Congressional Budget Office

JUNE 2016

Scanning and Imaging Shipping Containers Overseas: Costs and Alternatives

Provided as a convenience, this "screen-friendly" version is identical in content to the principal ("printer-friendly") version of the report. Any tables, figures, and boxes appear at the end of this document; click the hyperlinked references in the text to view them.

Summary

Each year, about 12 million shipping containers enter U.S. ports. After the September 11, 2001, attacks, concern arose that terrorists might use containers to smuggle weapons of mass destruction—particularly nuclear weapons—into the country. To reduce that threat, the federal government implemented several security measures. Among them, Customs and Border Protection (CBP), an agency of the Department of Homeland Security (DHS), scans every container entering the United States by sea or land to detect radiation.[1] CBP also identifies about 5 percent of all incoming seaborne containers as high risk, and it inspects those containers with X-ray or gamma-ray

1. In this study, "scan" means to use a passive radiation monitor to detect radiation—that is, without the scanner emitting radiation of its own. By contrast, active radiation monitors emit some radiation and look for a response from the object being monitored. Also in this study, "image" means to use a device to create an image of the contents of the container. An imaging device can be active (usually using X-rays or gamma rays) or passive. The imaging device is "nonintrusive" if the process of making the image does not require opening or disturbing the contents of the container. Finally, "screen" means to assess the risk that a container has nuclear weapons, nuclear materials, or other contraband by examining information about the container from shipping documents, information that shippers are required to give CBP, and intelligence information.

Notes: Unless otherwise indicated, all years referred to in this study are federal fiscal years (which run from October 1 to September 30 and are designated by the calendar year in which they end), all costs apply to fiscal years and are expressed in fiscal year 2015 dollars of budget authority, and all growth rates are adjusted for inflation by using the Congressional Budget Office's projection of the gross domestic product price index.

Numbers in the text and tables may not add up to totals because of rounding.

imaging systems. The agency opens and examines containers if the images suggest that the cargo is potentially dangerous or does not match the manifest.

In 2007, the Congress mandated that DHS use both radiation detectors and imaging systems to scan and image all incoming seaborne containers before they are loaded onto a U.S.-bound ship. That approach would shift the radiation scanning and nonintrusive imaging from U.S. ports to overseas ports, with the goal of detecting any serious threats before they arrive. The approach also would aim to image all containers instead of limiting the use of expensive imaging resources to high-risk containers. The law gave DHS until 2012 to fully implement this system, but the deadline has been extended three times and is now 2018. The Congressional Budget Office examined five options that illustrate the cost and implications of meeting the mandate as well as alternative approaches to increase the scanning and imaging of containers.

What Are the Costs and Other Challenges of Scanning and Imaging All U.S.-Bound Containers at Overseas Ports?

Exporters ship containers from hundreds of ports in other countries to the United States. The mandate to scan and image all inbound containers poses three challenges for CBP: cost, potential shipping delays, and possible refusal to comply by some operators and host countries. Although CBO examined the first two issues, full compliance will also require resolving the third issue, which is beyond the scope of this study.

CBO examined two options that would meet the requirement to scan and image 100 percent of U.S.-bound containers. Under Option 1, CBP or foreign partners would install scanning and imaging equipment at the 453 foreign ports in 130 countries that load containers onto U.S.-bound ships (see Summary Table 1). Conducting that scanning and imaging would cost, on average, $150 to $220 per container, which the U.S. government could either pay or recoup through fees assessed on shippers. If current flows of inbound containers grow at 2.5 percent per year, implementing and operating such a system would cost between $22 billion and $32 billion in 2015 dollars over 10 years, CBO estimates. For comparison, CBO estimates that, using current procedures and equipment, CBP would spend about $1.3 billion over 10 years to image about 5 percent of inbound containers. Hence, the estimated cost of Option 1 is about 17 to 25 times the cost of CBP's current scanning and imaging system. Paying for the more comprehensive system would require an increase of 17 percent to 25 percent in CBP's total budget, a reduction in other spending by CBP, an increase in fees assessed on shippers, or some combination of those actions.[2]

The range in CBO's estimates reflects the different ways that CBP could scan and image containers. The higher cost would result from using current procedures and equipment. The lower cost would result if CBP increased the imaging rate for containers

2. By coincidence, those percentages round to the same numbers as in the previous sentence.

by adopting more efficient procedures or new technology that could be deployed in the next several years.

Option 2 offers a cheaper way to meet the mandate: Focus on the busiest overseas ports. Under that option, CBP or foreign partners would install scanning and imaging equipment at the 121 foreign ports that load 97 percent of all containers on U.S.-bound ships. Shippers would have to route the remaining 3 percent of inbound containers to those ports. That option would cost $12 billion to $22 billion over 10 years—about $10 billion less than Option 1. The cost to scan and image a container would range from $80 to $150.

If the federal government implemented 100 percent scanning and imaging at overseas ports, other countries might in turn require that DHS scan and image all containers leaving the United States. (CBP does not routinely scan or image containers that leave the United States.) Under that scenario, the total costs over 10 years for implementing 100 percent scanning and imaging overseas could roughly double, rising to $37 billion to $63 billion for Option 1 and $27 billion to $53 billion for Option 2.

What Are Some Options to Increase Imaging at U.S. Ports?

CBO examined three lower-cost options that would increase imaging for containers arriving at U.S. ports rather than meet the mandate's requirement to image and scan all of them overseas:

- Doubling the fraction of containers imaged as they enter the United States to about 10 percent (Option 3) would increase costs by $1 billion to $2 billion over 10 years.
- Raising the imaging rate to 100 percent of containers at all 74 U.S. ports that receive international containers (Option 4) would increase costs by $4 billion to $8 billion over 10 years.
- Restricting imaging to the busiest 32 U.S. ports, representing 99.7 percent of all inbound containers (Option 5, which is similar to Option 2 for the busiest overseas ports), would cost $4 billion to $7 billion over 10 years.

What Are the Potential Effects of Increased Scanning?

Implementing the mandate under Option 1 or Option 2 would sharply increase the number of containers scanned and imaged; doing so also would increase the chances of detecting nuclear weapons or materials before they reached the United States. In addition, imaging every container would enhance CBP's ability to detect more common contraband and shipping irregularities. However, to be effective, those options would potentially require more than 100 countries and hundreds of port operators to agree to scanning and imaging.

More imaging of imported containers at U.S. ports (Options 3–5) also would increase the chances of detecting nuclear materials or weapons but would avoid the diplomatic challenges associated with widespread imaging of U.S.-bound containers overseas.

Increased imaging at domestic ports also could avoid the possible need for reciprocal scanning arrangements whereby the United States might have to scan shipments headed for other countries. However, scanning and imaging containers at U.S. ports rather than overseas ports could increase the chances that a weapon in a container could be detonated in a U.S. port before it is scanned or imaged.

All the options CBO examined involve imaging more containers. But how much those steps would reduce potential smuggling of nuclear weapons or materials into the United States is not clear. The options do not address other paths that smugglers might use, such as truck or rail at land crossings from Mexico or Canada, tunnels under the border, other types of commercial ships, private yachts, and aircraft. Those alternative paths could become more attractive if the United States sharply increased scanning and imaging of containers. No options considered here would address those other paths or other threats to the United States or its supply chain.

Chapter 1: Container Shipments and the Process for Inspecting Them

Each year, about 12 million shipping containers enter U.S. ports. The modular container shipping system allows large quantities of goods to be shipped to the United States and those containers to be distributed throughout the country within days via rail and truck. The containers and their distribution network not only facilitate global commerce but also serve as a means to smuggle contraband and people into the country. After the attacks of September 11, 2001, U.S. officials became concerned that terrorists might use containers to smuggle weapons of mass destruction—nuclear weapons, in particular—into the country.

The federal government took several steps to reduce that threat. For example, Customs and Border Protection (CBP) now runs a system that passively scans every container that enters the United States by sea or land for radiation before it leaves the domestic port or border crossing.[3] CBP also now screens the paperwork for nearly every container by using information about the shipper, country of origin, and contents to identify containers that present a high risk of posing a terrorist threat or containing other contraband. Under that process, CBP identifies about 5 percent of all seaborne containers entering the United States as high risk, although only a fraction of those are flagged for national security reasons. For that 5 percent, CBP uses nonintrusive inspection devices to image the contents with X-rays or gamma rays. The process is

3. Passive radiation monitors detect radiation without emitting radiation of their own. Active radiation monitors emit some radiation and look for a response from the object being monitored.

similar to the imaging that carry-on baggage undergoes at airport security stations. CBP personnel may open some containers and examine their contents by hand if the images suggest that the cargo is potentially dangerous or deviates from the contents stated in the manifest.

Imaging machines are expensive to purchase and operate, and the imaging process takes time; inspecting containers by hand is labor intensive and takes much longer. Both the cost of imaging and commercial interests in keeping trade flowing have led CBP to adopt a risk-based imaging strategy, focusing on the containers that it determines to be high risk.

To date, CBP has found no nuclear weapons or radiological materials for dirty bombs—weapons that do not create a nuclear explosion but instead disperse radioactive material to contaminate the surrounding area. But CBP has detected (and kept out of the country) several consumer goods made with metal contaminated with radioactive material. By using the computerized screening system and the X-ray and gamma-ray imaging systems intended primarily to find nuclear materials, the agency has also found other types of contraband being smuggled into the United States, particularly illicit drugs.[4] In fact, only a small portion of the containers CBP has identified as high risk are suspected of carrying nuclear or radiological materials; most were suspected of containing other contraband or materials that could represent trade violations.

Some experts have expressed concerns about the inspection system. First, the existing radiation detectors are well suited for detecting many radiological materials that might be used to make a dirty bomb; but those detectors have less ability to detect the fissile materials used to make nuclear weapons or to detect radiological materials that are shielded. Second, waiting to detect a nuclear weapon after it arrives at a U.S. port might be too late because it could be detonated there and cause severe damage.[5]

In response to the first concern, the Department of Homeland Security (DHS) has worked to develop radiation detectors that can better detect fissile materials. But those efforts encountered technical difficulties and ballooning costs and have been delayed or canceled. In response to the second concern, DHS and the Department of Energy established pilot programs at foreign ports to study the feasibility of keeping dangerous cargo overseas by scanning containers before they are shipped to the United States. Most of those programs have been halted, however, often because of resistance by the

4. Although engineers can design an imaging system optimized to find radiological materials, such a system would lose some of its capability to find other contraband. The systems that CBP uses produce images that are useful for detecting a broader array of threats.

5. Some experts believe that a nuclear detonation at any major world port would significantly disrupt world trade in addition to endangering the local population. They therefore argue that detection must occur earlier.

host countries or the companies that own the container terminals at the ports. Only one pilot program remains in operation: at Pakistan's port of Qasim.

