Draft Programmatic Environmental Assessment for Deployment and Operation of High Energy X-Ray Inspection Systems at Sea and Land Ports of Entry

May 2010

U.S. Customs and Border Protection

DEPARTMENT OF HOMELAND SECURITY
U.S. CUSTOMS AND BORDER PROTECTION
OFFICE OF INFORMATION AND TECHNOLOGY
LABORATORIES AND SCIENTIFIC SERVICES
INTERDICTION TECHNOLOGY BRANCH

DRAFT

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U.S. Department of Homeland Security
Washington, DC 20229

U.S. Customs and
Border Protection

May 25, 2010

Subject: Notice of Availability of the Draft Programmatic Environmental Assessment for Deployment and Operation of High Energy X-Ray Inspection Systems at Sea and Land Ports of Entry

Dear Reader,

The U.S. Customs and Border Protection (CBP), Office of Information and Technology (OIT), Laboratories and Scientific Services (LSS), Interdiction Technology Branch (ITB) has prepared a draft Programmatic Environmental Assessment (PEA) to address the potential effects of establishing High Energy X-Ray Inspection Systems at various sea and land ports of entry.

The purpose of the Proposed Action is to enable CBP to conduct non-intrusive inspections of high-density cargo containers for contraband such as illicit drugs, currency, guns, and weapons of mass destruction.

The draft PEA will be available for a 30-day review beginning May 25 and ending June 24, 2010. The PEA can be obtained from CBP/OIT/LSS/ITB 1300 Pennsylvania Avenue, NW, Suite 1575, Washington, DC 20229, telephone (202) 344-1531, facsimile (202) 344-1418. The PEA can also be viewed and downloaded via the internet at the following address: http://ecso.swf.usace.army.mil/Pages/Publicreview.cfm. Comments must be postmarked, e-mailed or faxed by June 24, 2010 to ensure that they receive full consideration. Please address all comments to the attention of Mr. Guy Feyen at the above address or facsimile number.

Executive Summary

Introduction

This Programmatic Environmental Assessment (PEA) documents the potential environmental consequences of deploying and operating High Energy X-Ray Inspection Systems (HEXRIS) at sea and land ports of entry (POE) in the United States (U.S.) and Puerto Rico by the U.S. Customs and Border Protection (CBP). Figures 1 through 5 in Chapter 1 of the PEA are representative pictures of the HEXRIS.

Purpose and Need

The purpose of deploying and operating HEXRIS is to perform non-intrusive inspections (NIIs) of high-density cargo containers for the detection of contraband such as illicit drugs, currency, guns, and weapons of mass destruction. Selection and deployment of NII equipment at POE is based on the following criteria: size of the POE and of the equipment, budget, schedule, mission requirements and cost.

HEXRIS are needed because they fill a unique niche in the types of inspection tools, including gamma-ray and standard X-ray NII technology, which are presently being used by CBP at the nation's POE. The systems are capable of penetrating dense cargo loads that cannot otherwise be examined with other technologies such as gamma imaging systems and low-energy X-ray systems. The systems will also assist in fulfilling the requirement for the 100% scanning of containers entering the U.S. as directed in the Security and Accountability For Every (SAFE) Port Act of 2006 (H.R. 4954). Thus, the Proposed Action adds a critical dimension to the inspection capabilities of CBP.

Proposed Action and Alternatives Considered

The Proposed Action consists of the deployment and operation of HEXRIS at sea and land POE in the U.S and Puerto Rico. Four different models are available for this purpose. Two models are mobile, truck-mounted systems: the Rapiscan Eagle® Mobile, and the Smiths Detection Heimann Cargo Vision Mobile (HCVM). Two models are stationary (gantry): the Varian Medical Systems' (formerly Bio-Imaging Research or BIR) IntellX2™ Gantry System, and the Smiths Detection Heimann Cargo Vision Gantry (HCVG). Selection of the systems will depend on the size of the POE, equipment, costs, specification requirements, and whether the manufacturers can meet mission deadlines. The systems are discussed in more detail, with representative photographs, in section 1.5.

No Action Alternative

The No Action Alternative is to continue to inspect trucks and high density cargo entering the U.S. with existing equipment and methods. This inspection process involves visual and manual inspection with a limited number of tools such as other NII technology. This approach is not as efficient and effective at detecting the range of materials which could be detected with HEXRIS in addition to current inspection techniques. Furthermore, it would not reduce the need for CBP officers to enter potentially dangerous situations to carry out these inspections.

Other Alternatives Considered

Other alternatives were initially evaluated to determine whether they could provide CBP with the capability to inspect trucks and containers with high-density cargoes. These alternatives are discussed in more detail in section 2.3. However, none of the alternatives were evaluated in detail in the PEA due to the fact that they could not meet the essential requirement of penetrating high density cargo and containers. Since only HEXRIS have this capability, it is the only alternative examined in detail in this PEA, along with the No Action Alternative.

Environmental Consequences of the Proposed Action and Alternatives

The conclusion of the analysis in this PEA is that the Proposed Action will result in no significant impacts to the human environment, as defined in National Environmental Policy Act (NEPA), as long as best management practices and mitigation measures are implemented.

Initially, the PEA assessed the potential for environmental impacts to the following resources:

Climate	Geology and Soils	Hydrology and Water Quality
Floodplains	Wetlands	Coastal Zones
Air Quality	Vegetation and Wildlife	Threatened and Endangered Species
Noise	Land Use and Zoning	Aesthetics and Visual Resources
Waste Management	Traffic and Transportation	Infrastructure and Utilities
Socioeconomics	Transboundary Impacts	Historic and Archeological Resources
Environmental Justice	Irreversible and Irretrievable Commitment of Resources	Radiological Health and Safety

A detailed discussion of these resource categories is provided in Chapter 3 of the PEA, along with explanations of why impacts to these resources were or were not carried forward for analysis in the PEA. Due to the fact that the Proposed Action will occur at developed industrial facilities in urbanized locations, significant impacts to most environmental resources are not anticipated. As a result, the only resource category evaluated in detail in this PEA is radiological health and safety.

Radiological Health and Safety – CBP has adopted the Nuclear Regulatory Commission's (NRC's) maximum dose to public standard which is 0.1 rem in a year. This standard applies to the public which includes system operators, POE personnel and other CBP personnel.

CBP's Radiation Safety Officer (RSO) conducted and supervised various tests to measure potential radiation doses that could occur. Results were measured against CBP's radiation dose standard to determine whether significant health effects were possible from the Proposed Action.

***Vehicle Occupants* –** Drivers and passengers exit their vehicles before scanning and remain outside of the controlled area during scanning. The only direct exposure that could occur would be to a person hidden inside a cargo container during a scan. Testing revealed that the worst-case potential dose under that circumstance would be approximately 0.0015 rem per scan. This dose is 240 times less than the average annual background dose in the U.S. of 0.360 rem and 66 times below levels permissible to the general public.

***Mobile HEXRIS Occupants* –** Mobile HEXRIS are designed so that the radiation dose levels within the driver's cab and at the inspector work-stations (systems operators) will be below the CBP prescribed limits of 0.1 rem in a year. Detailed radiation surveys, performed by or under the supervision of the CBP Radiation Safety Office, have confirmed that these design criteria have been met. In all cases, exposures were measured using a "worst-case" scatter in the X-ray beam. Furthermore, since such a worst-case scatter scenario is not likely to occur, these estimated exposure levels are conservative by a substantial amount. As an additional precaution, as the systems are deployed, exposure measurements will be made in the cabs and work-station areas to ensure that the systems are in compliance with exposure limits.

CBP Officers, POE Employees, and the General Public – CBP will protect its officers, other POE employees and the general public (including vehicle occupants) from radiation exposure by establishing "controlled areas" around each HEXRIS. No one will be allowed inside the controlled areas during a scan event. The controlled area dimensions are established by determining the distance from a HEXRIS at which radiation levels fall below a level of 0.00005 rem in any one hour. Assuming 2,000 work hours per year as the maximum exposure time, a person standing at the controlled area boundary could not receive a cumulative annual radiation dose in excess of 0.1 rem (0.00005 rem x 2000 hours = 0.1 rem).

In addition to establishing controlled areas around the equipment, CBP will undertake other mitigation measures to protect workers and the public from radiation. These precautions include training of operators and scanning operations supervisors in radiation safety, as well as, the incorporation of emergency stop buttons on the equipment. See section 3.2 for a complete discussion of all mitigation measures adopted as part of the Proposed Action.

Analysis and testing for this PEA shows that exposures are expected to be well below the maximum levels of exposure set by the NRC, the Occupational Safety and Health Administration (OSHA) and most states to protect workers and the general public; therefore, the health and safety impacts from radiological exposure for the Proposed Action were found to not be significant.

Cumulative Impacts

Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. With respect to the Proposed Action, the only categories with a potential for cumulative impacts would be radiological health and air quality. Due to the establishment of controlled areas around the HEXRIS, separation of NII equipment from other NII systems, and other safety precautions, it was determined there were no cumulative radiological health risks from the Proposed Action. In terms of air quality, analysis showed that HEXRIS do not produce enough emissions to cause measurable cumulative air quality impacts.

Findings and Conclusions

The evaluation of the Proposed Action, deployment and operation of HEXRIS at POE in the U.S. and Puerto Rico, demonstrates that there will be no significant, adverse effects to the human environment as long as identified mitigation measures are followed. Therefore, no further environmental impact analysis is warranted.

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1 Introduction

This Programmatic Environmental Assessment (PEA) addresses the potential environmental effects, beneficial and adverse, of the deployment and operation of High Energy X-Ray Inspection Systems (HEXRIS) by the United States (U.S.) Customs and Border Protection (CBP) at land and sea ports of entry (POE) in the U.S. and Puerto Rico. This PEA satisfies the requirements specified in the National Environmental Policy Act of 1969 (NEPA) as amended, the Council on Environmental Quality (CEQ) regulations implementing NEPA (40 CFR 1500-1508), and the Department of Homeland Security (DHS) Environmental Management Program (71 FR 16790-16820, April 4, 2006). NEPA requires CBP and other federal agencies to fully understand, and take into consideration during decision making, the environmental consequences of proposed federal actions.

HEXRIS, which are part of a comprehensive mix of technologies designed to complement one another and present a layered defense to smuggling attempts, allow CBP officers to inspect for contraband without having to physically enter into or unload cargo containers. Congressionally funded and directed, HEXRIS fulfill Non-Intrusive Inspection (NII) technology requirements found in (1) The Office of National Drug Control Policy (ONDCP) *National Drug Control Strategy*; (2) The ONDCP *Ten Year Counterdrug Technology Plan and Development Roadmap*; (3) The CBP *Container Security Initiative*; (4) National Security Presidential Directive – 17/Homeland Security Presidential Directive; 4 *National Strategy to Combat Weapons of Mass Destruction*; (5) National Security Presidential Directive – 43/Homeland Security Presidential Directive – 14 *Domestic Nuclear Detection*; (6) *U.S. Customs and Border Protection 2005-2010 Strategic Plan;* and (7) The *Security and Accountability For Every Port Act of 2006*.

1.1 Background

DHS was established in the aftermath of the terrorist attacks of September 11, 2001. The following elements are central to the mission of the department:

> AWARENESS – Identify and understand threats, assess vulnerabilities, determine potential impacts, and disseminate timely information to our homeland security partners and the American public.
>
> PREVENTION – Detect, deter, and mitigate threats to our homeland.
>
> PROTECTION – Safeguard our people and their freedoms, critical infrastructure, property, and the economy of our Nation from acts of terrorism, natural disasters, or other emergencies.
>
> RESPONSE – Lead, manage, and coordinate the national response to acts of terrorism, natural disasters, or other emergencies.

RECOVERY – Lead national, state, local, and private sector efforts to restore services and rebuild communities after acts of terrorism, natural disasters, or other emergencies.

SERVICE – Serve the public effectively by facilitating lawful trade, travel, and immigration.

ORGANIZATIONAL EXCELLENCE – Value our most important resource, our people. Create a culture that promotes a common identity, innovation, mutual respect, accountability and teamwork to achieve efficiencies, effectiveness, and operational synergies.

On March 1, 2003, the Immigration and Naturalization Service (INS) ceased to exist, U.S. Customs was renamed CBP and various border functions from INS and the Department of Agriculture were transferred to CBP. As the single, unified border agency, CBP's mission is vitally important to the protection of America and the American people. CBP's priority mission is preventing terrorists and terrorist weapons from entering the U.S., while also facilitating the flow of legitimate trade and travel. In performing its mission, CBP intercepts large quantities of contraband at sea and land POE. For example, in Fiscal Year 2007 alone, a total of 2,786,137 pounds of marijuana, 281,371 pounds of cocaine, 3,248 pounds of methamphetamine, and 2,167 pounds of heroin were seized nationally by CBP (CBP 2007).

To improve the inspection process, CBP continuously seeks technological solutions that are safe for both humans and the environment and are cost effective. One method of conducting inspections used by CBP involves the use of non-intrusive inspection (NII) technology, which uses X-ray or gamma radiation sources to "see" into cargo containers to identify potential contraband as well as persons attempting to illegally enter the country by hiding within a cargo container. These NII technologies can perform effective, rapid inspections without having to physically enter into or unload cargo containers, thereby reducing the risks for CBP officers.

