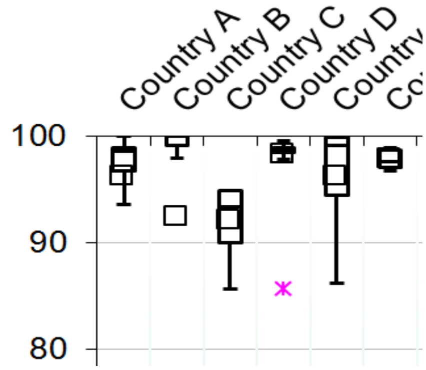


Figure 17. Sample box-and-whisker plot showing RPM availability for each country.

For all of FY 2016, the overall uptime for all RPMs was above 96%.

Software Tools: DART and MCAAW

Figure 18. Maintenance providers use MCAAW software to align RPM gamma detectors.

As part of its mission to analyze RPM data for NSDD, ORNL develops and distributes software tools to partner countries to enable them to perform the same analysis as ORNL. In person and over-the-internet training is available to all partner countries to assist them in taking on these responsibilities.

The first of these is the Desktop Analysis and Report Tool (DART), which allows maintenance providers to analyze daily file data while on site to provide additional information about any work they are about to perform. It is also the tool NSDD data analysts use to generate the MCRs (Figure 12). DART is useful for, among other things, identifying faulty or failing components and operational issues affecting RPM sensitivity, and analyzing secondary inspection wait times.

Another software tool is the Multi-Channel Analyzer Alignment Wizard (MCAAW). MCAAW leads technicians through the process of aligning (or calibrating) an RPM, and it automatically records all the necessary information for proper documentation and verification. Data files can be emailed to ORNL for confirmation as well. Monitoring and trending of calibration data over months and years can be crucial to identifying long-term trends and behaviors.

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IMPROVE

The Office of NSDD's data analysis efforts are part of a continuous improvement process for installed RDSs. Systems are installed in dynamic environments where operational changes, physical changes, or changes in the traffic being processed may indicate that the system is no longer ideally suited to the circumstances of the site. Therefore, a key element of NSDD's continuous improvement process is to take actions to adjust systems to new circumstances and to continually monitor data to understand the effects of those actions. NSDD fosters an environment of close collaboration to ensure that data analysis recommendations are understood and considered by project teams. NSDD project teams then take a variety of actions to improve the reliability and effectiveness of installed systems based on the recommendations of the data analysis team. These improvement recommendations generally fall in three categories: physical, operational, and settings adjustments.

Physical Improvements

Physical improvements are changes to the physical configuration of an RDS to improve its reliability or effectiveness. Because recommendations for physical improvements generally involve the deployment of equipment, project teams implement these recommendations by integrating them into the budget planning process, and recommendations are deployed using standard project management practices.

One opportunity for physical improvements occurs when an x-ray machine is installed near an existing RDS. The utility of x-ray systems makes this a common occurrence at airports, where baggage scanners may create an issue, and at some seaports, where there may be large systems to scan cargo containers. X-rays are identified by an RPM as gamma radiation, resulting in false alarms. The short-duration pulses from x-ray systems have a characteristic signature that is detected by the NSDD data analysis team, who may recommend to the project team that x-ray shielding be installed. Figure 19 diagrams a typical site layout that exposes an RPM to x-ray interference, and Figure 20 shows example RPM data and alarm rates for an RPM being exposed to x-ray interference before and after installation of shielding. The shielding also affects the normal background radiation observed by the RPM, which analysts must take into account when determining new settings. Data analysts monitor RPM data after shielding installation to ensure the x-ray interference has been eliminated and report their findings to the project team.