In August 2007, the President signed a law requiring DHS to establish a system whereby both radiation detectors and imaging systems inspect all U.S.-bound containers before they are loaded onto a U.S.-bound ship.[6] If implemented, that approach would aim to detect threats before they reach U.S. shores. DHS had until 2012 to fully implement this system. But the Secretary of DHS has extended the deadline, as the law allowed, first to 2014, then to 2016, and now to 2018. In a letter to the Congress announcing the extension to 2016, Secretary Jeh Johnson stated that he had reviewed U.S. port security as well as the short- and long-term prospects for DHS's complying with the requirement to scan all containers. He reported that DHS was highly unlikely to be able to fully comply with the mandate, even over the long term. He also noted the high cost of full compliance and questioned whether the mandate was the best use of taxpayers' money to meet the country's security needs.[7] In a letter announcing the most recent extension, Secretary Johnson expressed skepticism about whether DHS could meet the mandate in the next two years, but he committed the department to work toward the law's objectives. He emphasized, however, that the solution would probably be found in a "sustainable global scanning regime" that would require concerted efforts by many countries and not just unilateral efforts by the United States.

To implement a system that meets the requirements of the law, DHS faces three main challenges:

- Installing and operating the required scanners and imaging equipment at overseas ports would be costly.
- Such a system could slow commerce.
- The many port operators (and their hosting countries) that ship containers to the United States could resist.

Focusing on the first and second challenges, CBO has examined the cost of various options for scanning and imaging that would not increase delays at container terminals.

6. Implementing Recommendations of the 9/11 Commission Act of 2007, Public Law 110-53, 121 Stat. 266.

7. In the letter dated May 5, 2014, to the Honorable Thomas R. Carper, Chairman of the Senate Committee on Homeland Security and Governmental Affairs, Secretary Johnson used the term *scanning* to indicate both radiological portal monitor scanning and nonintrusive inspection via imaging.

The Global Container-Shipping System

After its introduction in 1956, the shipping container began to transform how goods are moved from place to place. Shipping containers have several characteristics that make them ideal to ship goods efficiently and inexpensively:

- The strength of a steel shipping container allows transporting a variety of cargoes.[8]
- The shipping container's dimensions are standardized, allowing efficient stacking on a ship and in storage at a port; they can also easily be moved around a port terminal.[9]
- The standardized shipping container streamlines freight transportation, increasing shipping speed, reducing pilferage, permitting better cargo tracking, and reducing the cost of both sea transport and intermodal freight transport in general.[10]

Ships, freight rail, and trucks are all designed to carry shipping containers. Containers can therefore easily be transferred directly from a container ship, using a crane at the pier side, onto a truck chassis and driven away. The container can then be transferred to another ship or to a road vehicle or a railcar at the port for transport on land. With this development, cargo no longer needs to be packed and unpacked at the port. The containers can be packed and unpacked at remote sites such as factories and warehouses away from the port.

Onboard the container ship, standardized shipping containers make loading and unloading much more efficient, and the containers allow for efficient packing onto the container ship. All these developments have substantially reduced shipping costs, increased shipping speeds, and boosted the volume of goods so shipped.[11] To

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8. For more detail on International Organization for Standardization (ISO) cargo shipping containers, see http://tinyurl.com/isocargo. Shipping containers also can be refrigerated and thus can transport perishable goods over long distances.

9. Containers are 8 feet wide and 8.5 feet high. They have standard lengths of 20 and 40 feet. The term 20-foot equivalent unit (TEU) is used today as a measure of shipping capacity; thus, a 20-foot container is 1 TEU and a 40-foot container is 2 TEUs. The shipping industry also uses 45- and 53-foot-length containers, although largely for domestic purposes.

10. Intermodal freight transport refers to the use of two or more means of transportation to move freight from origin to destination. For this study, the three primary means of transportation are seagoing container ships, commercial trucks, and freight rail. For more detail, see Jimmy Dobbins, John Macgowan, and Martin Lipinski, *Overview of the U.S. Freight Transportation System* (Center for Intermodal Freight Transportation Studies, University of Memphis, August 2007), http://tinyurl.com/imfreight (PDF, 3 MB).

11. The costs of shipping a container over time are hard to quantify because of inadequate data, costs that vary by route, and other factors such as the rising costs of ship construction and fuel. Hummels in 2007 estimated that shipping costs dropped by between 3 percent and 13 percent because of the use of containers. Moreover, Hummels concludes that containers have led to a definite, but hard-to-measure, drop in costs for the overall supply chain by providing faster, more secure, and traceable transport. See David Hummels, "Transportation Costs and International Trade Over Time," http://tinyurl.com/hummels2007 (PDF, 142 KB).

accommodate increasing container imports, ships have increased in size (see Figure 1-1), and the supporting infrastructure at ports and canals has been expanded.[12]

The global container system uses a hub-and-spoke system, similar to the system airlines use for passenger travel. Containers from a local region are shipped on small vessels to large regional ports, where they are then transferred (transshipped) onto large ships that cross oceans.

The Motivation for Scanning and Imaging

The shipping container network offers several features that terrorists could exploit. The network is global; in 2014, about 12 million containers from 130 countries entered through U.S. seaports (see Figure 1-2). Most major container ports in the United States are in or near the largest coastal cities, where an attack could kill many people. Moreover, the costs of shipping a container, even over long distances, are relatively modest, allowing even poorly financed terrorist groups to contemplate delivering weapons transcontinentally.[13]

After the September 11, 2001, terrorist attacks, U.S. officials reviewed modes of transportation that were either vulnerable to attack or that terrorists could exploit to attack the United States. According to the 9/11 Commission's 2004 report, the greatest danger of another catastrophic attack could occur when "the world's most dangerous terrorists acquire the world's most dangerous weapons."[14] One worrisome scenario that the commission identified involved terrorists using shipping containers to transport nuclear or radiological materials or weapons into the United States.[15]

The 9/11 Commission identified the need for what it called "the most powerful" investments in scanning and imaging technologies to inspect containers that can be transported by plane, ship, truck, or rail. Until those scanning and imaging technologies were available, the commission recommended tracking high-risk containers, operators, and facilities.

12. For a discussion of how container ships have evolved, see Jean-Paul Rodrigue, Claude Comtois, and Brian Slack, *The Geography of Transport Systems*, 3rd ed. (Routledge, 2013).

13. A new shipping container costs between $2,000 and $7,000, depending on the size. Shipping costs vary according to place of origin and destination; shipping a container from Shanghai to Los Angeles, for example, costs approximately $4,000.

14. See Thomas H. Kean and others, *The 9/11 Commission Report* (July 22, 2004), p. 380, http://govinfo.library.unt.edu/911/report.

15. Ibid., pp. 390–392.

Current Approach to Securing the Container System Against Radiological and Nuclear Threats

When lawmakers established the Department of Homeland Security in 2003, Customs and Border Protection—the largest agency of DHS—was formed, primarily by merging the Customs Service and the Border Patrol. CBP's mission includes protecting the nation's borders, safeguarding the U.S. homeland at and beyond its borders, and protecting the public against terrorists and the instruments of terror. CBP is the lead agency within DHS responsible for preventing illicit nuclear and radiological materials or devices from entering the United States, in coordination with other federal agencies and state and local governments; it also works through international partnerships. Nevertheless, detecting nuclear and radiological threats at seaports and border crossings is just a small part of CBP's role.

Much of CBP's activity at ports and border crossings focuses on traditional statutorily authorized missions of the Customs Service and Border Patrol: finding contraband, particularly illicit drugs; making sure duties are paid; and finding unauthorized immigrants. CBP has devoted considerable resources to detecting nuclear and radiological threats, but it also uses those resources to detect other types of contraband.

CBP maintains what it calls a layered defense-in-depth system to counter nuclear threats as well as to counter smuggling of contraband (see Figure 1-3). That system scans all containers for radiation and images about 5 percent of them on the basis of CBP's risk assessment for all types of threats.

CBP has set up several programs at U.S. seaports and land border crossings; it also has set up voluntary programs at overseas ports.[16] From the experience gained through those programs, CBP also established protocols to screen incoming cargo containers for potential threats and to scan, image, or inspect those containers once they arrive at U.S. ports or border crossings.[17] Several security-focused efforts are particularly relevant to detecting nuclear weapons in shipping containers:

- The Customs–Trade Partnership Against Terrorism (C-TPAT),
- The Automated Targeting System and the 10 + 2 Program,

16. CBP uses the same technologies at land crossings as at ports, but because the 100 percent scanning and imaging law applies only to seaborne container cargo, this study will not examine land crossings further.

17. For more information on CBP's programs related to the nuclear and radiological threats, see Government Accountability Office, *Supply Chain Security: Feasibility and Cost–Benefit Analysis Would Assist DHS and Congress in Assessing and Implementing the Requirement to Scan 100 Percent of U.S.-Bound Containers*, GAO-10-12 (October 30, 2009), www.gao.gov/products/GAO-10-12.

- The Container Security Initiative,
- Radiation portal monitoring,
- Secondary radiation monitoring systems,
- Nonintrusive imaging,
- Physical searches, and
- Other programs.

Some of those efforts begin overseas; others occur at U.S. ports after containers arrive. The United States also has several other programs to improve its ability to identify nuclear and radiological threats in containers.

Major Overseas Activities

The Customs–Trade Partnership Against Terrorism, the Automated Targeting System and the 10 + 2 Program, and the Container Security Initiative begin overseas, before containers are loaded onto inbound ships.

Customs–Trade Partnership Against Terrorism. C-TPAT was established after the 9/11 attacks and predates CBP's founding. Security activities under the program begin long before containers en route to the United States arrive at foreign ports. C-TPAT is a voluntary partnership between the U.S. government and private firms that offers businesses incentives to improve the security of their supply chain and the ability to police their own supply chain. Companies that join C-TPAT and demonstrate that their supply chain is secure are subject to fewer cargo inspections and examinations and enjoy expedited processing at land crossings.

The Automated Targeting System and the 10 + 2 Program. The first layer in screening containers is the computer-assisted Automated Targeting System (ATS). CBP uses ATS to integrate information about all U.S.-bound shipments to further identify high-risk containers. The system integrates information from law enforcement and intelligence databases with data received from the 10 + 2 program. The 10 + 2 program requires exporters or their agents that are sending containers to the United States by sea to provide 10 pieces of information about themselves and the cargo in the container. That information includes the importer's name, consignee's identification number, name and address of the buyer, name and address of the seller, party receiving the shipment, name and address of the manufacturer, country of origin, commodity code, location where the container was loaded, and name and address of the freight consolidator. Also, the company that owns the ship that will carry the container to the United States must provide two more pieces of information: the location of the container on the ship as well as container status messages that describe the path the container has taken. CBP must receive the first 10 pieces of information at least 24 hours before the ship leaves the foreign port, and the last 2 at least 24 hours before arrival at the United States.

From the information gathered, ATS assigns each container a risk level. Although the system was initially set up to reduce terrorist threats, it is also used to identify containers that might be high risk for smuggling narcotics, people, or weapons. Any container that ATS identifies as high risk undergoes further scrutiny on arriving at a U.S. port. ATS, however, is not the sole determinant of whether cargo will be examined; additional intelligence, information from foreign counterparts or other government agencies, and specialized training and experience of CBP officers also play a role.

Container Security Initiative. After a container enters a foreign port, it could be subject to inspection under the Container Security Initiative program, which CBP operates at most major overseas ports in conjunction with foreign governments. The program, designed to identify and inspect targeted high-risk containers at participating foreign ports before they are placed on inbound vessels, consists of three elements:

- Using the judgment of CBP officers and data from ATS to identify shipments in containers that pose a risk of terrorism,
- Prescreening and manually examining at the port of departure those containers identified as high risk, and
- Using state-of-the-art detection technology, where available, to scan or image containers that pose a risk.