HEXRIS directly support the four elements outlined below in the operational vision for secure borders at the POE. The successful combination of these elements creates POE where only lawful border crossers and legitimate goods are allowed to enter the U.S.:

Deterrence – Potential violators are unwilling to attempt to enter the country through the POE.
Interception – Dangerous and inadmissible people and goods are detected and prevented from entry.
Facilitation – Known low-risk people and goods are separated from those of higher risk and moved quickly and securely through the POE.
Consistency – Violators have an equal risk of detection and prevention regardless of mode of transportation or POE.

1.2 Purpose and Need

The purpose of the Proposed Action is to perform non-intrusive inspections (NIIs) of high-density cargo containers for the detection of contraband such as illicit drugs, currency, guns, and weapons of mass destruction. Selection and deployment of NII equipment at POE is based on the following criteria: size of the POE and of the equipment, budget, schedule, mission requirements and cost.

HEXRIS are needed because they fill a unique niche in the types of inspection tools, including gamma-ray and standard X-ray NII technology, which are presently being used by CBP at the nation's POE. The systems will also assist in fulfilling the requirement for the 100% scanning of containers entering the U.S. as directed in the Security and Accountability For Every (SAFE) Port Act of 2006 (H.R. 4954). Because of the sheer volume of sea container traffic and the opportunities it presents for terrorists, containerized shipping is uniquely vulnerable to terrorist attack. Thus, the Proposed Action adds a critical dimension to the inspection capabilities of CBP.

1.3 Public Involvement

In keeping with established policy regarding an open decision-making process, this PEA and resulting decision document of either a Finding of No Significant Impact (FONSI) or a Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) will be made available to agencies and the general public for review and comment. A Notification of Availability (NOA) will be published in applicable local newspapers and copies of the PEA made available to the general public at local libraries and public review website: http://ecso.swf.usace.army.mil/Pages/Publicreview.cfm.

For further information on the Proposed Action or to request a copy of the EA, please contact Mr. Guy Feyen, Project Manager, Office of Information and Technology, Laboratories and Scientific Services, Interdiction Technology Branch, 1300 Pennsylvania Avenue, NW, Suite 1575, Washington, DC 20229.

1.4 Framework for Analysis

This PEA was prepared in compliance with NEPA, (Public Law 91-190, 42 U.S.C. 4321-4347, as amended), the CEQ regulations for implementing the procedural provisions of NEPA (40 CFR parts 1500-1508) and DHS Management Directive 023-01 (formerly 5100.1), "Environmental Planning Program," (April 19, 2006). [See also, 71 Fed. Reg. 16,790 (April 4, 2006).] NEPA directs federal agencies to fully understand and take into consideration during decision-making, the environmental consequences of proposed federal actions. This PEA is intended to be a concise public document that provides sufficient evidence and analysis for determining whether to prepare an EIS or a FONSI.

In addition to the evaluation for potential direct and indirect impacts, the Proposed Action was also evaluated for cumulative impacts on the environment as described later in Chapter 4, "Cumulative Impacts," of this PEA.

1.5 Description of the HEXRIS

Four HEXRIS models have been identified by CBP as suitable for deployment at the various POE. Two models are mobile, truck-mounted systems: the Rapiscan Eagle® Mobile, and the Smiths Detection Heimann Cargo Vision Mobile (HCVM). Two models are stationary (gantry): the Varian Medical Systems (formerly Bio-Imaging Research or BIR) IntellX2™ Gantry System, and the Smiths Detection Heimann Cargo Vision Gantry (HCVG). HEXRIS employ an X-ray source to produce images of tankers, commercial trucks, sea and air containers, and other cargo containers. The systems are able to scan cargo containers in one pass. No radioactive source material is used to produce images. Representative photographs of the systems are shown in figures 1 through 5.

Figure 1: Eagle® Mobile (Stowed Configuration)

Image Source: CBP

Figure 2: Eagle® Mobile (Deployed Configuration)

Image Source: CBP

Figure 3: HCVM (Stowed Configuration)

Image Source: Smiths Heimann

Figure 4: HCVM (Deployed Configuration)

Image Source: CBP

Figure 5: Typical Stationary (Gantry) HEXRIS

Image Source: CBP

1.5.1 Mobile HEXRIS

Mobile HEXRIS are mounted on a truck chassis and operated by a three person crew. The systems are able to scan cargo containers and trucks in one pass by slowly driving past a cargo container with the boom extended over the target container. When deployed for scanning operations the Eagle® Mobile is approximately 17.5 feet high, 25.6 feet wide, and 40 feet long. Similarly deployed, the HCVM is approximately 18.33 feet high, 29.0 feet wide, and 34.5 feet long.

1.5.1.1 Detector and Source Boom Assembly

The detection boom is aligned with the X-ray emission subsystem, and when deployed, forms the complete detection subsystem. The detection boom is comprised of an L-shaped detection line made up of a series of detectors that convert the X-ray emissions produced by the accelerator into an electronic signal. These detectors are placed along the length of a rigid metal structure, which is enclosed in a casing.

1.5.1.2 Imaging System

HEXRIS utilize a linear accelerator to produce the X-ray emissions to the detector box assembly. An onboard generator provides the electric power supply during scanning operations. Emissions from the generator have been factored into the air quality analysis in Appendix A.

1.5.1.3 Radiation Safety Features

Operator Controls and Displays

HEXRIS are equipped with the operator controls and displays required for scanning targets and reviewing images acquired from the scan. The X-ray linear accelerator is controlled through these interfaces when performing inspections. Various emergency stop buttons can immediately stop all operations, including X-ray production when activated.

Radiation Controlled Area

Controlled Area is defined by 10 CFR 20.1003 as *"an area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason."* CBP uses the term "controlled area" rather than "restricted area" as the scanning systems are not in continuous scanning mode. Further, the traditional wording of restricted area has other uses at POE that does not accurately reflect the caution that CBP desires to show the public.

CBP establishes a controlled area around each HEXRIS that limits the potential radiation dose to CBP personnel and the public to below 0.00005 rem in any one hour. The dimensions of the controlled areas are established through radiation surveys conducted by the CBP Radiation Safety Office. At the edges of these controlled areas, the radiation dose will not exceed the 0.00005 rem limit. No personnel or members of the public will be allowed in the radiation controlled areas during scanning operations.

The Eagle® Mobile operates at 4.5 MeV. The safe operating dimensions of the controlled area are 108 feet in length and 142 feet in width, as depicted in Figure 6. The HCVM has two operational settings: 3.8 MeV and 4.2 MeV, with each operational setting having a specific controlled area which must be maintained during operation. System modes of operation are set based on the density of the walls of the containers scanned. In the event usable images are not acquired from an initial scan with the system set at 3.8 MeV, the HCVM can be operated at 4.2 MeV to obtain data from denser containers.

When operating at 3.8 MeV, the safe operating dimensions of the HCVM controlled area are 110 feet in length and 82 feet in width, as depicted in Figure 7. When operating at 4.2 MeV the safe operating dimensions for the controlled area are 135 feet in length and 133 feet in width, as depicted in Figure 8.

Controlled areas for mobile HEXRIS are moving footprints of specified dimensions. During an inspection process, the controlled area will be coincident with the movement of the system. Controlled area dimensions may be adjusted when needed by using cargo containers as a backstop, or by using masonry walls. When adjustments in the radiation control area are required or requested, the CBP Radiation Safety Officer (RSO) will be consulted in order to maintain the radiation exposure limit below 0.00005 rem in any one hour limit and 0.1 rem per year. In the event other NII technologies are present or planned for operation at a given POE, CBP will ensure that controlled areas for each technology are adequately designated and do not overlap with one another.

During scanning operations, signs in multiple languages are posted at the controlled area boundary indicating the radiation hazard. Ground guides, which are items such as jersey barriers, cones or other items or an individual (e.g. CBP RSO), who provides visual signals to the driver, are positioned at various locations around the controlled area to warn persons of the danger as well as provide visual references to the driver of the HEXRIS. The system incorporates an infrared safety barrier that stops the forward movement of the inspection system as well as the production of X-rays should the beam barrier be broken.