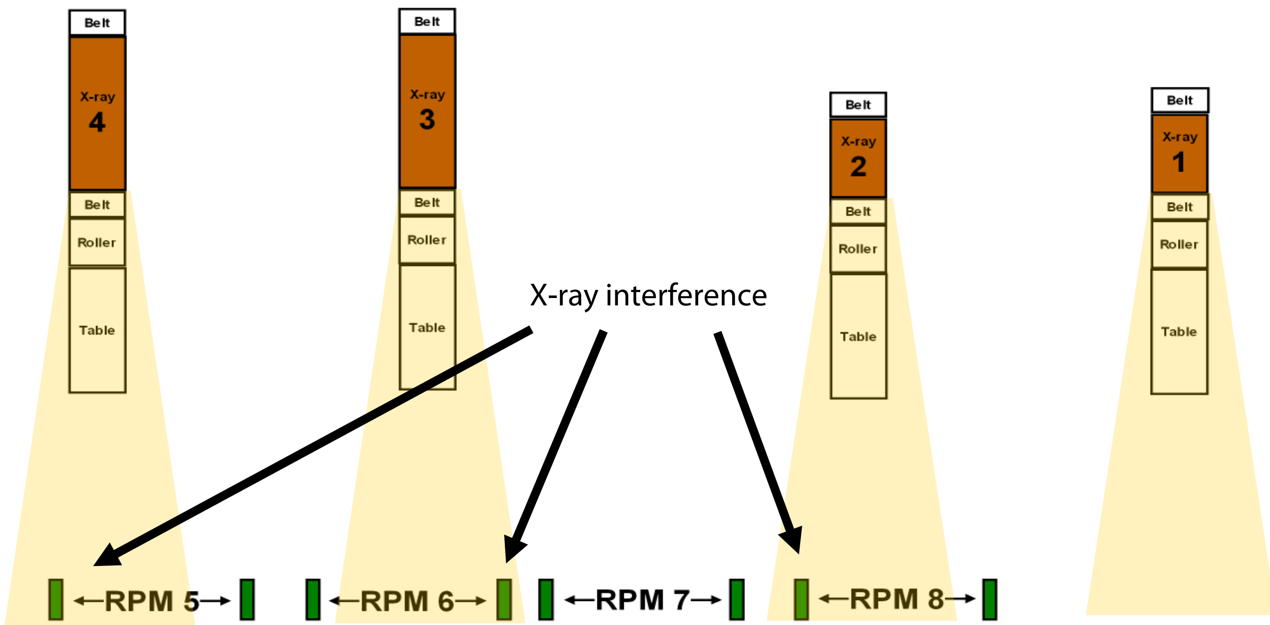
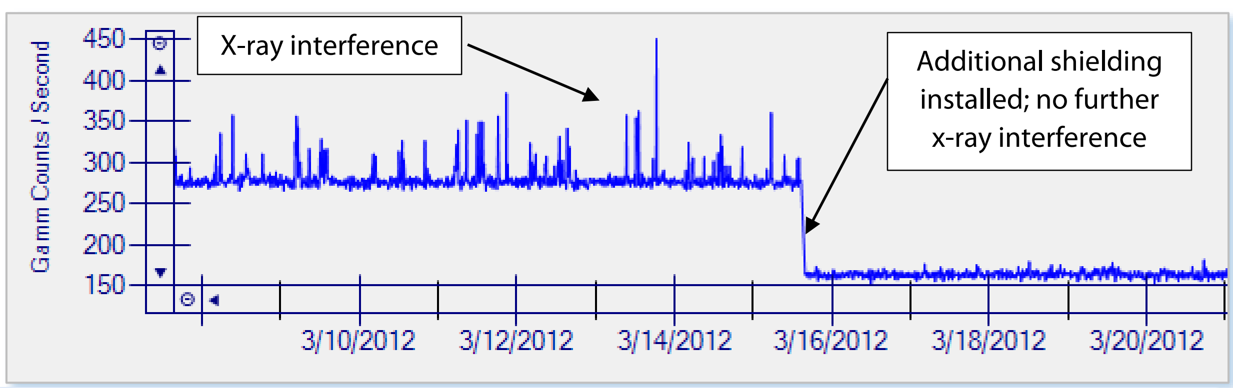


Figure 19. Diagram of typical x-ray interference.



	January	February	March	April	May
Alarm Rate: (Alarms/day)	6.0	5.9	2.6	0.2	0.3

Significant decrease after x-ray shielding was installed

Figure 20. Example RPM data before and after x-ray shield installation.

Over the years, NSDD's data analysis efforts have supported physical solutions like the one just described to decrease false gamma and neutron alarm rates and to improve RDS reliability and sensitivity.

Operational Improvements

NSDD strives to install RDSs that minimize operational impact to the site. However, not all issues detected through data analysis can be remediated by physical changes to the system. In some cases, adjustments to site operations are the most efficient way to improve RDS effectiveness. These adjustments may include changes to management practices, training, or procedures associated with RDS operation to improve its reliability or effectiveness.

One operational problem is known as "crowding," which occurs when people or vehicles crowd close to an RPM without occupying it (Figure 21), unintentionally manipulating the natural background radiation in a way that make false alarms more likely.

Figure 21. Pedestrians crowding a pedestrian RPM, which can lead to false alarms.

Data analysts are able to detect the crowding signature in RPM data and will recommend that project teams work with the appropriate partner country authorities to eliminate it. Typically, this involves working with local managers and operators to alert them to the issue and to identify changes to site operations that preclude unnecessary crowding. After operational changes are made, NSDD data analysts continue to monitor RPM data to ensure the issue has been resolved.