However, the Container Security Initiative is a voluntary program. CBP officials identify the high-risk containers, and port operators and local customs officials have discretion as to whether to inspect a container that CBP personnel identify and how it will be inspected. Currently, 58 foreign ports participate, covering 80 percent of maritime containers imported into the United States, but only a small fraction of U.S.-bound containers are inspected under the program.

Domestic Activities

Under the current system, after containers arrive at U.S. ports, CBP subjects them to at least one system to detect nuclear threats (radiation portal monitoring). The agency may subject containers to three other security layers (secondary radiation monitoring systems, nonintrusive imaging, and physical searches) if they are identified as high risk in ATS or raise concerns for other reasons.

Radiation Portal Monitoring. All seaborne containers arriving at a U.S. port go through radiation portal monitors to detect radiation before leaving that port (see Figure 1-4). However, containers identified as high risk (or identified for random checks) undergo additional radiation monitoring and nonintrusive imaging before they reach the portal monitors at the port's exit. If those additional steps uncover no problems, the containers rejoin the regular flow. But if the additional steps raise more concerns, the containers are subjected to further radiation checks and physical searches.

Radiation portal monitoring is CBP's primary means to detect nuclear and radiological materials. Every inbound container must pass through a large radiation detector before it leaves the port. That step occurs as the container leaves the terminal by truck or railcar. As the container passes through the portal, the detector indicates the presence of radiation and the rough location (from front to back and top to bottom) of the source in the container. If the radiation level is elevated, the CBP officer compares the signal with the manifest (which is in ATS) to judge whether the container should undergo further scrutiny. Some naturally radioactive cargo, such as ceramics from certain countries or cat litter, will trigger the detector. CBP trains its officers to distinguish normal from potentially threatening combinations of signals and manifests.

The detectors in the radiation portal monitors are passive (detecting radiation without emitting radiation of their own) and detect gamma and neutron radiation, which makes them better for detecting radiological materials than fissile materials (see Box 1-1). The detectors can detect radiation but cannot identify which radioactive isotope is the source. Containers that trigger an alarm when they pass though the radiation portal monitors go through a second set of the monitors. If the source of the alarm is not resolved, CBP officers inspect those containers, using handheld detectors that can identify the source and type of radiation and its location within the container. If those methods do not resolve the concern, agents will unpack the container and search it by hand. Because radiation portal monitors are relatively inexpensive, container terminals at ports typically have more than one set to reduce the waiting time for trucks or railcars. A scan by a radiation portal monitor takes just a few seconds: Trucks pass through the monitor at about 5 miles per hour.

Secondary Radiation Monitoring Systems. Although radiation portal monitors are the primary means to detect radiation in CBP's layered system, secondary radiation monitors also can detect radiation at other points in the path from ship to terminal exit. CBP uses two secondary systems to detect radiation: a handheld radioactive isotope identifier and a small personal radiation detector. The handheld device is used for high-risk containers. A high-risk container is unloaded from the ship and placed on the dock. Before examining it further, CBP personnel walk around the container while using a handheld detector. If any radiation is present, the detector can identify the radioactive material emitting radiation and can help to locate it within the container. (Some nonintrusive imaging machines also are equipped with radiation detectors.) In addition, all CBP personnel working near shipping containers carry personal radiation detectors, which are about the size of a cell phone and trigger an alarm when detecting radiation. Those devices are always on and can warn CBP personnel of radiation threats in containers that they pass.

Nonintrusive Imaging. Containers that ATS flags as having a risk above a certain threshold undergo nonintrusive imaging, which offers CBP officers a way to see inside a container without the time-consuming and labor-intensive process of unpacking it. Nonintrusive imaging machines use either X-rays or gamma rays to penetrate the container and create an image of the contents. CBP operators are trained to identify suspicious cargo and discrepancies between what they see in the container and what the manifest in ATS describes. For example, the machines can detect dense nuclear materials or shielding, much as an X-ray can show the location of shrapnel in a wound.

The containers flagged for nonintrusive imaging are removed from the ship and placed along the pier or taken to another fixed location. When an imaging machine becomes available and arrives at the pier, CBP officers use it to inspect the containers. Imaging a container takes only a few minutes (compared with hours to unpack and repack it), although containers can be delayed for a few hours while they await imaging. Nevertheless, imaging disrupts the flow of incoming containers much less than unpacking, and imaging requires fewer people.

Despite those advantages, the machines used to image containers cost hundreds of thousands to millions of dollars; operating and maintaining them costs tens of thousands to hundreds of thousands of dollars each year. They also require three or four people to operate. Therefore, CBP has only a few nonintrusive imaging machines at each port, enough to image only a small percentage of containers.

Physical Searches. If concerns about a container initially raised in ATS or by other means cannot be addressed through imagery and radiation detectors (or if those methods increase suspicions), the container may be unpacked and searched physically. That process is labor intensive, can take many hours, and usually is done after the container is moved to a facility designed for those purposes. Physical inspection for concerns other than radiological or nuclear threats (including for narcotics, counterfeit merchandise, and contraband) is fairly common for CBP. The agency uses physical inspections as a last resort because of the delays they impose and the personnel they require.

Other Programs

DHS and the Department of Energy have considered several other inspection and technology development programs to improve the detection of nuclear and radiological threats. Two such programs—the Secure Freight Initiative and the Nuclear Smuggling Detection and Deterrence Program, the successor to the Megaports Initiative—are both active. Other inspection programs are no longer in operation, and some technology programs, such as the advanced spectroscopic portals, were canceled before implementation. To date, none of the advanced technology programs have yielded breakthroughs in scanning or imaging devices.

The Secure Freight Initiative. The Secure Freight Initiative began as a test program in 2007 to scan all U.S.-bound containers at select foreign ports with radiation portal monitors and image all containers with nonintrusive devices before they could depart the originating port. Six ports initially agreed to participate in the U.S. program, but only one—the port in Qasim, Pakistan—still participates. The machines in Qasim send live images to CBP's National Targeting Center—Cargo in Herndon, Virginia. Because of concerns about safety, CBP has no physical presence in Qasim. But Pakistani Customs officials and local staff, whom the U.S. State Department vets and CBP hires, run the machines and can open the container to inspect cargo when CBP decides to scrutinize a particular shipment.

The Nuclear Smuggling Detection and Deterrence Program. The National Nuclear Security Administration within the Department of Energy created the Megaports Initiative in 2003. The initiative's goal was to outfit overseas ports with radiation detectors so that operators can scan as much container traffic as possible, regardless of destination, at overseas ports (including imports, exports, and transshipped containers)—with minimal effect on port operations. The Department of Energy's Nuclear Smuggling Detection and Deterrence Program has since supplanted the Megaports Initiative. The new program's broadened goals now include installing detectors away from ports. By the end of 2015, the program had helped other countries deploy detectors at more than 40 large container ports.[18]

Chapter 2: Options to Scan and Image Containers

In preparing this report, the Congressional Budget Office examined five options to increase scanning and imaging of containers entering the United States.

Options 1 and 2 would meet the requirements in the Implementing Recommendations of the 9/11 Commission Act of 2007. That law requires Customs and Border Protection to inspect all U.S.-bound containers at overseas ports by using nonintrusive imaging equipment and radiation detection equipment. Moreover, for allowing all U.S.-bound containers to be scanned and imaged in their countries, other countries might in exchange require the United States to scan and image all containers leaving U.S. ports. Therefore, CBO also examined what it might cost the United States to scan and image all outbound containers at U.S. ports.

Implementing the requirements of the law would be costly, and CBP has not implemented them despite three extensions that have delayed the deadline for meeting the law by six years. As a result, lawmakers could consider alternatives that would carry

18. This study has not included costs for scanning through the Nuclear Smuggling Detection and Deterrence Program in its cost calculations because those costs are not normally integrated with CBP's container scanning and inspection process. Although CBP could use some of the scanning equipment to partially satisfy the mandate to scan 100 percent of containers, doing so would require CBP to assess each port and negotiate individually with each port outfitted with the Department of Energy's equipment. Also, that equipment does not image the contents of containers and therefore would not meet the law's imaging requirement.

out less scanning and imaging than what is required under the current law but more than what CBP does now. For example, as an alternative to overseas scanning and imaging, CBP could increase the number of inbound containers that it images at U.S. ports. (Radiation portal monitors already scan every container at U.S. ports today.) Options 3 through 5 illustrate such alternatives: Although they would cost less than the first two options, they would not meet the mandate to scan and image 100 percent of containers overseas.

Under current policies and procedures, the Department of Homeland Security would spend about $1.3 billion over 10 years to image the roughly 5 percent of containers arriving at U.S. ports that it considers high risk, CBO estimates. Imaging more containers would cost more. The government could pay for those costs by using appropriated funds or by imposing fees on shippers or importers of containers.[19] The cost of any user fees would probably be passed on to consumers through higher prices for imported goods (or other goods with imported content). This study does not assess the potential economic effect of imposing fees.[20]

The five options described involve several important factors that CBO's estimates did not address. For some factors, not enough data were available on which to base analysis; others were beyond the scope of CBO's analysis. For example, CBO did not assess other possible ways to deliver a weapon of mass destruction to the United States, such as smuggling a device across the U.S.–Mexico border by truck or private aircraft. Nor did CBO determine how spending more on scanning and imaging containers (rather than on other activities that could deter attacks) would affect the likelihood of a nuclear or radiological attack (see Box 2-1). Finally, CBO did not consider factors that would be important for determining the appropriate amount to invest in scanning and imaging technology. One such factor is the probability that someone wants to smuggle a device into the United States. Another is the probability that the current generation of U.S. detectors (combined with the Automated Targeting System) would detect a nuclear or radiological device present in a container.

Options to Scan and Image All U.S.-Bound Containers at Overseas Ports

CBO examined two options that would comply with the mandate to scan and image all U.S.-bound containers at overseas ports.

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19. Certain U.S. ports impose fees on container freight to finance the construction of local freight infrastructure or to reduce congestion and emissions. For example, the Ports of Los Angeles and Long Beach, which handle more containers than other U.S. ports, assess an air-quality charge of $70 per 20-foot equivalent unit.

20. CBO has examined how imposing container taxes to account for external costs would affect U.S. truck and rail transport. Those costs include wear and tear on roads and bridges; delays caused by traffic congestion; injuries, fatalities, and property damage from accidents; and harmful effects from exhaust emissions. See David Austin, *Pricing Freight Transport to Account for External Costs*, Working Paper 2015-03 (Congressional Budget Office, March 2015), www.cbo.gov/publication/50049.

Option 1: Scan and Image at All Overseas Ports

Under Option 1, CBP or foreign partners would install scanning and imaging equipment at the 453 foreign ports in 130 countries that load containers onto U.S.-bound ships, in accordance with the mandate. CBO estimates that implementing and operating such a system would cost $22 billion to $32 billion in 2015 dollars over a 10-year period if incoming container traffic grew at 2.5 percent per year—about the average annual growth rate over the past 10 years (see Summary Table 1). Those costs are about 17 to 25 times the cost of CBP's current scanning and imaging system. Paying those costs would require increasing CBP's current total annual budget by 17 percent to 25 percent, reducing other spending by CBP, assessing higher fees on shippers, or some combination of those actions.[21] Implementing Option 1 would cost, on average, $150 to $220 per container.