Figure 6: Eagle® Mobile Controlled Area

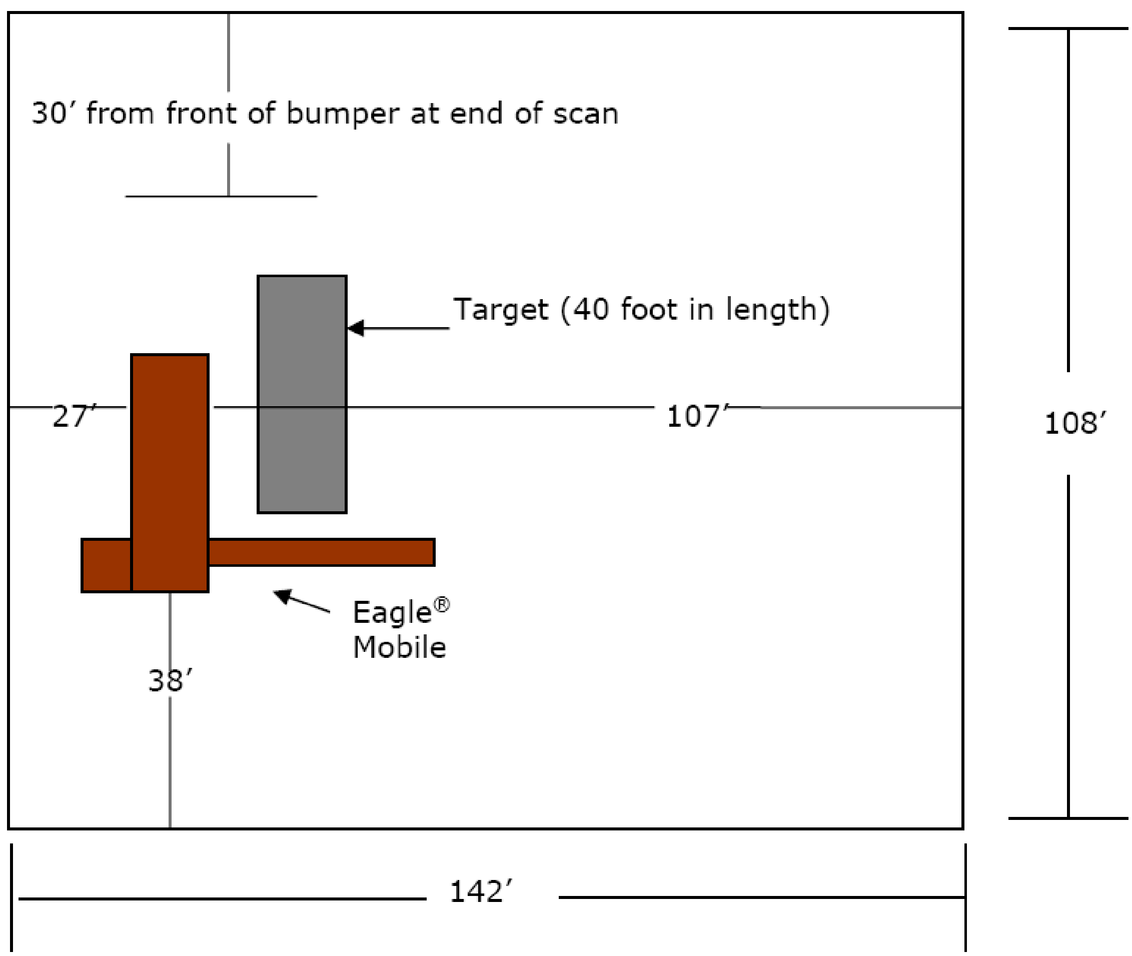


Figure 7: HCVM Controlled Area for Operation at 3.8 MeV

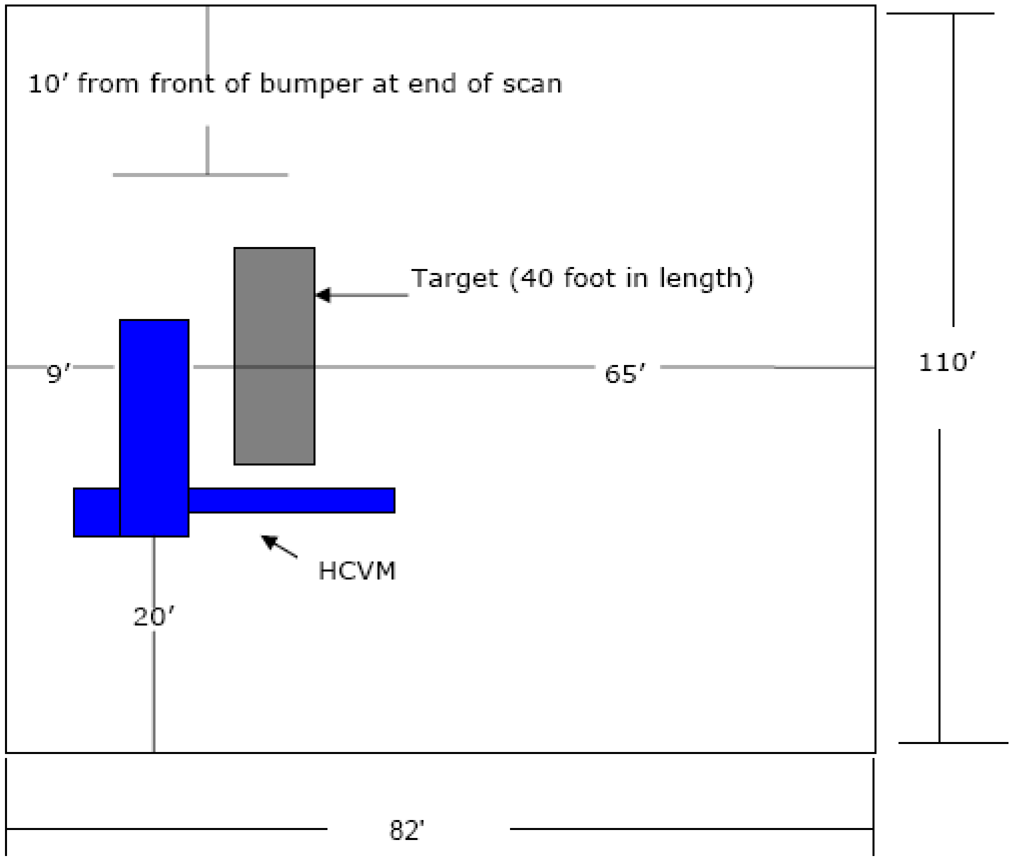
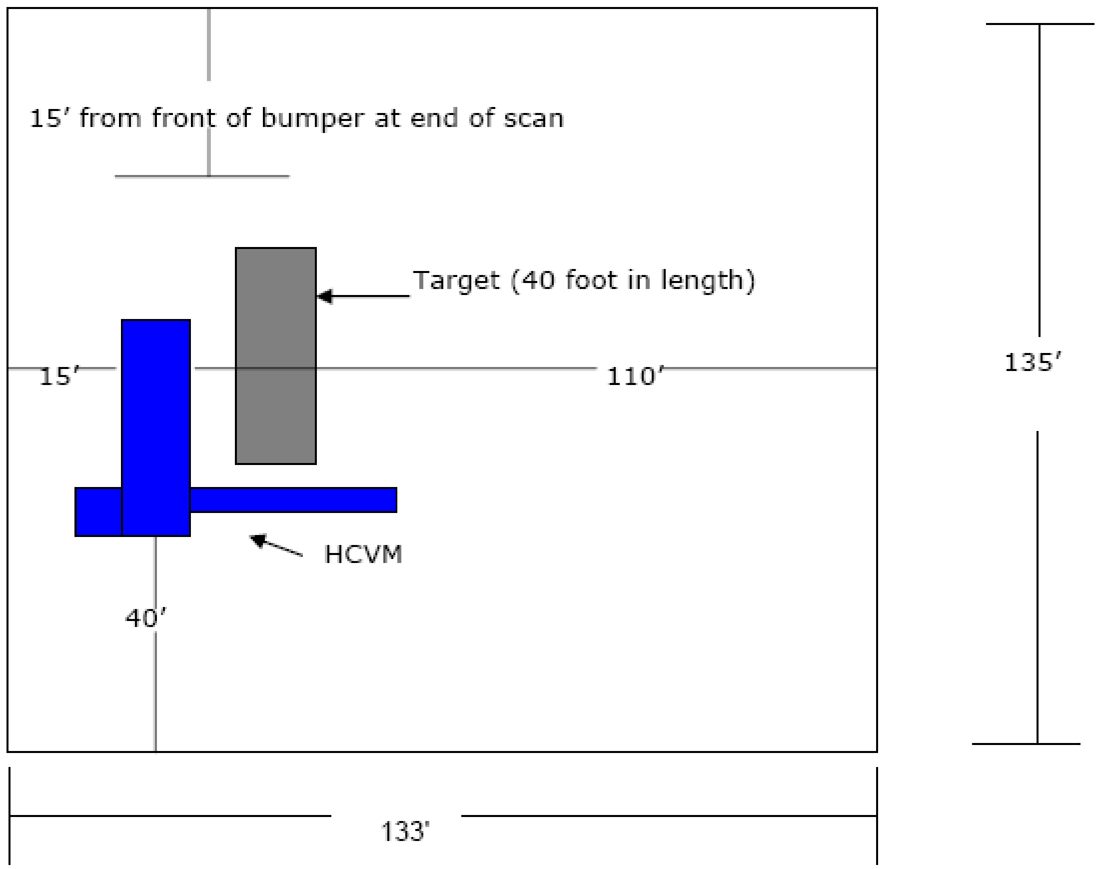


Figure 8: HCVM Controlled Area for Operation at 4.2 MeV



1.5.2 Stationary (Gantry) HEXRIS

Stationary gantry HEXRIS will employ a 6.0 million electron volt (MeV) X-ray source. The systems are capable of scanning 20 vehicles per hour. X-rays are only produced during active scanning.

1.5.2.1 Building

Each system will be housed in a building constructed upon a reinforced concrete pad. Motorized doors will allow trucks to enter the building and proceed to the gantry system. Each building will be equipped with sidewall (i.e. the two walls adjacent to the building's entrance and exit) shielding to ensure that no more than 0.00005 rem is detected in any one hour measured at 1 foot from the exterior of the building.

1.5.2.2 Gantry System, Detector and Source Assembly

Each detector system and X-ray source are built into a gantry (a framework) that moves along a parked vehicle during active scanning (see Figure 5). The detector system is aligned with the X-ray source on the opposite side of the gantry. During scanning, a motorized rail system translates the gantry over a stationary vehicle. X-rays are produced by a linear accelerator, and are converted into electronic signals by the detector system. All passengers exit the vehicle to a waiting area outside the building prior to the scanning process.

1.5.2.3 Operator Control Station

The operator control station for each system will be a portable, prefabricated structure, or other suitable structure, which will be placed outside the building that will house the gantry and outside of each system's controlled area.

1.5.2.4 Imaging System

Each system includes software that converts the electronic signals from the detector system into images that can be displayed, archived and retrieved by the operator.

1.5.2.5 Radiation Safety Features

Stationary gantry HEXRIS are equipped with interlock systems, which stop X-ray production and gantry movement when an interlock is broken. For example, when a truck enters the building, a light curtain will be interrupted, and an interlock is then broken, making X-ray generation and gantry movement impossible until all interlocks are restored.

In the unlikely event that a person is inside the radiation area within the building, audible and light alarms will alert to the possibility of radiation before exposure starts, allowing time to activate an emergency stop button.

Operator Controls and Displays

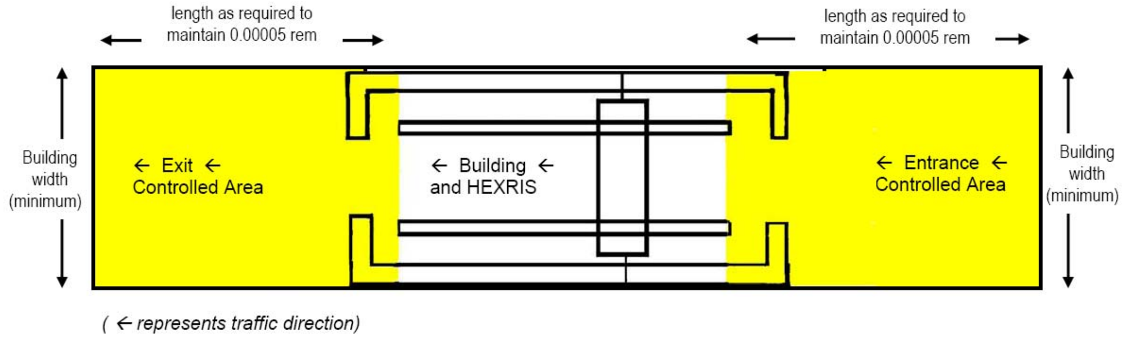
Each gantry HEXRIS is equipped with operator controls for scanning and image acquisition. The X-ray linear accelerator is controlled through these interfaces. Various emergency stop buttons can immediately stop all operations, including X-ray production when activated.

Radiation Controlled Area

As elaborated in section 1.5.1.3, CBP establishes radiation controlled areas around each HEXRIS which limit the cumulative potential doses to CBP personnel and the public to below 0.00005 rem in any one hour. The dimensions of the controlled areas are established through radiation surveys conducted by the CBP Radiation Safety Office. No personnel or members of the public will be allowed in the radiation controlled area during scanning operations.

The CBP Radiation Safety Office has performed a radiation survey of an IntellX2™ gantry HEXRIS at the manufacturer's demonstration facility. The system has similar design specifications as is proposed for various POE. The RSO determined that two controlled areas, one at the entrance and one at the exit of the building will be established. The dimensions for each controlled area will be equal to the building width, and will extend from the ends of the gantry rails to the extent necessary to keep the radiation exposure below 0.00005 rem per hour, as shown in Figure 9. In the case of the demonstration facility survey, the dimensions were the width of the building by 74 feet long. These dimensions are expected to be similar for stationary gantry HEXRIS that will be deployed and operated at various POE. The controlled area for individual systems may extend beyond the width of the building, depending upon site specific data. Controlled area dimensions will be verified for each system.

Figure 9: Stationary (Gantry) HEXRIS Controlled Area



2 The Proposed Action and Alternatives

Under NEPA, the proponent for an action is responsible for considering a reasonable range of alternatives that could accomplish the agency's objectives. If alternatives were eliminated from detailed study, reasons for their elimination must be briefly discussed.

Two alternatives were evaluated based upon their ability to provide the required operational capacities identified in the purpose and need statement. The two alternatives considered were:

1. Deployment and operation of HEXRIS
2. The No-Action Alternative

Deployment and operation of the HEXRIS was chosen as the preferred alternative and is presented as the Proposed Action.

2.1 Alternative 1 – Proposed Action

The Proposed Action consists of the deployment and operation of HEXRIS at sea and land POE in the U.S. and Puerto Rico for the purpose of conducting NIIs of high-density cargo containers. Four different models are available for this purpose. Two models are mobile, truck-mounted systems: the Rapiscan Eagle® Mobile, and the Smiths Detection Heimann Cargo Vision Mobile (HCVM). Two models are stationary (gantry): the Varian Medical Systems' (formerly Bio-Imaging Research or BIR) IntellX2™ Gantry System, and the Smiths Detection Heimann Cargo Vision Gantry (HCVG). These systems are discussed in section 1.5. Mobile HEXRIS will be moved to any developed area of POE suitable for conducting inspections as required.

2.2 Alternative 2 – No Action Alternative

The No Action Alternative is to continue to inspect high density truck and cargo containers entering the U.S. with existing equipment and methods. This inspection process involves visual and manual inspections with a limited number of tools such as other NII technology. This approach is not as efficient and effective at detecting the range of materials which could be detected with HEXRIS in addition to current inspection techniques. Furthermore, it would not reduce the need for CBP officers to enter potentially dangerous situations to carry out these inspections. Although the No Action Alternative does not meet the purpose and need, it serves as a basis of comparison to the Proposed Action.

2.3 Other Alternatives Considered

Three additional alternatives were initially considered to determine whether they could fulfill the purpose and need of the Proposed Action, which is to support CBP's mission by providing the capability to inspect high density cargoes and containers.

3. Mid-Energy X-Ray Inspections Systems;
4. Gamma Imaging Inspection Systems

5. Inspecting containers at a dedicated cargo inspection facility at another location other than the POE.

Alternative (3), Mid-Energy X-Ray Inspection Systems, was not evaluated further in this PEA because it does not meet the mission requirement for penetration of high-density cargo. Mid-Energy X-ray systems operate between 0.25 and 2 million electron volts (MeV) of energy and are useful for many inspection needs, but are not capable of imaging high-density cargo and containers. Therefore, it was determined that these systems did not meet the purpose and need of this federal action, and further analysis of this alternative was not undertaken.

Alternative (4), Gamma Imaging Inspection Systems, was dismissed from further consideration for the same reasons as Alternative (3). Gamma imaging systems use ionizing gamma radiation from either radioactive cesium-137 (^{137}Cs) or cobalt-60 (^{60}Co) to create images of the contents of cargo and containers. These systems are already in use by CBP at a number of POE. However, as with mid-energy X-ray systems, the gamma-imaging systems are not capable of penetrating high density cargoes and containers. Therefore, this alternative did not meet the purpose and need of the Proposed Action and was not evaluated further in this PEA.

Alternative (5) was not carried forward for detailed analysis because HEXRIS are intended to be a component in a mix of technologies designed to complement one another and present a layered defense against smuggling attempts. The systems will be used concurrently or in tandem with other methods and technologies at POE, such as radiation detection sensors and optical character recognition equipment. Placing the systems at other locations would defeat the layered defense strategy. Additionally, the SAFE Port Act requires that 100 percent of the containers that have been identified as high-risk are scanned before such containers leave a U.S. sea POE facility

3 The Affected Environment and Consequences

This section describes resources that exist at POE and the possible impacts to these resources from the Proposed Action and No Action Alternative. Since the POE are developed industrial facilities and the HEXRIS will be deployed on existing developed surfaces, impacts to sensitive environmental resources would not generally be expected. In view of this, most resource categories are briefly discussed but not submitted to detailed analysis. Cumulative impacts, or impacts attributable to the Proposed Action combined with other past, present or reasonably foreseeable future impacts regardless of the source, are presented in Chapter 4.