The same process may be applied for patients who recently received medical isotope treatments, which can cause excessive false alarms. Figure 22 depicts an example of such a case.

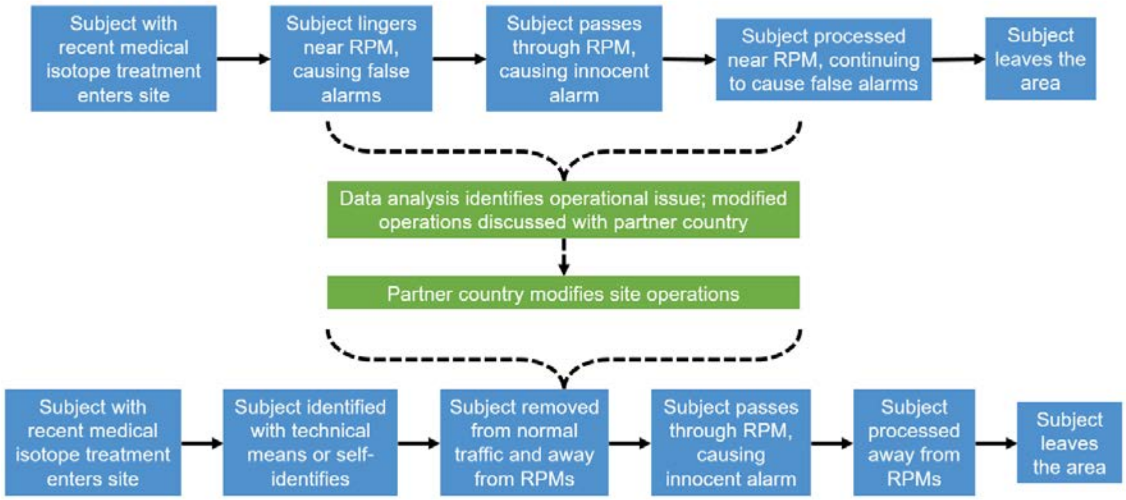


Figure 22. Example operational change as a result of data analysis.

Ongoing relationships between partner country authorities and NSDD project teams are vital to the success of these interventions, as they require the trust and cooperation of NSDD foreign partners.

Settings Improvements

Settings improvements are changes to the settings or firmware of RDS components to improve system reliability or effectiveness. Settings changes are a cost-effective way to improve the performance of a system while still meeting NSDD detection goals.

Settings changes have been used to decrease the rate of innocent alarms caused by NORM. In conjunction with a project team's on-the-ground knowledge, data analysis is able to show that high alarm rates at particular monitors are a result of the conveyance of higher than average amounts of NORM. In some cases, settings changes have allowed these RPMs to decrease their alarm rate. Additionally, by taking advantage of the tens of millions of occupancies collected each year, NSDD can predict what the effect on the global alarm rate would be for changes to various settings. A recent example in FY 2016 was to make changes to the neutron settings for rail RPMs. The new settings lessen the chances that an RPM incorrectly generates a neutron alarm when no neutron source is present, while still maintaining the required sensitivity to real neutron sources.

These settings and firmware updates are incorporated into existing site visit plans, such as during assurance visits or through maintenance provider contracts. Since no additional costs are typically incurred, settings changes can be made at very little cost to NSDD.

Continuous Improvement

Data analysis is part of NSDD's continuous improvement process for deployed RDS installations. After making changes to the physical, operational, or settings configuration of an RDS, RPM data is continually monitored to ensure the changes were effective. The effectiveness of these interventions are also verified through a project team's direct interactions with partner country stakeholders during assurance visits or through feedback received from LMPs. Together, these efforts ensure NSDD maximizes the efficiency and effectiveness of RDS deployments long after their initial installation.

Conclusions

FY 2016 was another successful year for NSDD:

- NSDD received its 500 millionth occupancy in FY 2016.
- NSDD received data from over 1,000 RPMs in FY 2016.
- RPM availability, or uptime, for FY 2016 was above 96%.
- Through objective measures provided by data analysis and through long-term relationships developed with partner countries, NSDD is able to direct resources appropriately to maintain capabilities at their intended levels.

NSDD is uniquely positioned among nonproliferation programs to make data-driven recommendations about how to best optimize RPM operations and, ultimately, to positively influence the ability of sites to deter, detect, and interdict illicit nuclear and radiological materials. Information such as this report—as well as additional site-specific information in conjunction with site visits and other assessment techniques—provides the Office of NSDD with valuable resources to support partner countries in strengthening their capability to prevent the illicit trafficking of nuclear and other radioactive materials. This report is just one of many tools used by NSDD to maintain the consistency, proficiency, and effectiveness of installed equipment.