The range in CBO's estimate reflects different ways that CBP could scan and image containers overseas. For the higher end of the range, CBP would use the same scanning and imaging equipment that it does today, which can achieve a throughput of 10 containers per hour if used efficiently. For the lower end of the range, CBP would enhance productivity by using available newer imaging technology, more efficient procedures, or both. CBO did not identify for this study any particular new imaging system for use, but CBO estimates that a throughput of 20 containers per hour might be feasible using available imaging technology. CBO's options all incorporate the assumption that CBP would use the same radiation detection equipment that it uses today: personal radiation detection equipment, radioisotope-identification devices, and radiation portal monitors. CBO's estimate includes the proportionally adjusted cost of the additional nuisance and false detections that would accompany increased scanning and imaging.[22] Equipment, construction, and setup would cost $3 billion to $4 billion in this option (see Table 2-1). Operating and maintenance costs over 10 years would range from $19 billion to $28 billion. (The appendix describes CBO's cost model.)

Other countries might respond to the U.S. requirement for overseas scanning and imaging by insisting that the United States scan and image all containers that leave its shores. (Officials from the European Union have stated that they would consider such measures, and other countries might follow suit.) Currently, CBP neither scans nor images outbound containers. If the agency had to scan and image all containers for export from a U.S. seaport in the same way that all U.S.-bound containers would be screened in ports overseas, the scanning and imaging of outbound containers, by itself,

21. By coincidence, those percentages round to the same numbers as in the previous sentence.

22. Nuisance detection occurs when the scanner detects radiological material, but it is not a weapon. Examples include cat litter, certain ceramics, and bananas. A false detection occurs when the scanner detects radiological material even though none is present. In discussion with CBO, CBP indicated that it had recently instituted procedures to reduce nuisance and false detections. But because the data were not available, CBO's costs do not include the savings from those procedures.

would cost $14 billion to $31 billion over 10 years (or $100 to $210 per container), CBO estimates. If that occurred, the cost of Option 1 would roughly double (to between $37 billion and $63 billion over 10 years).

Option 2: Concentrate Scanning and Imaging at the Overseas Ports Exporting the Most Containers to the United States

Option 2 would comply with the requirement to scan and image all containers before they arrive in the United States, but it would concentrate scanning and imaging at fewer ports. CBP or foreign partners would install scanning and imaging equipment at the 121 foreign ports that loaded at least 8,000 containers onto U.S.-bound ships in 2014 and accounted for 97 percent of all such containers (see Figure 2-1). Shippers would have to route the remaining 3 percent of containers that would have been loaded onto U.S.-bound ships at the other 332 ports through one of the 121 transshipment ports equipped with scanners and imagers. Option 2 would cost $12 billion to $22 billion over 10 years—about $10 billion less than Option 1. That range would amount to an average cost of $80 to $150 per container. The cost of Option 2 would roughly double (to between $26 billion and $53 billion over 10 years) if other countries responded to the U.S. requirement for overseas scanning and imaging by insisting that the United States scan and image all containers it exports.

The 332 ports from which cargo could no longer be shipped directly to the United States account for only 3 percent of total U.S.-bound containers. Therefore, the effect on overall shipping would be slight. The larger ports would probably have enough capacity to handle the additional containers that would be transshipped there without requiring more imaging machines. But implementing this option could increase the costs that shippers would have to bear (and presumably would pass on to the companies that use containers to transport goods).

Transshipping is a common practice in the shipping industry. As in the airline industry's hub-and-spoke system, transshipment serves to consolidate containers from small or low-volume ports at large, centrally located ports (lowering shipping costs per container, particularly for long ocean crossings). For example, because of its geographic and commercially strategic location, the Port of Singapore was the world's second-busiest container port in 2012. It transshipped about 30 million containers—nearly three times as many as arrived in the United States in that year.[23]

During transshipment, a container from a smaller ship is either transferred directly onto a larger container vessel or, more commonly, is first transferred to a storage area at the port and then loaded onto a larger container vessel when it arrives. The larger container vessel then transports the container from the transshipment port to the United

23. See American Association of Ports, "World Port Rankings—2012," http://tinyurl.com/worldportrankings (PDF, 334 KB); and Wen-Chih Huang, Hsu-Hsi Chang, and Ching-Tsyr Wu, "A Model of Container Transshipment Port Competition: An Empirical Study of International Ports in Taiwan," *Journal of Marine Science and Technology—Taiwan*, vol. 16, no. 1 (2008), pp. 19–26, http://jmst.ntou.edu.tw/marine/16-1/19-26.pdf (156 KB).

States, either directly or with additional stops along the way. Under Option 2, however, no containers would be transferred directly from one ship to a U.S.-bound ship, because they would have to be scanned and imaged at the transshipment port first.

Even though Option 2 would redirect 3 percent of U.S.-bound containers to transshipment ports, the ports and shipping lines would probably be able to adapt quickly. The required change would be similar to the changes they often make to respond to normal fluctuations in market conditions.[24] Furthermore, a few foreign transshipment ports intend to acquire or have already acquired scanning and imaging equipment to seek new business, with the hope that they would gain a competitive advantage.

An alternative approach to transshipping containers from low-volume ports or deploying scanning and imaging equipment there would be to manually inspect containers at those ports. (On average, ports that load 10,000 containers each year onto U.S.-bound ships would need to inspect about 30 containers per day; ports that load 100 containers per year would need to inspect one container every three days.) Manual inspections involve removing and inspecting the contents of the container and thus raise several issues. First, although manual inspections may be thorough, the lack of nonintrusive imaging or radiation portal monitoring would not meet the statutory requirement to scan and image all containers. Second, who would perform the inspections is not clear. Presumably, CBP personnel would not be present at low-volume ports. CBP would then have to rely on local inspectors, who may lack experience or skill searching for nuclear and radiological threats or may have other loyalties. Finally, removing the cargo from each container can take hours and requires enough people to unpack the container, conduct the inspection, and repack the container. Even at low-volume ports, manual inspections could slow the flow of commerce, especially if those inspections delayed shipments or damaged cargo.

Factors That Might Affect the Costs of Implementing the Requirement to Scan and Image All Containers Overseas

CBO's cost estimates for Options 1 and 2 exclude several factors that are not easily quantified yet probably would affect the feasibility, effectiveness, and cost of implementation:

- CBP might not succeed in negotiating agreements to scan and image containers at all ports and countries;
- Negotiated settlements or legal challenges could result in some additional costs to the federal government; and

24. In 2014, for example, 14 transpacific carriers rerouted inland traffic, diversified port gateways, and leased equipment to account for seasonal demand. See Niels Erich, "Strong Asia–U.S. Cargo Demand, Tight Vessel Space Suggest Early Peak Season," Transpacific Stabilization Agreement press release (April 30, 2014), www.tsacarriers.org/pr_031809.html.

- If CBP did not expand infrastructure enough, shippers and their customers would bear costs—such as from extra moves of containers within ports or delayed shipments.

Challenge of Negotiating With Foreign Governments and Port Operators. Through its Container Security Initiative, CBP has experience establishing container inspection protocols overseas. However, current agreements encompass fewer ports and countries than the mandate for scanning and imaging all containers would require. Because many shippers and foreign governments have not looked favorably on that requirement, negotiating agreements at 453 ports in 130 countries would probably be much more challenging than CBP's previous negotiations.[25] If some agreements were not reached, the federal government's costs would be lower, but less scanning and imaging would occur.

CBP's experience with its Secure Freight Initiative illustrates the challenges that could arise in trying to implement 100 percent scanning and imaging at many ports. Pilot programs for the initiative have operated in six foreign ports. But now only the program at Port Qasim, in Pakistan, continues operations, which CBP funds entirely. The other five participating ports have withdrawn for various reasons. For instance, the Port of Hong Kong withdrew by agreement with DHS after 16 months, citing equipment and infrastructure costs as well as effects on port efficiency.[26]

Costs of Negotiations and Legal Challenges. CBO's estimates exclude possible costs that could arise during negotiations with foreign governments. The estimates also exclude costs from legal challenges over sovereignty, maritime law, and regulatory barriers to trade as well as costs from legal proceedings associated with port operators' rights to inspect transshipped containers passing through their terminals.[27] Finally, CBO's estimates exclude any costs that might arise from disputes involving the World Trade Organization that result in settlements or reciprocal requirements.

Costs of Inadequate Infrastructure. CBO's estimates incorporate the assumption that port operators would reconfigure their ports and build infrastructure to allow additional scanning and imaging without creating extra moves or delays beyond what inbound containers experience today. Using factors it derived from CBP's experience at U.S. ports today, CBO estimated costs to build sufficient infrastructure—such as additional

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25. Jeff Berman, "Mandate for 100 Percent Ocean Container Scanning Blasted by Shippers," *Logistics Management* (June 3, 2014), http://tinyurl.com/blastedbyshippers.

26. Testimony of Stephen L. Caldwell, Director, Homeland Security and Justice, Government Accountability Office, before the Subcommittee on Border and Maritime Security of the House Committee on Homeland Security, *Supply Chain Security: Container Security Programs Have Matured, but Uncertainty Persists Over the Future of 100 Percent Scanning*, GAO-12-422T (February 7, 2012), www.gao.gov/products/GAO-12-422T.

27. Customs and Border Patrol staff at the Automated Targeting Center, personal communication to CBO staff (August 7, 2014).

vehicle lanes, scanning and imaging machines, and storage—to handle the flow of containers at each port. However, if CBP does not supply the scanning and imaging infrastructure necessary to implement the requirement expeditiously, or does not reimburse ports to acquire and build such infrastructure, container scanning and imaging could slow the flow of containers through their terminals. That situation could cause a container to miss the departure of its intended ship, thereby increasing costs for shippers and their customers.

Options to Increase Imaging at U.S. Ports

CBO assessed three options that would not involve scanning and imaging at overseas ports but instead would image more containers at U.S. ports than CBP does now. (CBP already *scans* all containers at U.S. ports.) Option 3 involves CBP's imaging twice as many containers as it does today. Option 4 entails imaging all incoming containers at every U.S. port. Option 5 concerns imaging all incoming containers only at the 32 busiest U.S. ports.

Because Options 3, 4, and 5 do not meet the current requirement for 100 percent scanning and imaging at overseas ports, CBP would not detect threats before they reached U.S. territory. However, imaging more containers at U.S. ports would cost less and be easier than meeting the requirement of the law overseas. Compared with CBP's existing practices, increasing imaging at U.S. ports could also boost the odds of detecting illicit nuclear cargo. In addition, each of those three options would avoid the potentially difficult diplomatic and security issues involved with scanning and imaging at foreign ports.

Option 3: Image 10 Percent of Arriving Containers

Option 3 would preserve CBP's risk-based system but complement it by imaging 10 percent of containers arriving at U.S. ports—about twice the number of containers imaged today.[28] CBO estimates that installing and operating the necessary additional equipment would cost \$1.0 billion to \$1.8 billion over 10 years (or \$7 to \$14 per container if costs are spread over all inbound seaborne containers). That approach would cost significantly less than any other option this study considers. For example, it would cost 95 percent less than Option 1 but would cost 70 percent to 130 percent more than CBP's current approach of imaging 5 percent of containers.