3.1 Preliminary Impact Scoping

Table 1 presents the results of the preliminary impact scoping and explains why certain resources were excluded from further discussion. In keeping with the CEQ guidelines (40 CFR 1500.4) on reducing paperwork and focusing the analysis on issues of concern to the public and policymakers, only those environmental resources that could potentially be affected (i.e. those resources that are retained in Table 1) will be discussed in detail.

Table 1: Preliminary Impact Scoping

Resource	Potential for Impact	Retained (Y/N)
Climate	The diesel engines and onboard generators on the mobile HEXRIS, as well as vehicles moving through the inspection process, will emit small amounts of air pollutants and greenhouse gases as a result of the Proposed Action. Analysis presented in this PEA has established that these emissions will be *de minimis,* as defined by the Clean Air Act. Accordingly, effects on the climate are expected to be negligible.	N
Geology and Soils	Scattered X-radiation will not contaminate soils because it is energy that dissipates as soon as the source is turned off, just as a room becomes dark as soon as the light switch is turned off. The system is mobile and can be moved as needed. No construction or excavation is required for the mobile HEXRIS and therefore deployment of these systems will have no direct impact to geology or soils. Stationary (gantry) HEXRIS will require trenching and excavations to prepare the ground surface for the concrete pad where the building will be placed and connected to utilities. Soils at each POE have been subject to grading and possibly filling to establish traffic lanes and other surfaces, such as inspection areas. Excavated soil will be	N

	used to backfill project sites. Erosion control measures and appropriate management practices will be implemented in accordance with the best management practices and applicable permit requirements. These actions will retain exposed soils and prevent soil erosion and migration. If any additional geotechnical requirements are identified for engineering or permitting requirements, they will be executed according to applicable permits and the final design plan for the Proposed Action.	
Hydrology and Water Quality	The Proposed Action will not affect hydrology, water resources or water quality.	N
Floodplains	It is likely that some POE will be located in the proximity of floodplains; however, since the HEXRIS will be deployed on existing developed surfaces, no impacts to floodplains would be expected.	N
Wetlands	It is likely that some POE will be located in the proximity of wetlands; however, since the HEXRIS will be deployed on existing developed surfaces, no impacts to wetlands would be expected.	N
Coastal Zones	Consistency determinations will be made in all cases where HEXRIS are deployed at POE that are located in coastal zones.	N
Vegetation and Wildlife	The Proposed Action will occur on previously developed surfaces that are designed for and currently utilized by cargo moving equipment. Sensitive vegetative and wildlife resources do not exist in these areas.	N
Threatened and Endangered Species	The Proposed Action will take place in developed, industrial areas where suitable wildlife habitat and species do not exist. The Proposed Action will have no effect on threatened or endangered species.	N

Air Quality	HEXRIS operations could result in increased air emissions from several sources, including the mobile HEXRIS diesel engine and onboard diesel generator. In addition, there could be small increases in idling and low speed emissions from vehicles being moved into scan areas. It is possible that the HEXRIS will be deployed to POE located in air quality "nonattainment" areas as defined by the Clean Air Act. Accordingly, an initial review, using worst-case assumptions, was conducted to estimate whether emissions resulting from HEXRIS operations for criteria air pollutants would reach levels requiring a conformity determination in accordance with 40 CFR 93.153. The results of these calculations are presented in Appendix A. The conclusion is that emission increases from the Proposed Action would be far below levels that would require a conformity determination. In terms of NEPA analysis, it is not expected that emissions from a single vehicle and generator would result in significant air impacts. In regions that have poor air quality, with large vehicle populations, it is impossible to accurately forecast impacts from small individual sources such as a single diesel vehicle. More important, state and federal efforts to improve air quality counterbalance minor increases in vehicle populations. In areas with good air quality, emissions from a single vehicle would not create noticeable, detrimental effects. There is some minor potential for cumulative effects, which is discussed in Chapter 4.	Y
Noise	The Proposed Action is consistent with other activities that occur at POE and will not measurably change the existing noise environment wherever the HEXRIS are located. As a result, the Proposed Action will not have a significant noise impact.	N
Land Use and Zoning	The Proposed Action is consistent with current land use and zoning practices at POE.	N
Aesthetics and Visual Resources	The Proposed Action would not obscure or result in abrupt changes to the complexity of the landscape and skyline when viewed from points readily accessible to the public at any POE. No long-term change to the character of the POE would occur as a result of the Proposed Action.	N

Infrastructure/Utilities	POE have pre-existing water and electrical services. The Proposed Action will not impact the infrastructure and utility services of the POE.	N
Traffic / Transportation	During the planning process for each NII system and prior to deployment, site surveys are conducted to ensure that the placement and operation of the systems is integrated with POE traffic patterns and facilities to minimize delays to the movement of vehicles and cargo.	N
Waste Management	Wastes associated with the Proposed Action are used oil and lubricants for the operation and maintenance of HEXRIS. These will be accumulated and stored in compliance with applicable regulations at or near the point of generation and recycled by a licensed used oil recycler. 40 CFR Part 279 exempts used oil and lubricants from regulation as a hazardous waste if they are recycled and not mixed with any other hazardous wastes. It is not anticipated that the operation and maintenance of the systems will generate amounts of hazardous wastes that would affect the current generator status of any POE. There is no radioactive source or byproduct material used in the systems, therefore there is no risk of a release of radioactive materials. HEXRIS might contain materials that could be hazardous if the materials are handled improperly. An example of such a material would be lead metal which is used for radiation shielding. As a system component, the lead will be innocuous and will provide a protective function from ionizing radiation. As a CBP asset, all materials within the system will be in use for their intended purpose, under the supervision of appropriately trained personnel. Under this scenario, there is no hazard to the human environment because the materials will be contained within the system as functional components of the system. In the event of an accident, hazardous materials would not be expected to cause any significant harm to the human environment, because the amount of materials is small, and most materials will be in solid form which would be readily contained and recovered. Accident response procedures are in place at each POE to contain and remove fluids such as lubricants and fuel. The most important action to ensure that hazardous materials have no significant effect on the human environment will be upon the replacement or	N

	decommissioning of a component or system. Appropriate disposition will depend upon type and quantity of materials involved and the applicable regulations. If a component is replaced or decommissioned, the handling, storage, use, transfer, and disposal of all materials will comply with applicable regulations. This will prevent human exposure and releases to the environment of any hazardous material.	
Historic and Archeological (Cultural) Resources	The HEXRIS will be deployed and operated in industrial settings where impacts to historic and cultural resources are not likely. A determination of effects will be made for each POE where HEXRIS are deployed and consultations will be made as appropriate in accordance with the National Historic Preservation Act.	N
Socioeconomics	The Proposed Action will not affect employment, housing or demographics. Implementation of the Proposed Action may produce indirect socioeconomic effects by deterring the movement of illicit drugs, explosives, firearms, or other contraband into the U.S. Similar indirect effects could result if the Proposed Action led to the apprehension of criminals or terrorists attempting to enter the U.S. Such effects, however, are only theoretical and will not be further evaluated in this document.	N
Environmental Justice	Implementation of the Proposed Action will not have any negative effect on minority and low-income populations or children.	N
Transboundary Impacts	Significant impacts have not been identified for any resource category reviewed in this PEA. The energy (rem) from ionizing radiation rapidly diminishes with distance, and would not cause transboundary impacts. No significant transboundary impacts will occur.	N
Irreversible and Irretrievable Commitment of Resources	The irreversible and irretrievable commitment of resources associated with the Proposed Action will be the procurement of the HEXRIS, materials, utilities, labor and time expended in the operation of the HEXRIS. No sensitive environmental resources will be lost or permanently altered due to the Proposed Action.	N
Radiological Health and Safety	X-radiation from the normal operation of HEXRIS has the potential to impact the health and safety of operators, officers, and the general public. Although exposures are expected to be well below the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) prescribed limits, further evaluation is warranted.	Y

3.2 Radiological Health and Safety

3.2.1 Criteria for Significance

Evaluation of the potential effect of radiation exposure on public safety is based on both the potential for an accident and the consequences of any project-related effect associated with normal operations. Beneficial impacts may result from any direct or indirect safety improvements due to project implementation. An alternative could have a significant impact if it would increase or decrease the risk of exposure of personnel or the public to radiation hazards.

3.2.2 Baseline Environment

3.3.2.1 Ionizing Radiation

Radiation is the most complex of all considerations pertaining to the operation of HEXRIS. The focus of this section, Radiological Health and Safety, is ionizing radiation. See Appendix B for background information on ionizing radiation.

HEXRIS employ advanced high energy digital X-ray imaging technology that has been used successfully in various industrial applications such as field inspection of structures like bridges and buildings. As radiation-producing devices, these systems are subject to review by radiation protection authorities. It should be noted that radiation equipment being operated by a federal agency is not subject to state regulation. Therefore, the information in this PEA related to the states' radiation regulations is for informational purposes only. Regulations that cover radiation related to the operation of the HEXRIS are discussed in detail in Appendix B.

During normal operating conditions, the affected environment includes the area surrounding the cargo containers being scanned by the HEXRIS. System operators and maintenance personnel, as well as people in the area around the systems, are the key component of this affected environment. For purposes of discussion, people are classified into two categories:

1. Maintenance personnel
2. General public (including system operators, truck drivers, POE personnel and other CBP personnel)

All maintenance personnel are employees of the equipment manufacturer. Due to the nature of their jobs, they have the potential to be exposed to a higher level of radiation than system operators and members of the general public.

For its officers, POE employees and truck drivers, CBP has adopted the same effective radiation dose standard that the Nuclear Regulatory Commission (NRC) prescribes for members of the general public, which is 0.1 rem in a year.

3.2.3 Potential Consequences

3.2.3.1 Proposed Action - Deployment and Operation of HEXRIS

3.2.3.1.1 Exposure Pathways

The radiation exposure pathway for all personnel and the general public is created from exposure to scattered radiation from the X-ray source during scanning operations. However, in all cases, the radiation dose will not exceed 0.1 rem in a year.

3.2.3.1.2 Normal Operations

3.2.3.1.2.1 Human Exposure

All maintenance personnel who maintain the linear accelerator (linac) and X-ray source components are employees of the equipment manufacturer. By the nature of their jobs, they have the potential to be exposed to a higher level of radiation than the system operators and members of the general public. Maintenance of the linac and X-ray source components will have to comply with the EPA, OSHA and states' (where applicable) strict dose standards for radiation workers. For a more detailed discussion of dose standards, see Appendix B.

HEXRIS are designed so that the radiation dose levels where members of the public will be, e.g. work-stations, operator control stations, and waiting areas, will be below the CBP prescribed limits of 0.1 rem in a year. Detailed radiation surveys, performed by or under the supervision of the CBP Radiation Safety Office, have confirmed that these design criteria have been met. In all cases, exposures were measured using a "worst-case" scatter in the X-ray beam. A worst-case scatter scenario is not likely to occur; therefore the estimated exposure levels are conservative by a substantial amount. As an additional precaution, as the HEXRIS are delivered, exposure measurements will be made to ensure that the systems are in compliance with exposure limits.

CBP has adopted the same effective radiation dose standard that the NRC and most states prescribe for members of the general public (i.e. 0.1 rem). CBP has adopted the NRC standard because the Occupational Safety and Health (OSH) Act only addresses occupational dose exposure limits. As defined by the International Commission on Radiological Protection (ICRP), CBP officers are "occupationally exposed," because their assigned duties involve exposure to radiation or to radioactive material (ICRP 2007). CBP has decided to limit the officers "occupational dose" to no more than that allowable for the general public.

This exposure limit applies to all CBP employees or contractors who work on or maintain HEXRIS, but not the linac or X-ray source components. This means that system operators are not exposed to a higher radiation dose than the standard established for the general public. For a more detailed discussion of dose standards, see Appendix B. Occupational exposure, to the effective radiation dose standard CBP has adopted, is not expected to cause a significant increase in the risk of cancer. For a more detailed discussion of information concerning risks from occupational radiation exposure, see Appendix C.

To meet the threshold radiation dose limit, CBP establishes controlled areas for HEXRIS. No personnel are allowed in the controlled areas during scanning operations. The Eagle® Mobile operates at 4.5 MeV. The safe operating dimensions of the controlled area are 108 feet in length and 142 feet in width, as depicted in Figure 6. The HCVM has two operational settings: 3.8 MeV and 4.2 MeV, with each operational setting having a specific controlled area which must be maintained during operation. System modes of operation are set based on the density of the walls of the containers scanned. In the event useful images are not acquired from an initial scan with the system set at 3.8 MeV, the HCVM can be operated at 4.2 MeV to obtain data from denser containers.

When operating at 3.8 MeV, the safe operating dimensions of the HCVM controlled area are 110 feet in length and 82 feet in width, as depicted in Figure 7. When operating at 4.2 MeV the safe operating dimensions are 135 feet in length and 133 feet in width, as depicted in Figure 8.

The controlled areas of mobile HEXRIS are moving footprints of specified dimensions. During an inspection process, the controlled area will be coincident with the movement of the HEXRIS. In the event other NII technologies are present at the POE, CBP will ensure that controlled areas for each technology are adequately designated and do not overlap with one another.