Option 4: Image All Arriving Containers

Under Option 4, CBP would greatly expand imaging operations in the United States from the 5 percent it does today to imaging all containers as they enter U.S. ports. That approach would comply with the goal of scanning and imaging all incoming seaborne

28. The additional containers could be selected randomly or by adjusting the threshold so that lower risk scores trigger inspection.

containers, but the option would not comply with the law's requirement to do that scanning and imaging overseas.

CBO estimates that installing and operating the necessary additional nonintrusive imaging equipment at U.S. ports would cost $4 billion to $8 billion more than the current system over 10 years (or $30 to $50 per container). (CBP already scans every container with radiation portal monitors.) As in Options 1 and 2, the range in CBO's estimate reflects different ways that CBP could scan and image containers. For the higher end of the range, CBP would use the same scanning and imaging equipment at U.S. ports that it does today, but deploy them at fixed facilities. That approach should allow CBP to achieve a throughput of 10 containers per hour. For the lower end of the range, CBP would enhance productivity by using available newer imaging technology, more efficient procedures, or both. Option 4 would cost about $18 billion to $24 billion less than scanning and imaging all containers overseas: It would involve fewer ports, would take advantage of existing equipment and infrastructure, and would avoid the potentially higher costs of basing CBP personnel overseas.

Option 5: Concentrate Imaging at the 32 Busiest U.S. Ports

Under Option 5, CBP would install imaging equipment at the 32 U.S. ports that account for 99.7 percent of all inbound containers. Containers shipped to the remaining 42 ports would have to be routed first to one of the 32 imager-equipped ports. Option 5 would cost between $4 billion and $7 billion over 10 years (or between $30 and $50 per container), CBO estimates. Costs would be 7 percent to 12 percent less than those under Option 4 over 10 years, because Option 5 would avoid the cost of equipping the 42 smaller ports that account for only 0.3 percent of incoming containers. However, both shipping costs and shipping times would increase for containers headed to those smaller ports: Such containers would be shipped instead to one of the large ports, where they would be scanned and imaged before continuing to the smaller port. Containers could be transported by ship, rail, or truck to the smaller ports. If those containers were transported instead by rail or truck, implementing Option 5 would reduce the container traffic entering the 42 smaller ports by ship.

Appendix: CBO's Model of a Generic Port

To estimate costs of scanning and imaging containers, the Congressional Budget Office used a model of generic port operations and data from Customs and Border Protection (CBP) about container flows into the United States in 2014 and the costs of scanning and imaging. For that estimate, CBO expects that the scanning and imaging process would adhere as closely as possible to that described in the Implementing Recommendations of the 9/11 Commission Act of 2007: All shipping containers would be scanned for radiation and would be imaged by a nonintrusive inspection system before being placed on a U.S.-bound ship.[29]

CBO's estimates were based on the premise that the equipment used and the procedures for operating that equipment would follow CBP's current practices at U.S. ports. To ensure that all containers met the requirement for radiation detection, CBO expects that all containers would pass through a radiation portal monitor. Additional scans, which are required when the preliminary and secondary scan or image indicates the possible presence of radioactive material, would also use both handheld and personal radiation detectors. CBO's estimate is not based on a choice of imaging systems for specific ports. Instead, for its base case, CBO estimated the cost and capability according to CBP's existing mix of detectors that are used domestically. CBO also explored how improving the rate of container imaging affects cost.

CBO's analysis suggests that two factors determine the costs of scanning and imaging at a port: the flow of containers through the port that end up on U.S.-bound ships and the number of containers an imaging machine can process in an hour. Those imaging machines are expensive to purchase and to operate and generally take longer to scan a container than radiation portal monitors do. Variations in the configuration of ports and terminals also affect costs. The total cost to implement the mandate to scan or image 100 percent of containers overseas would be the sum of those costs for each port where containers are loaded onto U.S.-bound ships.

Ports and Container Volumes

CBP's data showed that other countries shipped more than 11.5 million containers by sea to the United States in 2014.[30] Those containers were loaded onto U.S.-bound

29. Implementing Recommendations of the 9/11 Commission Act of 2007, Public Law 110-53, 121 Stat. 266.

30. Unlike the maritime industry at large, CBP does not use 20-foot equivalent units as a measure to quantify containers. Therefore, CBP does not distinguish between 20-foot and 40-foot (or other sized) containers in its data. Those data also include ports located in U.S. possessions and territories, such as American Samoa and the U.S. Virgin Islands, that shipped containers to a port in one of the 50 states. Also included are 2,225 containers whose port of lading (where it was placed on a U.S.-bound ship) is classified in the data as "unknown."

ships at 453 ports in 130 countries. The outbound volume from each port ranged from almost 1.5 million containers exported from Shanghai, China, to one container exported from each of 28 other foreign ports. The data for each port included only containers loaded onto a U.S.-bound ship. But those containers could have originated at a different port and been shipped to the port reported in CBP's data before being loaded on a U.S.-bound ship, a process called transshipment. For example, Vietnam exports many containers to the United States, but according to CBP's data, only one was loaded directly on a U.S.-bound ship at the Hai Phong Port in 2014. That fact suggests that most U.S.-bound containers that left Hai Phong were shipped to another port, where they were transshipped onto a U.S.-bound ship. CBP's data did not include information about the origin of the container or whether it had been transshipped. As described below, that lack of specificity affected CBO's ability to model the different types of flows into the ports.

Generic Port Model

Because every port is different, CBO could not model each port and terminal individually. So to describe how exporting ports operate, CBO developed a generic model (see Figure A-1, upper panel) that combined the flow from all the terminals in each port into one value for that port. CBP's data did not include information about how the containers arrived at the port (by ship, rail, or truck) before being loaded onto U.S.-bound ships. That lack of information made it impossible to model the number of machines needed to scan and image each type of traffic flow separately. Therefore, CBO developed a simplified model of a generic port that considers container flow as one stream into the port, regardless of how it arrives there (see Figure A-1, lower panel).

CBO's model for estimating the costs of establishing scanning and imaging capability at overseas ports does not include savings from reducing CBP's current practice of scanning inbound containers. CBO expects that the equipment and personnel engaged in that operation will still be needed for normal customs purposes even if all containers are scanned and imaged overseas. Similarly, because CBP would still use the Automated Targeting System for other customs enforcement even if every container was scanned and imaged overseas, CBO did not consider savings from no longer using that system.

Capacity of Imaging Machines

The throughput of imaging machines—how many containers each machine can image per hour—is a key variable in estimating costs of an overall scanning and imaging system. With lower throughput, ports would require more machines. Having more machines would require more land, people, and maintenance.

CBO examined throughput of several existing nonintrusive inspection machines and estimated three containers per hour as CBP's current average. That value represents a combination of the capacity of the machine itself and how CBP's system uses the machines now. To determine the range of values for faster imaging, CBO examined both new technology that could be deployed in the next several years and improvements in CBP's procedures that could increase throughput. For new installations at overseas ports, CBO's estimates incorporate the assumption that CBP can achieve a throughput of at least 10 containers per hour by using fixed facilities and dedicated crews.[31] From surveys of new technology vendors and discussions with CBP personnel, CBO determined 20 containers per hour as a reasonable upper end for throughput—if the appropriate infrastructure was available to support that rate.[32]

One way to achieve that higher throughput would be to perform scanning and imaging at the same time that a truck carrying a container was checked into the terminal. Wait times for check-in, which takes at least several minutes, are usually longer than the times to scan and image containers.[33] However, scanning and imaging containers during check-in requires scanners and imagers that rely on passive technology because scanners that actively emit radiation to make an image (such as CBP's X-ray and gamma-ray machines) pose health risks to drivers. Therefore, drivers must leave their vehicles, which can cause delays. Experience during the Secure Freight Initiative demonstrations suggests that active scanners also can make truck drivers nervous about possible health effects even with appropriate steps to ensure their safety.[34]

CBP does not use passive imagers today, but several companies have developed them, some of which reportedly cost about the same as today's active scanners.[35] If truck-borne containers are imaged during check-in, however, containers that enter a terminal

31. CBO's estimates for options in which all containers are scanned at U.S. ports incorporate the assumption that each imaging machine would have the same throughput as incorporated in the estimates for foreign ports using current technology and procedures—10 containers per hour. CBO's estimate for the option that boosts the number of containers imaged at U.S. ports from 5 percent to 10 percent incorporates the assumptions that CBP would continue to use its current approach to imaging and that each imaging machine would have the same throughput as CBP achieves today—on average, 3 containers per hour.

32. In CBO's model, the throughput rate for the imagers was an average value based on a mix of 20-foot and 40-foot containers.

33. Allison C. Bennett and Yi Zhuan Chin, "100% Container Scanning: Security Policy Implications for Global Supply Chains" (master's thesis, Engineering Systems Division, Massachusetts Institute of Technology, 2008), p. 128, http://dspace.mit.edu/handle/1721.1/45248.

34. Jayson Ahern, Deputy Commissioner, U.S. Customs and Border Protection, response to written questions submitted by the Honorable Frank R. Lautenberg after a hearing before the Subcommittee on Surface Transportation and Merchant Marine Infrastructure, Safety, and Security of the Senate Committee on Commerce, Science, and Transportation, Supply Chain Security: Secure Freight Initiative and the Implementation of 100 Percent Scanning, S. Hrg. 110-1227 (June 12, 2008), http://go.usa.gov/cuYkJ. See the answer to question 2 in that document's appendix.

35. For example, the manufacturer of the passive muon-based detection system (a muon is a subatomic particle) claims to have about the same cost as active scanners, but it has not yet been sold commercially or approved by CBP. One system does operate at the port in Freeport, Bahamas.

by other means—such as by rail, feeder vessel, or barge—would still require a scanning and imaging facility inside the terminal.[36] CBO's simplified model of a generic port includes scanning and imaging of containers that arrive by rail, feeder vessel, and barge.

Container Flows and Port Configurations

Although U.S.-bound container traffic has grown steadily, the growth rate has fluctuated. For example, between 2012 and 2013, container traffic grew by about 0.2 percent, whereas it grew by 5.0 percent from 2013 to 2014. For this analysis, CBO used a growth rate of 2.5 percent—about the average annual rate over the past 10 years. Also, a trend toward larger ships and the upcoming opening of the larger Panama Canal means that traffic patterns for inbound containers will shift. Most likely, flows to some ports on the east coast of the United States will increase and flows to ports on the west coast will decrease. But the precise distribution of the effects is hard to predict and unlikely to affect the total flow of containers to U.S. ports.

The data from CBP that CBO used did not indicate which terminal in a port loaded the container. Some ports have multiple terminals; others do not (see Figure A-2). CBO's model grouped all container terminals at a port into a single entity for that port and adjusted the equipment needed for multiple terminals with a dispersion factor that varied by port size. Large ports that would have multiple machines had no dispersion factor because they could distribute the machines as needed. Similarly, small ports with only one machine would not have enough traffic to justify additional machines, and in practice such ports usually have only one terminal. For midsized ports that handle 10,000 to 100,000 containers per year, however, CBO increased the number of machines needed to account for multiple terminals.[37] CBO checked the results against terminals for several ports. On average, the model's estimated numbers of machines per terminal and terminals per port matched those of actual ports reasonably well.

Because scanning and imaging machines are not always available (they sometimes need maintenance and repairs), CBO's estimates also included extra machines to account for that down time (known as the operational availability factor).

36. New technology may change this situation. For example, the Port of Rotterdam installed a system that can scan rail-mounted containers at train speeds up to 35 miles per hour. That scanner is set up outside the port with operators monitoring the scanner from several miles away. See Andrew Goldsmith, "Port of Rotterdam's Ability to Scan Cargo on Trains Moving at 35 mph Accelerates Screening With No Loss of Security," *Government Security News* (July 22, 2014), http://tinyurl.com/portrotterdam.

37. The dispersion factor measures how efficiently the scanners and imagers can be spread across the terminals. Midsized ports with more than one terminal might need more scanners or imagers per 1,000 containers than a port with larger terminals. Each terminal would need at least one scanner and one imager even if it exports only a fraction of the scanner's or imager's capacity to the United States each year.

The literature about scanning and imaging containers often describes how delays resulting from increased scanning and imaging might affect costs for shippers. Keeping trade flowing is important to the health of the global economy. CBO's model, based on operations at U.S. ports, built in enough scanning and imaging machines; personnel; and real estate for lanes, storage, and office space to match the average flows at each port. That approach incorporates the expectation that ports would smooth the flow of inbound trucks, trains, and ships to avoid large spikes in flows—a practice that some port operators have instituted.[38] With resources properly allocated, container traffic would not be delayed any more than it is for U.S.-bound containers arriving by sea.

Construction, Land, and Installation

Installing scanners and imagers requires construction and land on which to build. CBO estimated that each imaging machine would require one acre of land and just under $1 million per acre in construction costs. CBO based the construction costs on its survey of costs to construct similar facilities in the United States. The estimate includes the costs for road lanes, fencing, offices, lighting, and container-handling trucks and stackers. The cost of the land is not included unless dredging would be used to create the land.

Once containers are scanned and imaged, they must be stored in a secure area until they are loaded onto a U.S.-bound ship. Storage would not require much additional land, because the containers are already stored at the terminals until the ship arrives. But ports would have to create secure storage areas to separate scanned from unscanned containers. Those secure areas would require fencing and access lanes. Therefore, CBO included costs for preparing land for container storage at a rate of 20 percent of the per-acre construction cost that it used for installing scanners and imagers. CBO used an industry standard of 150 containers per acre. In CBO's model, a U.S.-bound ship would visit the port every seven days. Therefore, the container storage area would have to be large enough to hold seven days of container flow (an estimate CBO based on the average annual flow).

At many container terminals, land is at a premium (Figure A-3 shows the congestion at a large port). Many rely on dredging and landfill to expand the terminal area because existing land is fully occupied. Some terminals may not have land available for scanning and imaging infrastructure in their present configuration. However, many container terminals are redesigning their facilities and planning expansion projects to accommodate the new, very large Super Post-Panamax container ships, which have a capacity of 18,000 TEU or greater (see Figure 1-1). That process would serve as a good opportunity for terminals to incorporate areas for scanning infrastructure.

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38. Allison C. Bennett and Yi Zhuan Chin, "100% Container Scanning: Security Policy Implications for Global Supply Chains" (master's thesis, Engineering Systems Division, Massachusetts Institute of Technology, 2008), http://dspace.mit.edu/handle/1721.1/45248.

Representatives of some terminals across the world have stated that they plan to do so to gain a competitive advantage over other terminals.[39]

CBO's estimates include costs to construct additional port space for truck lanes, to house the nonintrusive inspection devices, and to store containers waiting to be scanned. The estimates also incorporate costs for setup, shipping the machines to overseas ports, and constructing secure storage areas. The estimates do not include the cost of additional moves that might be needed within a port terminal to transport containers to and from the area for nonintrusive inspection.

Few, if any, ports are configured to scan or image transshipped containers. This study includes costs that ports would incur to invest in infrastructure to efficiently scan and image containers entering on other ships for transshipment. Usually, each terminal would need a facility to enable local in-terminal trucks to haul the containers. That aspect of implementing the law's mandate is perhaps the largest break from current practice because few transshipment ports scan or image transshipped containers.

Nonintrusive Imaging Machines

In its review of nonintrusive imaging machines fielded at U.S. ports, CBO examined an assortment of systems and vendors now operating at the ports. Part of that variety is attributable to the different applications for nonintrusive inspection (for example, fixed facilities for trucks, mobile systems for containers at pier side, or systems to image cargo loaded on pallets). In addition, whether the available nonintrusive inspection systems are operating at capacity is unclear; if they are not, which nonintrusive inspection systems are in use and which are not also is unclear. CBP will have to decide which nonintrusive inspection systems are most appropriate for which foreign port.

Radiation Portal Monitors

For every two nonintrusive inspection machines in the model, CBO added a radiation portal monitor. The radiation portal monitors can scan more quickly than existing nonintrusive inspection machines. Therefore, in CBO's judgment, one radiation portal monitor can handle the flow possible from two slower nonintrusive inspection machines.

Secondary Radiation Detectors

Besides radiation portal monitors, U.S. ports use two other devices to detect radiation: personal radiation monitors and handheld devices that identify the type of radioactive material. Both are used for container inspections. Meeting the mandate to image all containers at overseas ports would require purchasing a substantial number of both devices. In its cost estimate, CBO projected that each nonintrusive imaging machine at a foreign port would require four radioisotope identification devices. CBO did not include the cost of the personal devices in its estimate because that cost is very small.

39. See "For Khalifa Port Security Solution, AS&E Taking Integration Up a Notch," *American Science and Engineering News* (January 15, 2013), http://tinyurl.com/khalifa-portsecurity.

Operating Expenses

CBO estimates that CBP spends about $172 million per year to operate and maintain the current scanning and imaging system for all U.S. ports, including labor costs. CBO used those costs, which recur each year, to calculate how much the additional machines would cost to operate. In CBO's estimate, the cost of machine operators and maintainers in overseas ports is the same as the cost of stationing CBP personnel at those ports. Although some foreign ports might allow CBP personnel to operate the machines, other ports might not. If personnel from the host country operate the equipment and cost less than CBP personnel, the cost to implement the mandate could be lower.

About This Document

This Congressional Budget Office report was prepared at the request of the Chairman and Ranking Member of the Subcommittee on Homeland Security of the House Committee on Appropriations. In accordance with CBO's mandate to provide objective, impartial analysis, the report makes no recommendations.

Bernard Kempinski of CBO's National Security Division and Chris Murphy (formerly of CBO's National Security Division) prepared the report, with guidance from Matthew Goldberg and David Mosher. David Arthur, David Austin, Kim Cawley, and Joseph Kile of CBO offered comments on the report, as did Michael Schmitz, director of the World Customs Organization from 2005 to 2010, and several experts from the Department of Homeland Security and other government agencies. (The assistance from external reviewers implies no responsibility for the final product, which rests solely with CBO.)

Jeffrey Kling, John Skeen, and Robert Sunshine reviewed the report; Gabe Waggoner edited it; Maureen Costantino prepared the graphics and produced the cover; and Jeanine Rees and Gabe Waggoner prepared the report for publication. An electronic version is available on CBO's website (www.cbo.gov/publication/51478).

Keith Hall Director

June 2016

Summary Table 1. n to Reference 1,

Configuration and Costs of the Current Container Scanning and Imaging Program and Five Options

	Number of Ports That Perform Scanning and Imaging	Number of NII Machines Purchased	Number of RPMs Purchased	Estimated Cost Over 10 Years (Billions of 2015 dollars): Current Procedures and Equipment	Estimated Cost Over 10 Years (Billions of 2015 dollars): New Procedures and Equipment
Current Scanning and Imaging Program	74[a]	92[b]	366[b]	1.3	n.a.
Scan and Image All U.S.-Bound Containers Overseas					
Option 1[c] Scan and Image at All Overseas Ports	453	495–557	471–498	32.0	22.1
Option 2 Concentrate Scanning and Imaging at the Top 121 Overseas Ports	121	163–225	139–166	22.1	12.1
Increase Imaging of Arriving Containers					
Option 3 Image 10 Percent of Arriving Containers	74	74–87	0	1.8	1.0
Option 4 Image All Arriving Containers	74	139–221	0	7.6	4.3
Option 5 Concentrate Imaging at the Top 32 U.S. Ports	32	97–179	0	7.1	3.8
Memorandum: Scan and Image All Containers Exported From U.S. Ports	74	140–229	103–148	31.4	14.5

Source: Congressional Budget Office, using data from Customs and Border Protection (CBP).

Options incorporate the assumption that CBP personnel would operate scanning and imaging equipment at overseas ports. Ranges in the numbers of nonintrusive imaging (NII) machines and radiation portal monitors (RPMs) reflect current technology and procedures (lower end) to new technology or improved procedures (higher end).

n.a. = not applicable.

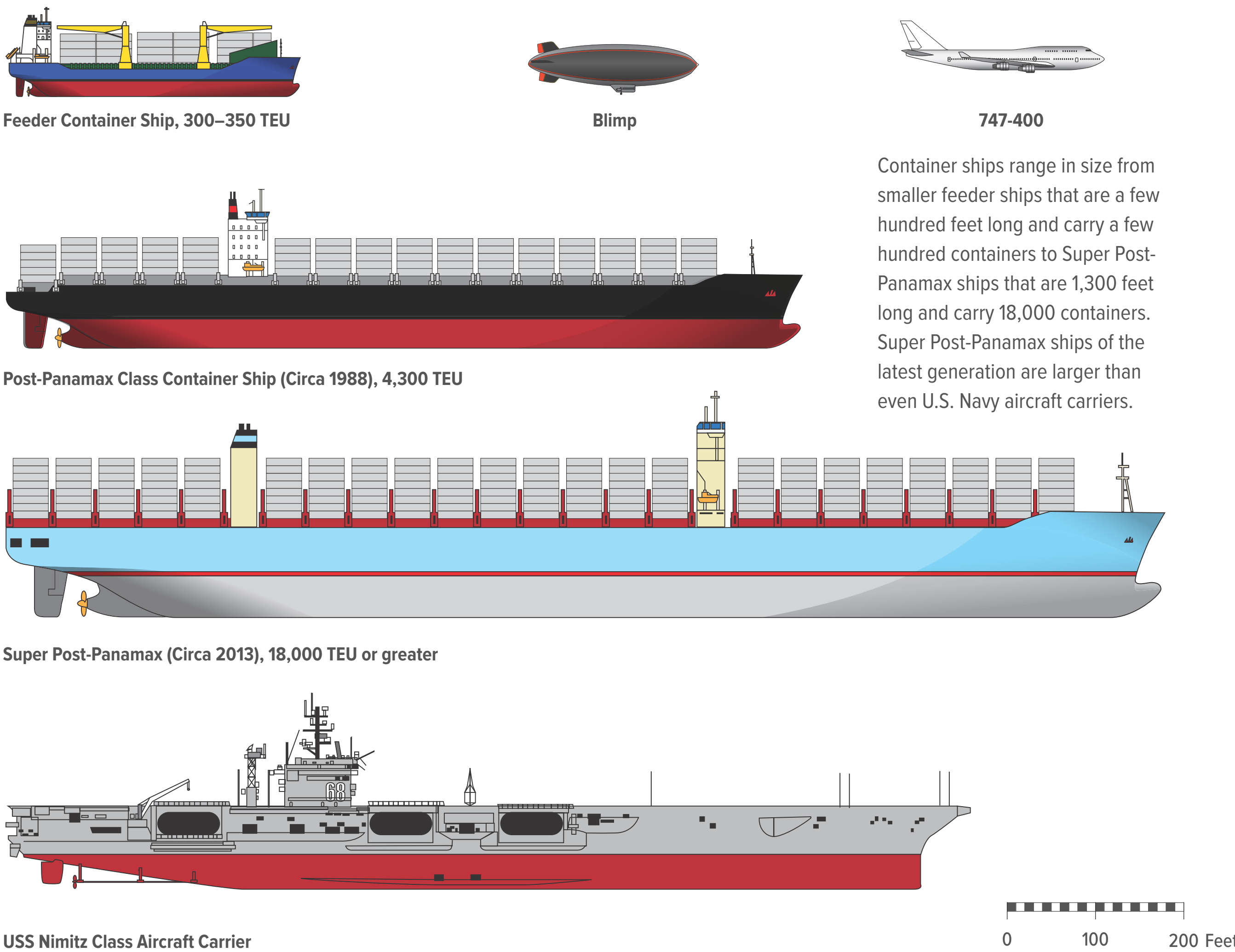
a. Of the 74 U.S. ports that receive containers, only 29 have imaging equipment.

b. Existing machines.

c. If other countries required the United States to scan and image all containers exported from U.S. ports in response to the U.S. requirement to scan and image U.S.-bound containers at foreign ports, the cost of Option 1 and Option 2 would roughly double. With the cost of scanning U.S. exports added (see "Memorandum"), the cost range of Option 1 would rise to $36.6 billion to $63.5 billion over 10 years, and the cost range of Option 2 would be $26.6 billion to $53.5 billion over 10 years.