Two controlled areas will be established for each stationary (gantry) system, one at the entrance and one at the exit of each building. The dimensions for each controlled area are expected to be equal to the building width and extend from the ends of the gantry rails to the extent necessary to keep the radiation exposure below 0.00005 rem in any one hour (see Figure 9). The controlled area for individual systems may extend beyond the width of the building, depending upon site specific data. Controlled area dimensions will be verified for each system.

During scanning operations, signs in multiple languages are posted at the controlled area boundary indicating the radiation hazard. Ground guides, which are items such as jersey barriers, cones or other items or individuals (e.g. CBP RSO), who provide visual signals, are positioned at various locations around the controlled area to warn persons of the danger as well as provide visual references. Ground guides delimit the controlled area, as prescribed in Figures 6 through 9. Each system incorporates an infrared safety barrier that stops the forward movement of the inspection system, as well as, the production of X-rays should the beam barrier be broken.

In the extreme with respect to radiation exposure, a system operator (or a member of the general public) could be situated at the edge of a controlled area 8 hours a day, every workday of the year (that is to say, 2,000 hours per year) and not receive more exposure than the limits prescribed by the NRC and the states. The controlled areas ensure that the systems conform to the radiation protection guidelines of reducing the radiation levels to As Low as is Reasonably Achievable (ALARA).

ALARA is defined in 10 CFR 20.1003 as: *"…means making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest."* In addition, 10 CFR 20.1101(b) requires that: *"[t]he licensee shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA)."*

Controlled areas are calculated and verified for each NII system and are designed to provide adequate separation from other NII operating areas, adjacent structures, work areas and traffic flows to protect workers, the general public and occupants of adjacent buildings. Controlled area dimensions may be adjusted when needed by using cargo containers as a backstop, or by using masonry walls. When adjustments in the radiation controlled area are required or requested, the CBP RSO will be consulted in order to maintain the radiation exposure limit of 0.00005 rem in any one hour limit and 0.1 rem per year.

Analysis and testing for this PEA shows that exposures are expected to be well below the maximum levels of exposure set by the NRC, OSHA, Food and Drug Administration (FDA) and the states to protect the general public (which includes system operators, truck drivers, POE personnel and other CBP personnel); therefore, the health and safety impacts from radiological exposure for the Proposed Action were found to not be significant.

3.2.3.1.2.2 Effects of Irradiation on Food

The CBP Radiation Safety Office has conducted tests to determine the worst-case scenario of radiation doses to food as a result of implementing the Proposed Action. The total absorbed dose deposited in food subjected to scanning by a HEXRIS operating at 6.0 MeV (worst case, gantry system) is approximately 0.0015 rem per scan, on the same order as that received by a person hidden in a cargo container. This dose is 240 times less than the average annual background dose in the U.S. of 0.360 rem.

The FDA at 21 CFR 179.21 requires a label be affixed to each machine stating that no food shall be exposed to X-ray radiation sources to receive an absorbed dose in excess of 50 rem. The HEXRIS absorbed dose is approximately 33,333 times less than this limit.

3.2.3.1.2.3 Maintenance

CBP personnel will not perform any maintenance of the linac or the X-ray source enclosure. CBP personnel will periodically perform maintenance of the detectors and test the systems using procedures described in the operator's manuals. Non-routine linac and X-ray source maintenance will be performed by the manufacturers.

3.2.3.1.2.4 Radiation Safety Engineering Controls

HEXRIS incorporate redundant safety controls, such as emergency stop buttons, at several locations on the systems that allow the system, including X-ray production, to be quickly shut down, if necessary. In addition, the personnel assigned to operate the systems will be specifically trained for safe X-radiation system operations according to standards established by CBP's Office of Training and Development. Training for the system operators will consist of lectures, courses and a written examination in basic radiation physics, radiation safety, biological effects of radiation, instrumentation, radiation control, and operating procedures during normal and emergency conditions.

3.2.3.1.3 Abnormal Events

3.2.3.1.3.1 Effects of Irradiation on Persons Hiding in Cargo Containers

As stated in section 3.2.3.1.2.1 (Human Exposure), the NRC has established the maximum allowable value of radiation dose that may be received by individuals (individual members of the general public) to be 0.1 rem in a year. Most state regulations also adopt this same standard.

It is possible that people will hide themselves in cargo containers in order to surreptitiously enter the U.S. A person concealed in a cargo container that is scanned by a HEXRIS will be exposed to X-radiation as a direct consequence of the inspection process.

The CBP RSO has conducted testing to determine the dose that a person hidden in a truck or cargo container would experience during a scanning operation. The total absorbed dose from a system operating at 6.0 MeV (worst case, gantry system) is approximately 0.0015 rem per scan, on the same order of that received by food. This dose is 240 times less than the average annual background dose in the U.S. of 0.360 rem and 66 times below levels permissible to the general public. Neither cargo container drivers nor any other personnel pass through the beam during scanning operations.

Assuming 0.0015 rem per scan, to reach the maximum allowable "in a year" radiation dose, a person would have to be scanned over 66 times in a year. Since the chance of this frequency of exposure is remote, it is concluded that radiation from the HEXRIS will not have a significant impact on persons located in scanned cargo containers.

3.2.3.1.4 Best Management Practices and Mitigation Measures for Radiological Health and Safety

Best management practices for radiological health and safety include but are not limited to:

- Incorporation of safety warnings and precautions into technical manuals and operator manuals.

- Training of operators and scanning operations supervisors in the hazards associated with radiation producing equipment.
- Incorporation of emergency stop buttons on the equipment that allow the system, including X-ray production, to be quickly shut down if necessary.
- Training operators and scanning operations supervisors in the location and use of emergency stop buttons.
- The establishment of radiation controlled areas during scanning operations.

The combination of these precautions will ensure that the cumulative radiation dose to CBP officers and the general public will not exceed 0.00005 rem in any one hour or 0.1 rem per year.

3.3.3.2 No Action Alternative

Under the No Action Alternative, the inspection process at the POE will continue to be conducted with current techniques and equipment, including other NII technology and visual and manual inspections to detect contraband. Persons entering the U.S. hidden in cargo containers would not be exposed to radiation levels above those that are naturally occurring if the No Action Alternative is implemented.

Alternatively, contraband that HEXRIS are designed to detect could pass through sea and land POE unnoticed. As a consequence, there would be no health, public safety or environmental benefits to society that could theoretically result from intercepting a higher percentage of contraband at the U.S. border. Moreover, CBP officers would continue to engage in the same rate of potentially risky inspections of confined spaces to intercept contraband and prevent illegal entry into the U.S.

4 Cumulative Impacts

The CEQ regulations stipulate that the cumulative effects analysis in an environmental assessment should consider the potential environmental impacts resulting from "the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions" 40 CFR 1508.7. Recent CEQ guidance addressing cumulative effects affirms this requirement, stating that the first steps in assessing cumulative effects involves defining the scope of the other actions and their interrelationship with the Proposed Action (CEQ 1997). The scope must consider other projects that coincide with the location and timetable of the Proposed Action and other actions. Cumulative effects analysis must also evaluate the nature of interactions among these actions.

This PEA identifies actions that are being considered and are in the planning phase at this time that could affect the area in the vicinity of the proposed HEXRIS. To the extent that details regarding such actions exist and the actions have a potential to interact with the Proposed Action in this PEA, these actions are included in this cumulative analysis. This approach enables decision-makers to have the most complete information available so that they can evaluate the environmental consequences of a Proposed Action in relation to other projects that may affect the same region of influence.

4.1 Past and Present Actions Relevant to the Proposed Action and Alternative

CBP presently operates, or plans to operate in the near future, other NII technologies suited to the various inspection needs at different POE throughout the U.S. and Puerto Rico. As the HEXRIS are deployed, cumulative emission estimates for other NII will be made, based on similar assumptions as the HEXRIS (Appendix A) and the processing speeds of each system. Cumulative controlled area dimensions will also be evaluated as the systems are deployed.

4.2 Reasonably Foreseeable Actions that Could Interact with the Proposed Action and Alternative

It is likely that future projects at various POE would be expected to improve the efficiency of the movement of traffic through POE and therefore reduce air quality impacts related to POE operations. Alternatively, this could be counterbalanced by an increase in trade between the U.S. and neighboring countries, such as Canada and Mexico, leading to increased numbers of trucks moving through the POE, with increased emissions. Other national factors, such as more stringent emissions controls on diesel engines or an increase in fuel costs, will also effect vehicle emissions and the number of vehicle miles driven.

4.3 Summary of Cumulative Effects

The potential for cumulative impacts resulting from the actions described above when combined with the Proposed Action in this PEA are summarized here. The scope is limited to air quality and radiological health and safety. Since the Proposed Action will have no impact on the resources that were determined to be unaffected in Chapter 3 by the Proposed Action, they would not contribute to cumulative impacts either.

4.3.1 Air Quality

Past, present and foreseeable actions in different states and regions related to air quality will likely result in the control and/or reduction of emissions and improvement of air quality at the different POE. Planned expansions of the POE and potential additions of NII systems could result in additional emissions in the future. However, this will take place in the context of ongoing emissions reductions efforts and other state and federal regulatory actions. Therefore, future growth at the POE and NII deployments are not expected to result in significant, cumulative air quality effects.

4.3.2 Radiological Health and Safety

NII equipment has little potential to create cumulative health impacts under normal operating conditions when it is used for its intended purpose by qualified personnel under the supervision of a RSO in accordance with applicable heath and safety regulations.

Controlled areas are calculated and verified for each NII system and are designed to provide adequate separation from other NII operating areas, adjacent structures, work areas and traffic flows to protect workers, the general public and the contents of adjacent buildings. Limiting access to the controlled areas, and preventing overlap of these areas, ensures that the public (which includes system operators and POE personnel) is not exposed to cumulative radiation levels exceeding those prescribed by state and federal regulations (see Appendix B and Appendix C).

5 Findings and Conclusions

5.1 Environmental Consequences of the Proposed Action and Alternatives

This PEA examined potential effects to the human environment, as defined in NEPA, from the deployment of HEXRIS at different sea and land POE in the U.S. and Puerto Rico. As indicated in the impact matrix in Chapter 3, impacts to most natural resources would not be expected due to the fact that this NII equipment is being deployed in heavily impacted industrial areas where sensitive resources do not exist. Two resource categories were evaluated in greater detail, air quality and radiological health and safety. Detailed analysis of these resource areas indicates that impacts would not be expected as long as identified mitigation measures are followed. Accordingly, the analysis presented herein demonstrates that the Proposed Action, deployment and operation of HEXRIS at sea and land POE in the U.S. and Puerto Rico, will result in no significant impacts to the human environment.

5.2 Summary of Mitigation Actions Planned

Mitigation Measures for Air – To reduce emissions from the Proposed Action, trucks waiting for the inspection of containers by HEXRIS will follow applicable regulations regarding the control of idling times. The mobile HEXRIS are 2006-2007 model vehicles that include the Best Available Control Technology as defined by the U.S. EPA.

Mitigation Measures for Wastes – Petroleum, oils, and lubricants will be stored, handled, and disposed of in compliance with applicable laws and regulations. Procedures for the safe refueling of mobile HEXRIS and for the containment and clean-up of potential spills will be in accordance with existing POE procedures for preventing and controlling releases. CBP personnel will be trained in spill prevention and countermeasures as required by the Resource Conservation and Recovery Act (RCRA) (42 U.S.C. §6901, *et seq.*) and the Oil Pollution Act of 1990 (OPA) (33 U.S.C §2701 *et seq.*)

Mitigation Measures for Radiological Health and Safety – Mitigation measures for radiological health and safety include but are not limited to:

- Incorporation of safety warnings and precautions into technical manuals and operator manuals.
- Training of operators and supervisors in the hazards associated with radiation producing equipment.
- Incorporation of emergency stop buttons on the equipment.
- Training operators and supervisors in the location and use of emergency stop buttons.
- The establishment of radiation controlled areas during scanning operations.

The combination of these precautions will ensure that the cumulative radiation dose to officers and the general public will not exceed 0.00005 in any one hour, or 0.1 rem cumulatively in a year.

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8 Acronyms and Abbreviations

^{137}Cs	Cesium 137
^{60}Co	Cobalt 60
ALARA	As Low As is Reasonably Achievable
BEIR	Biological Effects of Ionizing Radiation
CAA	Clean Air Act
CBP	Customs and Border Protection
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO	Carbon Monoxide
CSI	Container Security Initiative
dB	Decibel
dBA	Audio decibel
DHS	Department of Homeland Security
DOT	Department of Transportation
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
Erg	An erg is a small but measurable amount of energy
FDA	Food and Drug Administration
FONSI	Finding of No Significant Impact
FR	Federal Register
Gy	Gray
HEXRIS	High Energy X-Ray Inspection System
HDDV	Heavy Duty Diesel Vehicle
HP	HorsePower
Hr	Hour
H_T	Dose equivalent
Hz	Hertz
ICRP	International Commission on Radiological Protection
lb	Pounds
Ldn	Day-Night average sound level
Linac	linear accelerator
MeV	Million Electron Volts
mrad	millirad
mrem	millirem
NAA	Nonattainment Area
NAAQS	National Ambient Air Quality Standards
NCRP	National Council on Radiation Protection
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NII	Non-Intrusive Inspection
NOA	Notice of Availability
NOI	Notice of Intent
NOx	Nitrogen Oxides

NRC	Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
O_3	Ozone
ONDCP	Office of National Drug Control Policy
OSH Act	Occupational Safety and Health Act
OSHA	Occupational Safety and Health Administration
PEA	Programmatic Environmental Assessment
PM_{10}	Particulate matter 10 micrometers or smaller in diameter
rad	Radiation Absorbed Dose
rem	Roentgen Equivalent Man
RPM	Revolutions Per Minute
RSO	Radiation Safety Officer
SAFE	Security and Accountability for Every (i.e. SAFE Port Act of 2006)
SCAQMD	South Coast Air Quality Management District
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SOx	Sulfur Oxides
Sv	sievert
TEDE	Total Effective Dose Equivalent
µrad	microrad
µrem	microrem
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
U.S.C.	United States Code
VOC	Volatile Organic Compounds

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Appendix A: Air Quality Analysis

This analysis considers operational impacts to local and regional air quality that could result from implementation of the Proposed Action.