Figure 1-1. n to Reference 1,

Size and Capacity of Commercial Container Ships



Source: Congressional Budget Office.

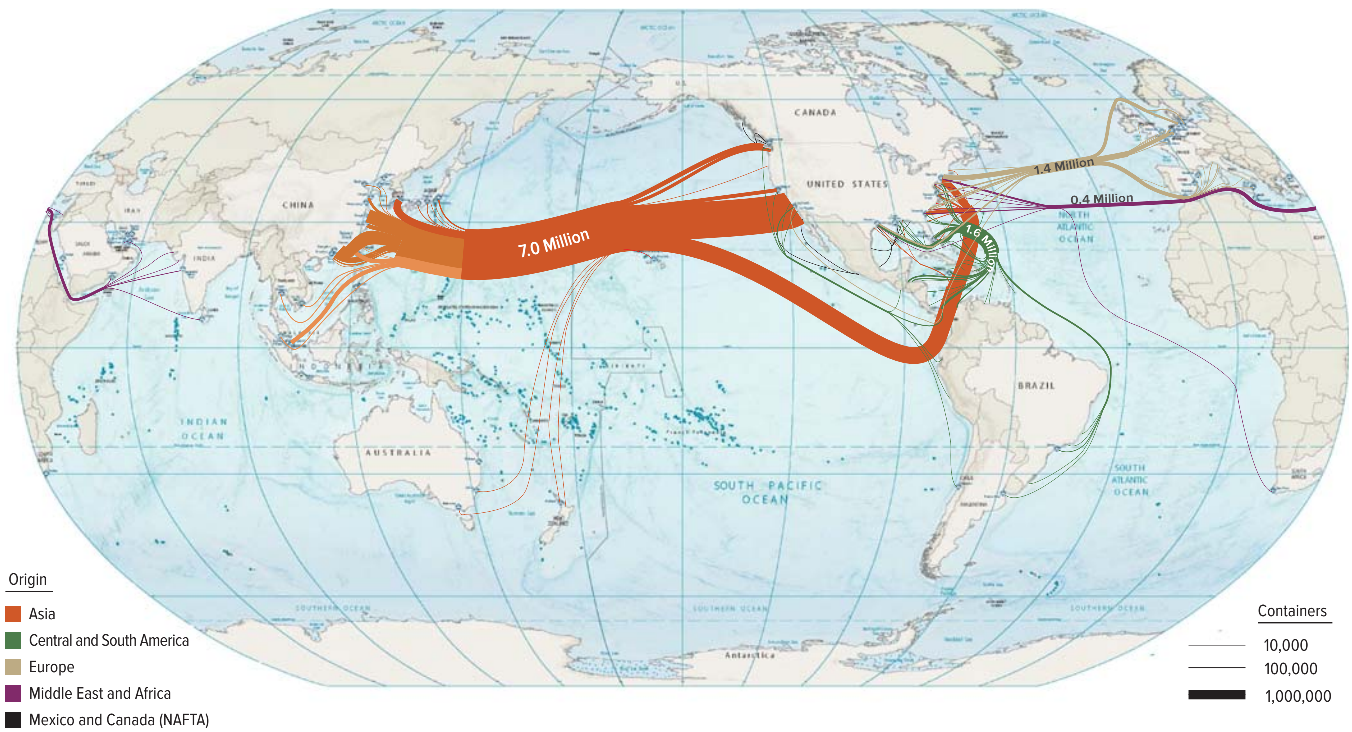
The blimp, 747-400 airplane, and Nimitz class aircraft carrier are shown for scale only.

Panamax container ships carry that designation because they are the largest container ships that can still pass through the Panama Canal. They can support a container load of 4,000–5,000 TEUs.

TEU = 20-foot equivalent unit.

Figure 1-2. Return to Reference

Container Traffic Flow to the United States, 2014



Source: Congressional Budget Office, using data from Customs and Border Protection.

For readability, ports that exported fewer than 10,000 containers to the United States in 2014 are not shown. The chart includes 100 foreign ports and 32 U.S. receiving ports. Together, the 42 U.S. ports not shown received a total of 37,000 containers in 2014.

Paths are generic and do not show the actual routes that ships would take. The figure does not show the port of origin for containers sent to a major port for transshipment. In those cases, the figure shows the transshipment point as the point of origin.

Asian ports have different colors at the origin but are grouped into one color as they approach the United States.

For containers arriving from Canada and Mexico (NAFTA), only those arriving by sea are shown.

NAFTA = North American Free Trade Agreement.

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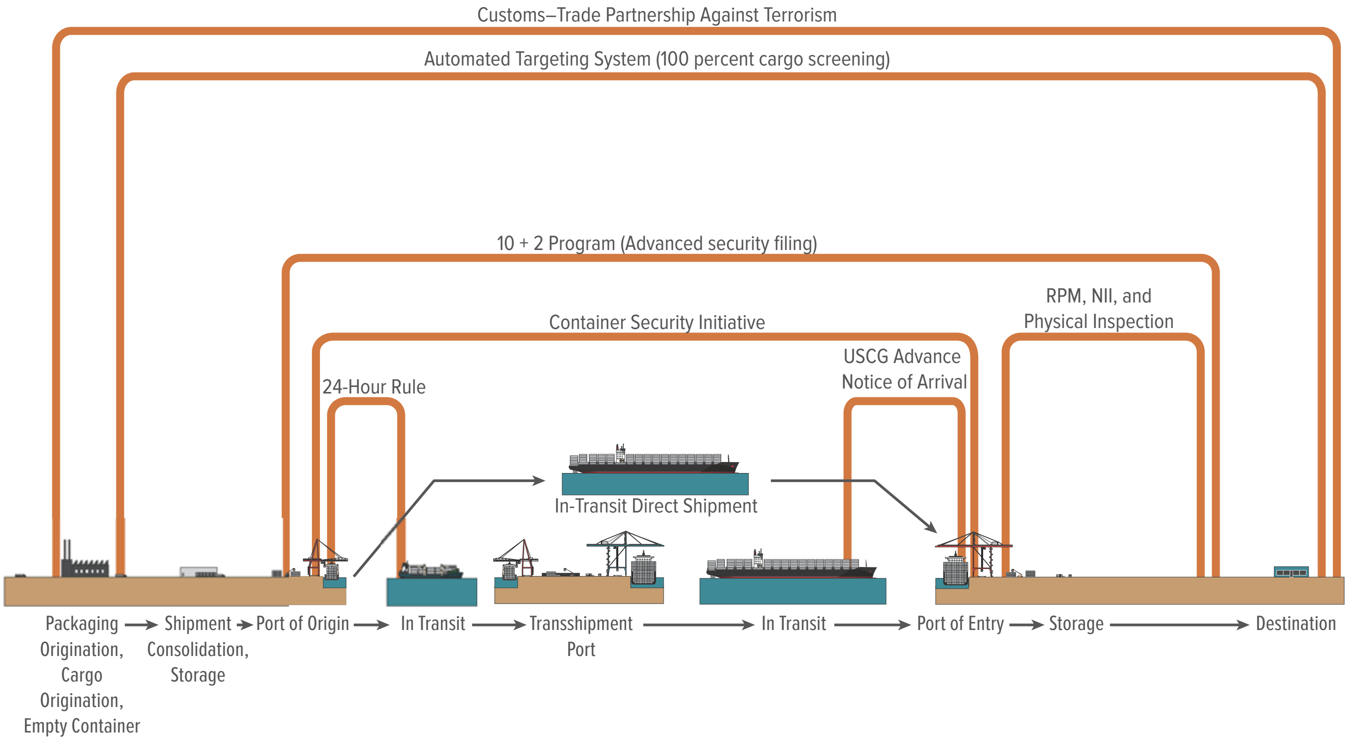
Figure 1-3.

Layered Defense Strategy of U.S. Customs and Border Protection

The figure shows the container delivery system from initial manufacture of goods, through packing and loading onto a container ship, and through arrival at a U.S. port and delivery to the final customer. Mapped against this delivery system are programs CBP describes as its layered defense against overseas threats delivered via shipping containers, with each layer indicated by the placement of the curves.