Construction Emissions

Construction of stationary gantry HEXRIS will create a minor source of temporary emissions that could affect local air quality. The quantity of emissions from proposed construction operations is estimated here using the South Coast Air Quality Management District's (SCAQMD) guidance document, "Sample Construction Scenarios for Projects Less than Five Acres in Size." This guidance provides emission estimate examples for 1, 2, 3, 4, and 5 acre construction sites that may be used to approximate emissions for planned projects based on SCAQMD's quantification of typical construction phase durations and equipment populations. Approximation may be made by direct application of the most appropriate example, modification of the appropriate example's conditions (e.g. duration of tasks, equipment populations) and/or use of linear regression to calculate emissions estimates for variable project sizes. Linear regression of the total emissions data from the five examples was used to estimate total construction emissions for the Proposed Action.[1] Given a project size of 0.26 acres, which is the approximate size anticipated for construction of stationary HEXRIS, construction related emissions would result in: 37.0 pounds carbon monoxide (CO), 83.9 pounds nitrogen oxides (NOx), 4.80 pounds of particulate matter 10 micrometers or smaller in diameter (PM_{10}) and 4.42 pounds of particulate matter 2.5 micrometers or smaller in diameter ($PM_{2.5}$).

Idling Emissions

The Environmental Protection Agency (EPA) has determined that for analysis not requiring detailed specific emission estimates tailored to local conditions, the summary of idle emission factors contained in EPA420-F-98-014 can be used to obtain first-order approximations of emissions under idling conditions (e.g., drive-thru lanes). Emissions for mobile and stationary gantry systems are summarized below in Table 2.

Mobile HEXRIS Operations

The engine type to be used on the mobile HEXRIS is the International DT570 medium duty diesel engine with an average horsepower (HP) rating of 285 HP at 2,200 revolutions per minute (RPM). Designated as a clean fuel fleet vehicle/low emissions vehicle, all engine types meet the EPA Tier 3 requirements for emissions. The onboard generators are approximately equivalent to the Martin Diesel 35.2 kilowatt, 61.2 HP at 1,800 RPM. The generators are certified to be compliant with EPA Tier 2 emission requirements.

Emission estimates for mobile HEXRIS assumes the systems and the diesel powered generators will be operated 16 hours per day, 365 days per year and the systems will be continuously

[1] Demolition emissions were removed from the examples because the Proposed Action does not include any demolition and will occur on developed surfaces.

idling, or scanning cargo containers at a speed of less than 0.5 miles per hour. Emission estimates for vehicles that will be inspected assume that each mobile system processes an average of 20 vehicles per hour (i.e. processing time equals 3 minutes per vehicle and each system processes 320 vehicles per day).

Stationary Gantry HEXRIS Operations

Gantry HEXRIS do not produce emissions; however operations may result in increased emissions due to idling of queued vehicles awaiting inspection. Emissions estimates for the systems assume that they will be operated 16 hours per day, 365 days per year, each system processes 20 vehicles per hour (i.e. processing time equals 3 minutes per vehicle and each system processes 320 vehicles per day); and, the average idling time would be increased by 5 minutes per vehicle (i.e. the total idling time per vehicle is 3 + 5 = 8 minutes per vehicle).

Table 2: Emissions Estimate from Proposed, HEXRIS Operations

Source	NOx (tons/yr)	VOC (tons/yr)	CO (tons/yr)	PM_{10} (tons/yr)	$PM_{2.5}$ (tons/yr)
Mobile HEXRIS Operations	6.84	0.769	3.42	0.455	0.419
Gantry HEXRIS Operations	0.959	0.215	1.62	0.0445	0.0411

[1]Emission factor source for vehicles, "Idling Vehicle Emissions" (EPA 1998). Average of winter and summer factors for HDDV were used
[2]Emission factor source for generators, AP 42, Fifth Edition, Volume I, Chapter 3, Gasoline and Diesel Industrial Engines (EPA 1996).
[3]Final PM2.5 Calculation Methodology and PM2.5 Significance Thresholds, South Coast Air Quality Management District. October 2006.

Tables 3 and 4 compare the data presented in above in Table 2 with the conformity criteria that are applicable to non-attainment and maintenance areas. This comparison shows that the estimated yearly emissions attributable to HEXRIS operations are well below the allowable limits set in 40 CFR Part 93.153, Determining Conformity of Federal Actions to State or Federal Implementation Plans (the rule). The rule applies to those federal actions that are located in areas of non-attainment of the NAAQS.

Table 3: Conformity Criteria for Nonattainment Areas

	Tons/year
Ozone (VOC or NOX):	
Serious NAA……………………………………………	50
Severe NAA……………………………………………	25
Extreme NAA…………………………………………	10
Other ozone NAA outside an ozone transport region………………………………………………	100
Other ozone NAA inside an ozone transport region:	
VOC……………………………………………………	50
NOX……………………………………………………	100
Carbon monoxide: All NAA…………………………	100
SO2 or NO2: All NAA………………………………	100
PM10:	
Moderate NAA………………………………………	100
Serious NAA……………………………………………	70
PM2.5:	
Direct emissions………………………………………	100
SO2……………………………………………………	100
NOX (unless determined not to be a significant precursor)……………………………………………	100
VOC or ammonia (if determined to be significant precursors)……………………………………………	100
Pb: all NAA……………………………………………	25

40 CFR 93.153

Table 4: Conformity Criteria for Maintenance Areas

	Tons/year
Ozone (NOX, SO2 or NO2):	
All maintenance areas..	100
Ozone (VOC):	
Maintenance areas inside an ozone transport Region..	50
Maintenance areas outside an ozone transport Region..	100
Carbon monoxide: all maintenance areas....................	100
PM10: all maintenance areas…...................................	100
PM2.5:	
Direct emissions...	100
SO2..	100
NOX (unless determined not to be a significant precursor)...	100
VOC or ammonia (if determined to be significant precursors)...	100
Pb: all maintenance areas...	25

40 CFR 93.153

Conclusion

All emission levels from the activities associated with the HEXRIS are below the tons/year *de minimis* threshold values applicable to nonattainment and maintenance areas for all pollutants as specified in 40 CFR 93.153(b)(1)(2). Therefore it is not anticipated that deployment and operation of a HEXRIS at a sea or land POE will cause an exceedance of any NAAQS for criteria pollutants. The Proposed Action will not conflict with conformity requirements of section 176 of the Clean Air Act for federal actions or any approved SIP. The Proposed Action will not have a significant impact on local or regional air quality within the context of the Clean Air Act or NEPA.

Appendix B: Background Information on Ionizing Radiation

The background material contained in this appendix is an excerpt of information found in National Council on Radiation Protection and Measures (NCRP) *Uncertainties in Fatal Cancer Risk Estimates Used in Radiation Protection, NCRP Report Number 126*, and is intended to provide the user with the best available background and regulatory information on ionizing radiation.

- ## Measurement of Radiation Dose

Radiation is measured using units that people seldom encounter. It is important to relate the amount of radiation received by the body to its physiological effects. Two terms used to relate the amount of radiation received by the body are "absorbed dose" and "dose equivalent."

Absorbed dose means the energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray (Gy).

The term "rad" (radiation absorbed dose) is the special unit of absorbed dose of 100 ergs per gram. Different materials that receive the same exposure may not absorb the same amount of energy. The rad is the basic unit of the absorbed dose of radiation (i.e., alpha, beta, gamma, and neutron) to the energy they impart in materials. The dose of one rad indicates the absorption of 100 ergs (an erg is a small but measurable amount of energy) per gram of absorbing material. To indicate the dose an individual receives in the unit rad, the word "rad" follows immediately after the magnitude, for example "50 rad." One thousandth of a rad (millirad) is abbreviated "mrad," and one millionth of a rad (microrad) is abbreviated "μrad."

Dose equivalent (H_T) means the product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv). At the present time, rem is used in the U.S. while sieverts are used internationally. Eventually, the U.S. will adopt these international terms.

The term "rem" (Roentgen equivalent man) is a special unit used for expressing dose equivalent. Some types of radiation produce greater biological effects for the same amount of energy imparted than other types. The rem is a unit that relates the dose of absorbed radiation to the biological effect of that dose. Therefore, to relate the absorbed dose of specific types of radiation, a "quality factor" must be multiplied by the dose in rad. To indicate the dose an individual receives in the unit rem, the word "rem" follows immediately after the magnitude, for example "50 rem." One thousandth of a rem (millirem) is abbreviated "mrem," and one millionth of a rem (microrem) is abbreviated "μrem." The quality factor allows for the effect of higher energy deposition along particle tracks produced by various radiation types such as neutrons or alpha particles.

Regulations Covering Radiation Dose

Regulations pertaining to radiation exposure are administered by many different federal and state agencies under a variety of legislative authorities.

- **Nuclear Regulatory Commission (NRC) (10 CFR Part 20)**

The Nuclear Regulatory Commission (NRC) promulgates regulations and establishes standards for protection against radiation arising out of activities conducted under licenses issued by the Commission. NRC regulations control the receipt, possession, use, transfer, and disposal of licensed material by any licensee. CBP currently holds an NRC Materials License for ^{137}Cs/ ^{60}Co sealed sources. The HEXRIS do not require source or byproduct material for their operation; therefore these regulations do not apply. However, as discussed above, CBP uses the levels provided by the NRC as a conservative approach for limiting radiation exposure by the systems.

- **Occupational Safety and Health Administration (OSHA) (29 CFR 1910.1096)**

OSHA regulations establish standards for protection against ionizing radiation that result in an occupational risk, but do not regulate the safety of licensed radioactive materials.

- **Food and Drug Administration (FDA) (21 CFR 1020) Performance Standards for Ionizing Radiation Emitting Products)**

The Food and Drug Administration (FDA) promulgates regulations and establishes standards for the protection against radiation by setting performance standards that manufacturers of ionizing radiation emitting products must meet.

- **Environmental Protection Agency (EPA) (Radiation Protection Guidance to Federal Agencies for Occupational Exposure FR 52 2822 January 27, 1987)**

Federal radiation exposure protection guidance for occupational exposure is defined in *Radiation Protection Guidance to Federal Agencies for Occupational Exposure.* Administered by the EPA, the guidance was developed cooperatively by the Nuclear Regulatory Commission, the Occupational Safety and Health Administration, the Mine Safety and Health Administration, the Department of Defense, the Department of Energy, the National Aeronautics and Space Administration, the Department of Commerce, the Department of Transportation, the Department of Health and Human Services, and the Environmental Protection Agency. The guidance provides general principles, and specifies the numerical primary guides for limiting worker exposure. It applies to all workers who are exposed to radiation in the course of their work, either as employees of institutions and companies subject to federal regulation or as federal employees. It is expected that individual federal agencies, on the basis of their knowledge of specific worker exposure situations, will use the guidance as the basis upon which to revise or develop detailed standards and regulations to the extent that they have regulatory or administrative jurisdiction.

- **State Regulations**

Many states have adopted regulations modeled on the *Suggested State Regulations for Control of Radiation.*

Without Congressional expression that sovereign immunity is waived, a federal agency would not be subject to these state regulations. Most states implicitly recognize this in their regulations, which provide state regulators with the authority to enter premises to enforce the radiation control law, not to enter the areas under federal jurisdiction unless the federal government concurs.

Regulatory Jurisdiction

As it applies to the operation of HEXRIS, the applicable regulations are FDA [21 CFR Part 1020] and OSHA [29 CFR 1910.1096].

- The NRC Guidance provided in 10 CFR Part 20 Standards for Protection Against Radiation apply to persons licensed by the Commission to receive, possess, use , transfer, or dispose of byproduct, source, or special nuclear material or to operate a production or utilization facility.
- The EPA guidance provided in FR 52 2822, *Radiation Protection Guidance to Federal Agencies for Occupational Exposure,* is to be used as the basis upon which individual federal agencies revise or develop detailed standards and regulations to the extent that they have regulatory or administrative jurisdiction.

Dose Limits

Dose limits represent the upper bound limit below which risks from radiation exposure are deemed to be acceptable. Various federal and state regulations establish dose limits for occupational exposures that occur as a result of a person's employment, and limits for the total exposures received by the public in general.

In 10 CFR Part 20, the NRC identifies two classifications of radiation dose to people. The first classification, "occupational dose," is the ":

> *…dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released under §35.75, from voluntary participation in medical research programs, or as member of the public."*

The individuals subject to the occupational dose classification must closely monitor their degree of radiation exposure using dosimeters. The annual occupational dose limit for adults shall not exceed whichever is the more limiting of: a) a total effective dose equivalent of 5 rem; or b) the sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rem.

The second radiation dose classification, "public dose," is the ":

> *…dose received by a member of the public from exposure to radiation or to radioactive material released by a licensee, or to another source of radiation under the control of a licensee. Public dose does not include occupational dose or doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released under §35.75 or from voluntary participation in medical research programs."*

The total effective dose equivalent to individual members of the general public from the licensed operations shall not exceed 0.1 rem in a year. A summary of pertinent dose limits is presented below in Table 5.

Table 5: Summary of Regulatory Dose Limits

Dose Limit by Agency and Regulation (rem in a year)			
	NRC 10 CFR 20	**EPA 52 FR 2822**	**OSHA 29 CFR 1910.1096**
"Occupational Dose" = "Radiation Workers" in "Restricted Areas"			
Whole Body	5	5	5 (1.25 rem/calendar quarter)
Lens of Eye	15	15	5 (1.25 rem/calendar quarter)
Skin, Hands and Feet	50	50	
Skin of Whole Body			30 (7.5 rem/calendar quarter)
Hands and forearms; feet and ankles			75 (18.75 rem/calendar quarter)
Minors	10% of above limits	10% of above limits	10% of above limits
Pregnant Women [a]	10% of above limits	10% of above limits	Not Addressed
"Non-Occupational Dose" = "Controlled Area"			
Member of the General Public	0.1 rem in a year	Not Addressed	Not Addressed
Radiation Levels in Unrestricted (Uncontrolled) Areas			
Member of the General Public	0.002 rem in any one hour		Not Addressed

[a] Applicable period is nine months, or during the entire length of the pregnancy, rather than 1 year.

Although OSHA subscribes to dose limits set in NRC regulations, EPA guidance, and various consensus standards, they have not incorporated these limits into 29 CFR 1910.1096. The NRC regulations incorporate the most recent guidance from the International Commission on Radiological Protection (ICRP) as well as the National Council on Radiation Protection and Measurements (NCRP).

Radiation Protection Principles

In the United States and most other countries, three basic principles have governed radiation protection of workers and members of the general public:

1. Any activity involving occupational exposure should be useful enough to society to warrant the exposure of the worker. This same principle applies to virtually any human endeavor that involves some risk of injury.
2. For justified activities, exposure of the work force should be as low as reasonably achievable (ALARA).
3. To provide an upper limit on risk to individual workers, "limitation" of the maximum allowed dose is required. This is required above the protection provided by the first two principles because their primary objective is to minimize the total harm from occupational exposure to the entire work force; they do not limit the way that harm is distributed among individual workers.

As Low as is Reasonably Achievable (ALARA)

"As Low as is Reasonably Achievable" (ALARA) means making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical, consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest. This common sense approach means that radiation doses for both workers and the general public are typically kept lower than their regulatory limits.

The principle reduction of exposure to levels that are "as low as is reasonably achievable" is typically implemented in four different ways.

1. Shielding of the source holder.
2. Selection of as small of an amount of source material as is needed.
3. Designing facilities to reduce the anticipated exposure.
4. Designing work practices to reduce the anticipated exposure.

Effective implementation of the ALARA principle involves most facets of an effective radiation protection program: education of workers concerning the health risks of exposure to radiation;

training in regulatory requirements and procedures to control exposure; monitoring, assessment and reporting of exposure levels and doses; and management and supervision of radiation protection activities, including the choice and implementation of radiation control measures.

A comprehensive radiation protection program will also include, as appropriate: properly trained and qualified radiation protection personnel; adequately designed, operated and maintained facilities and equipment; and quality assurance and audit procedures.

Customs and Border Protection Dose Limits

In conformance with ALARA principles, CBP has adopted for its workers the same dose limit as the NRC and many states prescribe for the general public – 0.1 rem in a year. As a result, CBP establishes a controlled area around HEXRIS as described in the section 3.2.3.1.2.1 (Human Exposure) to equally protect the general public and CBP personnel from radiation emissions in accordance with the maximum dose permitted under 10 CFR 20. CBP has taken care to model and explore potential exposure to employees working around these systems, and has even made measurements if someone were to be scanned by this or other NII systems. See "Radiation Dose Equivalent to Stowaways in Vehicles," Khan, et al, Health Physics Journal, Volume 86, No. 5, p. 483, May 2004.

Health Risks

In their August 2004 revised position statement on radiation risk, the Health Physics Society recommended against the quantitative estimation of health risks below an individual dose of 5 rem in a year or a lifetime dose of 10 rem above that received from natural sources. Doses from natural background radiation in the U.S. average about 0.360 rem per year. Estimation of health risks associated with radiation doses that are of similar magnitude as those received from natural sources should be strictly qualitative and encompass a range of hypothetical health outcomes, including the possibility of no adverse health effects at such low levels.

The Society further states "While there is substantial and convincing scientific evidence for health risks following high-dose exposures, below 5-10 rem (which includes occupational and environmental exposures), risks of health effects are either too small to be observed or nonexistent."

The Society has concluded that estimates of risk should be limited to individuals receiving a dose of 5 rem in any one year or a lifetime dose of 10 rem in addition to natural background. Below these doses, risk estimates should not be used. Expressions of risk should only be qualitative, that is, a range based on the uncertainties in estimating risk (NCRP 1997) emphasizing the inability to detect any increased health detriment (that is zero health effects is a probable outcome).

Appendix C: Background Information Concerning Risks from Occupational Radiation Exposure

The background material contained in this appendix is excerpted of from the U.S. Nuclear Regulatory Commission Regulatory Guide 8.29, "Instruction Concerning Risks From Occupational Radiation Exposure," February 1996 and the Health Physics Society "Radiation Basics" http://www.hps.org/publicinformation/ate/faqs/radiation.html. This material is intended to provide the user with the best available information about the health risks from occupational exposure to ionizing radiation. Ionizing radiation consists of energy or small particles, such as gamma rays and beta and alpha particles, emitted from radioactive materials, which can cause chemical or physical damage when they deposit energy in living tissue. A question and answer format is used. Many of the questions or subjects were developed by the NRC staff in consultation with workers, union representatives and licensee representatives experienced in radiation protection training.

How Is Radiation Measured?

In the United States, radiation dose or exposure is measured in units called rad, rem, or roentgen(R). For practical purposes with gamma and X-Rays, these are considered equal: 1 R = 1 rad = 1 rem.

Milli (m) means 1/1000. For example, 1,000 mrad = 1 rad. Micro (μ) means 1/1,000,000. So, 1,000,000 μrad = 1 rad, or 10 μR = 0.000010 R.

The International System of Units (SI system) for radiation measurement use "gray" and "sievert."
1 Gy = 100 rad
1 mGy = 100 mrad
1 Sv = 100 rem
1 mSv = 100 mrem

Is It Safe To Be Around Sources Of Radiation?

A single high-level radiation exposure (i.e., greater than 10,000 mrem) delivered to the whole body over a very short period of time may have potential health risks. From follow-up of the atomic bomb survivors, we know acutely delivered very high radiation doses can increase the occurrence of certain kinds of disease (e.g., cancer) and possibly negative genetic effects. To protect the public and radiation workers (and environment) from the potential effects of chronic low-level exposure (i.e., less than 10,000 mrem), the current radiation safety practice is to prudently assume similar adverse effects are possible with low-level protracted exposure to radiation. Thus, the risks associated with low-level medical, occupational, and environmental radiation exposure are conservatively calculated to be proportional to those observed with high-level exposure. These calculated risks are compared to other known occupational and environmental hazards, and appropriate safety standards and policies have been established by international and national radiation protection organizations (e.g., International Commission on Radiological Protection and National Council on Radiation Protection and Measurements) to control and limit potential harmful radiation effects.

Both public and occupational regulatory dose limits are set by federal agencies (i.e., Environmental Protection Agency, Nuclear Regulatory Commission, and Department of Energy) and state agencies (e.g., agreement states) to limit cancer risk. Other radiation dose limits are applied to limit other potential biological effects with workers' skin and lens of the eye.

Annual Radiation Dose Limits	**Agency**
Radiation Worker - 5,000 mrem	(NRC, "occupationally" exposed)
General Public - 100 mrem	(NRC, member of the public)
General Public - 25 mrem	(NRC, D&D all pathways)
General Public - 10 mrem	(EPA, air pathway)
General Public - 4 mrem	(EPA, drinking-water pathway)

What Is Meant By Health Risk?

A health risk is generally thought of as something that may endanger health. Scientists consider health risk to be the statistical probability or mathematical chance that personal injury, illness, or death may result from some action. Most people do not think about health risks in terms of mathematics. Instead, most of us consider the health risk of a particular action in terms of whether we believe that particular action will, or will not, cause us some harm. The intent of this appendix is to provide estimates of, and explain the basis for, the risk of injury, illness, or death from occupational radiation exposure. Risk can be quantified in terms of the probability of a health effect per unit of dose received.

When X-Rays, gamma rays, and ionizing particles interact with living materials such as our bodies, they may deposit enough energy to cause biological damage.

Radiation can cause several different types of events such as the very small physical displacement of molecules, changing a molecule to a different form, or ionization, which is the removal of electrons from atoms and molecules. When the quantity of radiation energy deposited in living tissue is high enough, biological damage can occur as a result of chemical bonds being broken and cells being damaged or killed. These effects can result in observable clinical symptoms.

The basic unit for measuring absorbed radiation is the rad. One rad (0.01 gray in the International System of units) equals the absorption of 100 ergs (a small but measurable amount of energy) in a gram of material such as tissue exposed to radiation. To reflect biological risk, rads must be converted to rems. The new international unit is the sievert (100 rem = 1 Sv). This conversion accounts for the differences in the effectiveness of different types of radiation in causing damage. The rem is used to estimate biological risk. For beta and gamma radiation, a rem is considered equal to a rad.

What Are The Possible Health Effects Of Exposure To Radiation?

Health effects from exposure to radiation range from no effect at all to death, including diseases such as leukemia or bone, breast and lung cancer. Very high (100s of rads), short-term doses of radiation have been known to cause prompt (or early) effects, such as vomiting and diarrhea, skin burns, cataracts and even death. It is suspected that radiation exposure may be linked to the potential for genetic effects in the children of exposed parents. Also, children who were exposed to high doses (20 or more rads) of radiation prior to birth (as an embryo/fetus) have shown an increased risk of mental retardation and other congenital malformations. These effects (with the exception of genetic effects) have been observed in various studies of medical radiologists, uranium miners, radium workers, radiotherapy patients and the people exposed to radiation from atomic bombs dropped on Japan. In addition, radiation effects studies with laboratory animals, in which the animals were given relatively high doses, have provided extensive data on radiation-induced health effects, including genetic effects.

It is important to note that these kinds of health effects result from high doses, compared to occupational levels, delivered over a relatively short period of time.

Although studies have not shown a consistent cause-and-effect relationship between current levels of occupational radiation exposure and biological effects, it is prudent from a worker protection perspective to assume that some effects may occur.

Who Developed Radiation Risk Estimates?

Radiation risk estimates were developed by several national and international scientific organizations over the last 40 years. These organizations include the National Academy of Sciences (which has issued several reports from the Committee on the Biological Effects of Ionizing Radiations, BEIR), the National Council on Radiation Protection and Measurements (NCRP), the International Commission on Radiological Protection (ICRP), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Each of these organizations continues to review new research findings on radiation health risks.

Several reports from these organizations present new findings on radiation risks based upon revised estimates of radiation dose to survivors of the atomic bombing at Hiroshima and Nagasaki. For example, UNSCEAR published risk estimates in 1988 and 1993 (UNSCEAR 1988; UNSCEAR 1993). The NCRP also published a report in 1988, “New Dosimetry at Hiroshima and Nagasaki and Its Implications for Risk Estimates” (NCRP 1988). In January 1990, the National Academy of Sciences released the fifth report of the BEIR Committee, “Health Effects of Exposure to Low Levels of Ionizing Radiation,” National Research Council, 1990). Each of these publications also provides extensive bibliographies on other published studies concerning radiation health effects for those who may wish to read further on this subject.

What Are The Estimates Of The Risk Of Fatal Cancer From Radiation Exposure?

We don't know exactly what the chances are of getting cancer from a low-level radiation dose, primarily because the few effects that may occur cannot be distinguished from normally occurring cancers. However, we can make estimates based on extrapolation from extensive knowledge from scientific research on high dose effects. The estimates of radiation effects at high doses are better known than are those of most chemical carcinogens (NCRP 1989).

From currently available data, the NRC has adopted a risk value for an occupational dose of 1 rem (0.01 Sv) Total Effective Dose Equivalent (TEDE) of 4 in 10,000 of developing a fatal cancer, or approximately 1 chance in 2,500 of fatal cancer per rem of TEDE received. The uncertainty associated with this risk estimate does not rule out the possibility of higher risk, or the possibility that the risk may even be zero at low occupational doses and dose rates.

The radiation risk incurred by a worker depends on the amount of dose received. A worker who receives 5 rems (0.05 Sv) in a year incurs 10 times as much risk as another worker who receives only 0.5 rem (0.005 Sv). Only a very few workers receive doses near 5 rems (0.05 Sv) per year (Raddatz and Hagemeyer 1995).

According to the BEIR V report (National Research Council 1990), approximately one in five adults normally will die from cancer from all possible causes such as smoking, food, alcohol, drugs, air pollutants, natural background radiation and inherited traits. Thus, in any group of 10,000 workers, we can estimate that about 2,000 (20%) will die from cancer without any occupational radiation exposure.

To explain the significance of these estimates, we will use as an example a group of 10,000 people, each exposed to 1 rem (0.01 Sv) of ionizing radiation. Using the risk factor of 4 effects per 10,000 rem of dose, we estimate that 4 of the 10,000 people might die from delayed cancer because of that 1 rem dose (although the actual number could be more or less than 4) in addition to the 2,000 normal cancer fatalities expected to occur in that group from all other causes. This means that a 1 rem (0.01 Sv) dose may increase an individual worker's chances of dying from cancer from 20 percent to 20.04 percent. If one's lifetime occupational dose is 10 rem, we could raise the estimate to 20.4 percent. A lifetime dose of 100 rem may increase chances of dying from cancer from 20 to 24 percent.[2] It is important to understand the probability factors here. A

[2] Given the CBP standard of 0.1 rem (0.001 Sv) exposure in any one year, the risk would equate to 4 effects per 100,000. This means that a 0.1 rem (0.001 Sv) dose may increase an individual workers chance of dying from cancer from 20 percent to 20.005 percent. The average measurable dose for radiation workers reported to the NRC was 0.31 rem (0.0031 Sv) for 1993 (Raddatz and Hagemeyer, 1995). Today, very few CBP employees ever accumulate 100 rem (1 Sv) in a working lifetime, and the average career dose of workers at NRC-licensed facilities

similar question would be, "If you select one card from a full deck of cards, will you get the ace of spades?" This question cannot be answered with a simple yes or no. The best answer is that your chance is 1 in 52. However, if 1000 people each select one card from full decks; we can predict that about 20 of them will get an ace of spades. Each person will have 1 chance in 52 of drawing the ace of spades, but there is no way we can predict which persons will get that card. The issue is further complicated by the fact that in a drawing by 1000 people, we might get only 15 successes, and in another, perhaps 25 correct cards in 1000 draws. We can say that if you receive a radiation dose, you will have increased your chances of eventually developing cancer. It is assumed that the more radiation exposure you get, the more you increase your chances of cancer.

The normal chance of dying from cancer is about one in five for persons who have not received any occupational radiation dose. The additional chance of developing fatal cancer from an occupational exposure of 1 rem (0.01 Sv) is about the same as the chance of drawing any ace from a full deck of cards three times in a row. The additional chance of dying from cancer from an occupational exposure of 10 rem (0.1 Sv) is about equal to your chance of drawing two aces successively on the first two draws from a full deck of cards.

It is important to realize that these risk numbers are only estimates based on data for people and research animals exposed to high levels of radiation in short periods of time. There is still uncertainty with regard to estimates of radiation risk from low levels of exposure. Many difficulties are involved in designing research studies that can accurately measure the projected small increases in cancer cases that might be caused by low exposures to radiation as compared to the normal rate of cancer.

These estimates are considered by the NRC staff to be the best available for the worker to use to make an informed decision concerning acceptance of the risks associated with exposure to radiation. A worker who decides to accept this risk should try to keep exposure to radiation as low as is reasonably achievable (ALARA) to avoid unnecessary risk.

If I Receive A Radiation Dose That Is Within Occupational Limits, Will It Cause Me To Get Cancer?

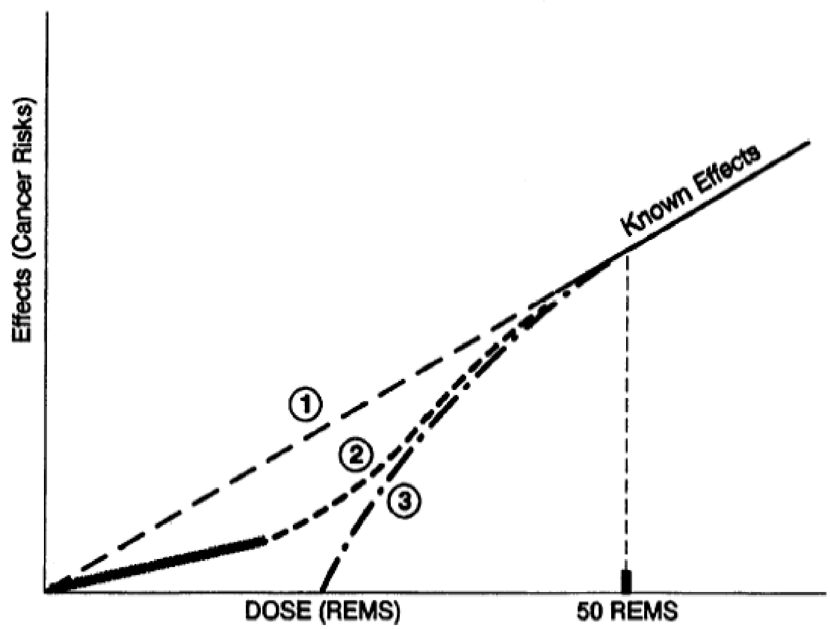
Probably not. Based on the risk estimates previously discussed, the risk of cancer from doses below the occupational limits is believed to be small. Assessment of the cancer risks that may be associated with low doses of radiation are projected from data available at doses larger than 10 rems (0.1 Sv) (ICRP 1991). For radiation protection purposes, these estimates are made using the straight line portion of the linear quadratic model (Curve 2 in Figure 1). We have data on cancer probabilities only for high doses, as shown by the solid line in 8. Only in studies involving radiation doses above occupational limits are there dependable determinations of the risk of cancer, primarily because below the limits the effect is small compared to differences in

is 1.5 rem (0.015 Sv), which represents an estimated increase from 20 to about 20.06 percent in the risk of dying from cancer.

the normal cancer incidence from year to year and place to place. The ICRP, NCRP and other standards-setting organizations assume for radiation protection purposes that there is some risk, no matter how small the dose (Curves 1 and 2). Some scientists believe that the risk drops off to zero at some low dose (Curve 3), the threshold effect, The ICRP and NCRP endorse the linear quadratic model as a conservative means of assuring safety (Curve 2).

For regulatory purposes, the NRC uses the straight line portion of Curve 2, which shows the number of effects decreasing linearly as the dose decreases. Because the scientific evidence does not conclusively demonstrate whether there is or is not an effect at low doses, the NRC assumes for radiation protection purposes, that even small doses have some chance of causing cancer. Thus, a principle of radiation protection is to do more than merely meet the allowed regulatory limits; doses should be kept as low as is reasonably achievable (ALARA). This is as true for natural carcinogens such as sunlight and natural radiation as it is for those that are manmade, such as cigarette smoke, smog and X-Rays.

Figure 1 Some Proposed Models for How the Effects of Radiation Vary with Doses at Low Levels



How Can We Compare The Risk Of Cancer From Radiation To Other Kinds Of Health Risks?

One way to make these comparisons is to compare the average number of days of life expectancy lost because of the effects associated with each particular health risk. Estimates are calculated by looking at a large number of persons, recording the age when death occurs from specific causes, and estimating the average number of days of life lost as a result of these early deaths. The total number of days of life lost is then averaged over the total observed group.

Several studies have compared the average days of life lost from exposure to radiation with the number of days lost as a result of being exposed to other health risks. The word “average” is important because an individual who gets cancer loses about 15 years of life expectancy, while his or her coworkers do not suffer any loss.

Some representative numbers are presented in Table 1. For categories of NRC-regulated industries with larger doses, the average measurable occupational dose in 1993 was 0.31 rem (0.0031 Sv). A simple calculation based on the article by Cohen and Lee (Cohen and Lee 1991) shows that 0.3 rem (0.003 Sv) per year from age 18 to 65 results in an average loss of 15 days. These estimates indicate that the health risks from occupational radiation exposure are smaller than the risks associated with many other events or activities we encounter and accept in normal day-to-day activities.

It is also useful to compare the estimated average number of days of life lost from occupational exposure to radiation with the number of days lost as a result of working in several types of industries. Table 2 shows average days of life expectancy lost as a result of fatal work-related accidents. Table 2 does not include non-accidental types of occupational risks such as occupational disease and stress because the data are not available.

These comparisons are not ideal because we are comparing the possible effects of chronic exposure to radiation to different kinds of risks such as accidental death, in which death is inevitable if the event occurs. This is the best we can do because good data are not available on chronic exposure to other workplace carcinogens. Also, the estimates of loss of life expectancy for workers from radiation-induced cancer do not take into consideration the competing effect on the life expectancy of the workers from industrial accidents.

Table 1 Estimated Loss of Life Expectancy from Health Risks

Health Risks	Estimate of Life Expectancy Lost (Average)
Smoking 20 cigarette a day	6 years
Overweight (by 15%)	2 years
Alcohol consumption (U.S. average)	1 year
All accidents combined	1 year
Motor vehicle accidents	207 days
Home accidents	74 days
Drowning	24 days
All natural hazards (earthquake, lightning, flood, etc.)	7 days
Medical radiation	6 days
Occupational Exposure	
0.3 rem/y from age 18 to 65	15 days
1 rem/y from age 18 to 65	51 days

(Cohen and Lee 1991)

Table 2 Estimated Loss of Life Expectancy from Industrial Accidents

Industry Type	Estimated Days of Life Expectancy Lost (Average)
All Industries	60
Agriculture	320
Construction	227
Mining and Quarrying	167
Transportation and Public Utilities	160
Government	60
Manufacturing	40
Trade	27
Services	27

(Cohen and Lee 1991)

What Are The Health Risks From Radiation Exposure To The Embryo/Fetus?

During certain stages of development, the embryo/fetus is believed to be more sensitive to radiation damage than adults. Studies of atomic bomb survivors exposed to acute radiation doses exceeding 20 rads (0.2 Gy) during pregnancy show that children born after receiving these doses have a higher risk of mental retardation. Other studies suggest that an association exists between exposure to diagnostic X-Rays before birth and carcinogenic effects in childhood and in adult life. Scientists are uncertain about the magnitude of the risk. Some studies show the embryo/fetus to be more sensitive to radiation-induced cancer than adults, but other studies do not. In recognition of the possibility of increased radiation sensitivity, and because dose to the embryo/fetus is involuntary on the part of the embryo/fetus, a more restrictive dose limit has been established for the embryo/fetus of a declared pregnant radiation worker. See Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure."

If an occupationally exposed woman declares her pregnancy in writing, she is subject to the more restrictive dose limits for the embryo/fetus during the remainder of the pregnancy. The dose limit of 500 mrems (5 mSv) for the total gestation period applies to the embryo/fetus and is controlled by restricting the exposure to the declared pregnant woman. Restricting the woman's occupational exposure, if she declares her pregnancy, raises questions about individual privacy rights, equal employment opportunities and the possible loss of income. Because of these concerns, the declaration of pregnancy by a female radiation worker is voluntary. Also, the declaration of pregnancy can be withdrawn for any reason, for example, if the woman believes that her benefits from receiving the occupational exposure would outweigh the risk to her embryo/fetus from the radiation exposure.

Can A Worker Become Sterile Or Impotent From Normal Occupational Radiation Exposure?

No. Temporary or permanent sterility cannot be caused by radiation at the levels allowed under NRC's occupational limits. There is a threshold below which these effects do not occur. Acute doses on the order of 10 rems (0.1 Sv) to the testes can result in a measurable but temporary reduction in sperm count. Temporary sterility (suppression of ovulation) has been observed in women who have received acute doses of 150 rads (1.5 Gy). The estimated threshold (acute) radiation dose for induction of permanent sterility is about 200 rads (2 Gy) for men and about 350 rads (3.5 Gy) for women (National Research Council 1990; Scott et al 1993). These doses are far greater than the NRC's occupational dose limits for workers.

Although acute doses can affect fertility by reducing sperm count or suppressing ovulation, they do not have any direct effect on one's ability to function sexually. No evidence exists to suggest that exposures within the NRC's occupational limits have any effect on the ability to function sexually.

What Are Background Radiation Exposures?

The average person is constantly exposed to ionizing radiation from several sources. Our environment and even the human body contain naturally occurring radioactive materials (e.g., potassium-40) that contribute to the radiation dose that we receive. The largest source of natural background radiation exposure is terrestrial radon, a colorless, odorless, chemically inert gas, which causes about 55 percent of our average, non-occupational exposure. Cosmic radiation originating in space contributes additional exposure. The use of X-Rays and radioactive materials in medicine and dentistry adds to our population exposure. As shown below in Table 3, the average person receives an annual radiation dose of about 0.36 rem (3.6 mSv). By age 20, the average person will accumulate over 7 rems (70 mSv) of dose. By age 50, the total dose is up to 18 rems (180 mSv). After 70 years of exposure this dose is up to 25 rems (250 mSv).

Table 3 Average Annual Effective Dose Equivalent to Individuals in the U.S.

Source		Effective Dose Equivalent (mrems)	
Natural			
	Radon	200	
	Other than Radon	100	
	Total Natural		300
Nuclear Fuel Cycle			0.05
Consumer Products[b]			9
Medical			
	Diagnostic X-Rays	39	
	Nuclear Medicine	14	
	Total Medical		53
Total			About 360 mrems/year

(NCRP 1987).

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