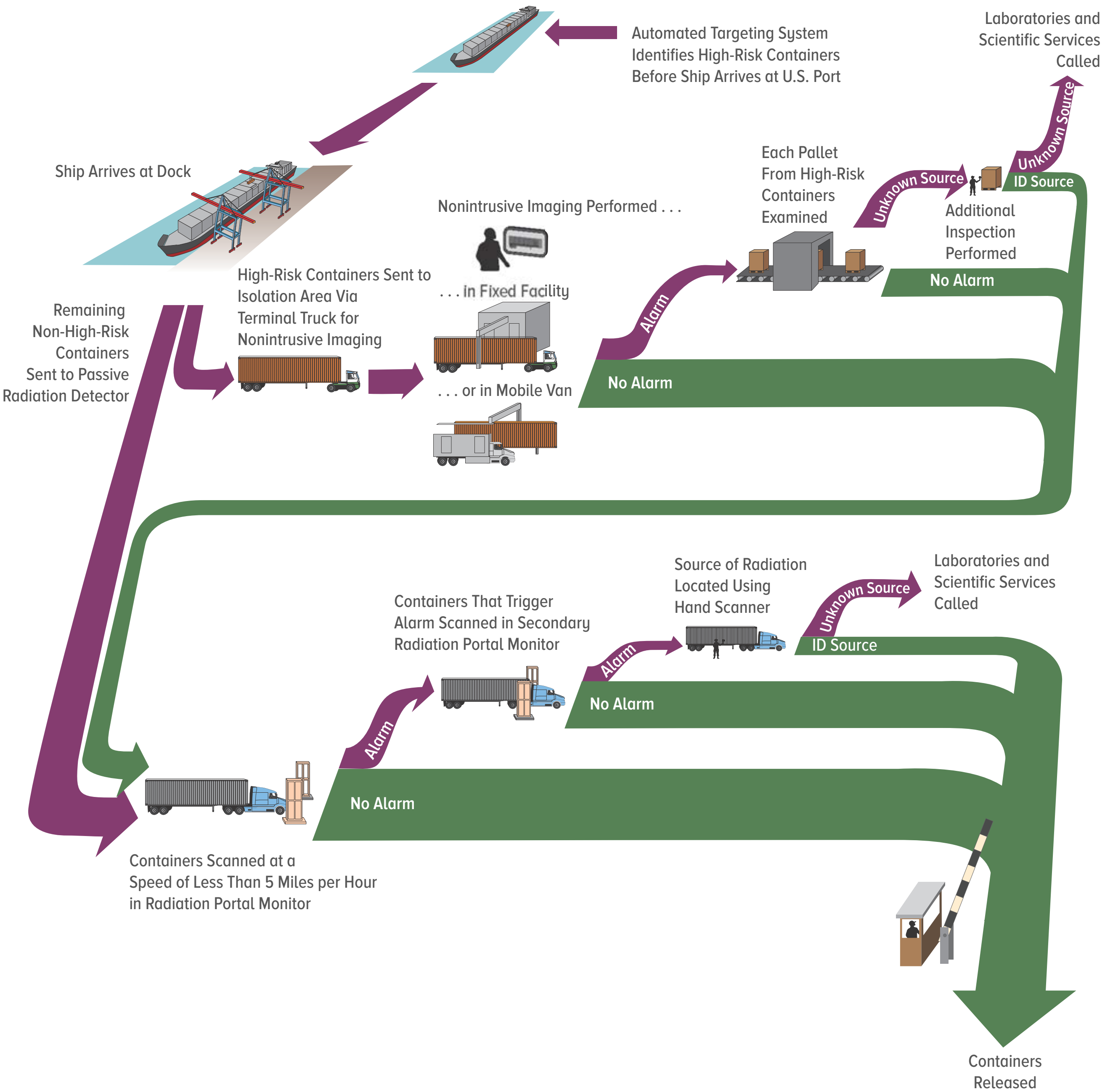
Source: Congressional Budget Office, using data from Customs and Border Protection (CBP).

NII = nonintrusive imaging; RPM = radiation portal monitor; USCG = U.S. Coast Guard.

Figure 1-4.

Return to Reference

Current Approach to Scanning and Imaging Containers Arriving at U.S. Ports



Source: Congressional Budget Office, using information from Customs and Border Protection.

Box 1-1.

Return to Reference

Detecting Nuclear and Radiological Materials

Two types of threat devices can be constructed with materials that emit radiation: a nuclear weapon and a radiological dispersal device (also called a radiological weapon or dirty bomb). A nuclear weapon uses fissile materials (plutonium or highly enriched uranium) to initiate a nuclear chain reaction that splits an atom's nucleus into smaller components. That reaction rapidly releases radiation and heat, which create a large blast and long-term radioactive fallout that are characteristic of nuclear bombs. By contrast, a radiological weapon does not result in nuclear chain reaction. Instead, the device spreads radioactive material to contaminate a wide area, often by using conventional explosives.

The material for both types of weapons emits detectable radiation that results from radioactive decay. Four types of radiation are associated with radioactive materials: alpha, beta, gamma, and neutron. Alpha and beta particles are stopped after passing through short distances in air or small amounts of denser materials and therefore are difficult to detect outside a container's walls. Gamma and neutron radiation, however, can travel through container walls and are more easily detected.

The radiological materials best suited for a radiological weapon tend to be highly radioactive and to emit much easily detectable radiation (although some exceptions exist). But some fissile materials useful for making nuclear weapons (particularly highly enriched uranium) are harder to detect because they have low levels of radioactivity. Those fissile materials can also be shielded with dense materials such as lead or bricks, which absorb some of the gamma or neutron radiation and thus make them harder to detect. The passive radiation detectors placed outside shipping containers can usually detect emissions from materials for radiological weapons but are less effective at detecting emissions from nuclear weapons and the fissile materials used to make them.[40] The portal radiation monitors that Customs and Border Protection (CBP) uses today are of that type.

Further complicating the detection task is the fact that some common materials, such as cat litter, bananas, and ceramics and glazes from certain parts of the world, are naturally radioactive and can trigger an alarm on a detector. Also, radioactivity has been found in some consumer goods that should not have it—usually items made from recycled metal that have inadvertently become contaminated by radioactive sources disposed of inappropriately.

To address passive detectors' limitations for finding fissile materials, CBP can take X-ray (or gamma-ray) images of the contents of a container to look for dense objects that could be fissile materials or shielding for fissile materials. Under current policies, CBP images only the 5 percent of containers that it has determined to be high risk. The Department of Homeland Security and the Department of Energy have funded several programs to improve CBP's radiation monitoring capability at an affordable price, but to date none have succeeded.

40. Testimony of JayEtta Z. Hecker, Director, Physical Infrastructure Issues, General Accounting Office (now the Government Accountability Office), before the Subcommittee on National Security, Veterans Affairs, and International Relations of the House Committee on Government Reform, *Container Security: Current Efforts to Detect Nuclear Materials, New Initiatives, and Challenges*, GAO-03-297T (November 18, 2002), www.gao.gov/products/GAO-03-297T.

Box 2-1. Return to Reference

Choosing Between Scanning Containers and Other Activities That Could Deter Attacks

This report focuses on scanning and imaging shipping containers to clarify the implications of complying with the current law and related alternatives. However, smugglers have many ways to bring a nuclear weapon or radiological device into the country. So to protect the United States from such an attack, policymakers should consider all the pathways a terrorist group could use and strive to allocate limited resources in a way that minimizes the overall risk of such an attack.

The main objective of increased scanning and imaging of seaborne containers is to reduce the chances that they will be used in an attack. The hope is that increased security will either deter someone from trying to use containers in an attack or will thwart such an attack if not deterred. Similarly, increased monitoring of other delivery methods could reduce the risks of an attack using those methods. Also, attacks could be deterred or prevented by disrupting them in the planning stages. For example, the materials to make weapons could be made harder to acquire, or more intelligence could be gathered about groups that might be planning an attack. All those activities require resources.

The choice between providing resources to increase the scanning and imaging of seaborne containers versus increasing deterrence and prevention against attacks using other methods involves trade-offs. If spending on more scanning and imaging of containers would reduce the chances of an attack more than spending on deterring attacks using other pathways would, it would be the most efficient use of any given amount of spending on deterrence. But if some method of delivery other than a container was significantly more likely to result in a successful attack under current policies, potential attackers would probably use that method; additional spending on scanning of containers would consequently have little or no deterrent effect in that case.

The Congressional Budget Office has no basis to gauge how the probabilities of successful attacks vary by method of delivery or how allocating any given amount of spending to different types of deterrence would affect the overall probability of an attack. If those probabilities could be estimated reliably, they would be helpful to policymakers making decisions about funding for homeland security.

Table 2-1.

Return to Reference

10-Year Costs for Option 1: Scan and Image at All Overseas Ports

Investment	Cost (Billions of 2015 dollars): Current Procedures and Equipment	Cost (Billions of 2015 dollars): New Procedures and Equipment	Number Purchased: Current Procedures and Equipment	Number Purchased: New Procedures and Equipment
Purchase Equipment				
Nonintrusive imaging equipment	1.7	1.6	557	495
Radiation portal monitors	0.5	0.5	498	471
Radioisotope identification detectors	*	*	2228	1980
Construction, setup, and shipping	1.0	0.9	n.a.	n.a.
Storage areas for scanned containers	0.4	0.4	n.a.	n.a.
Total Investment	3.6	3.3		
Operation and Maintenance (10 years)				
Nonintrusive imaging equipment	18.0	11.4	n.a.	n.a.
Radiation portal monitors	10.4	7.4	n.a.	n.a.
Radioisotope identification detectors	0.1	0.1	n.a.	n.a.
Total Operation and Maintenance	28.4	18.8	n.a.	n.a.
Total 10-Year Costs	**32.0**	**22.1**		

Source: Congressional Budget Office, using data from Customs and Border Protection (CBP).

Option 1 incorporates the assumption that CBP would implement 100 percent scanning and imaging at all 453 ports that loaded containers on U.S.-bound ships in fiscal year 2014.

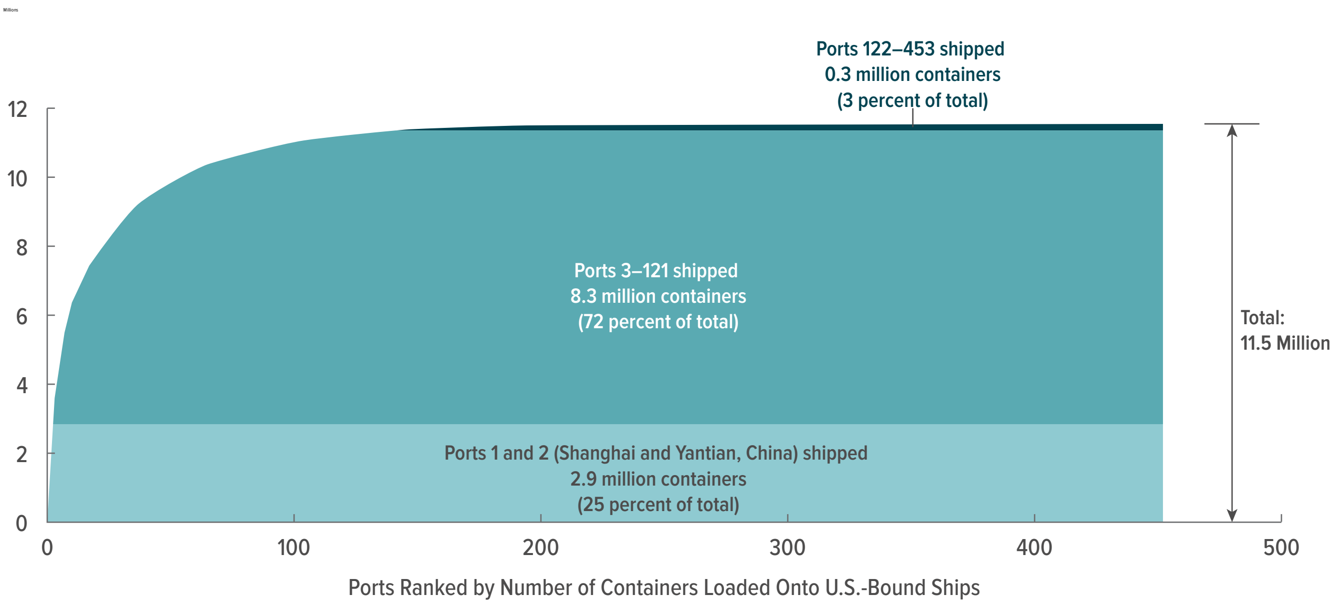
Costs are rounded to the nearest $100 million and may not add up to totals because of rounding.

n.a. = not applicable; * = between zero and $50 million.

Figure 2-1.

Return to Reference

Number of Containers Loaded Onto U.S.-Bound Ships, 2014

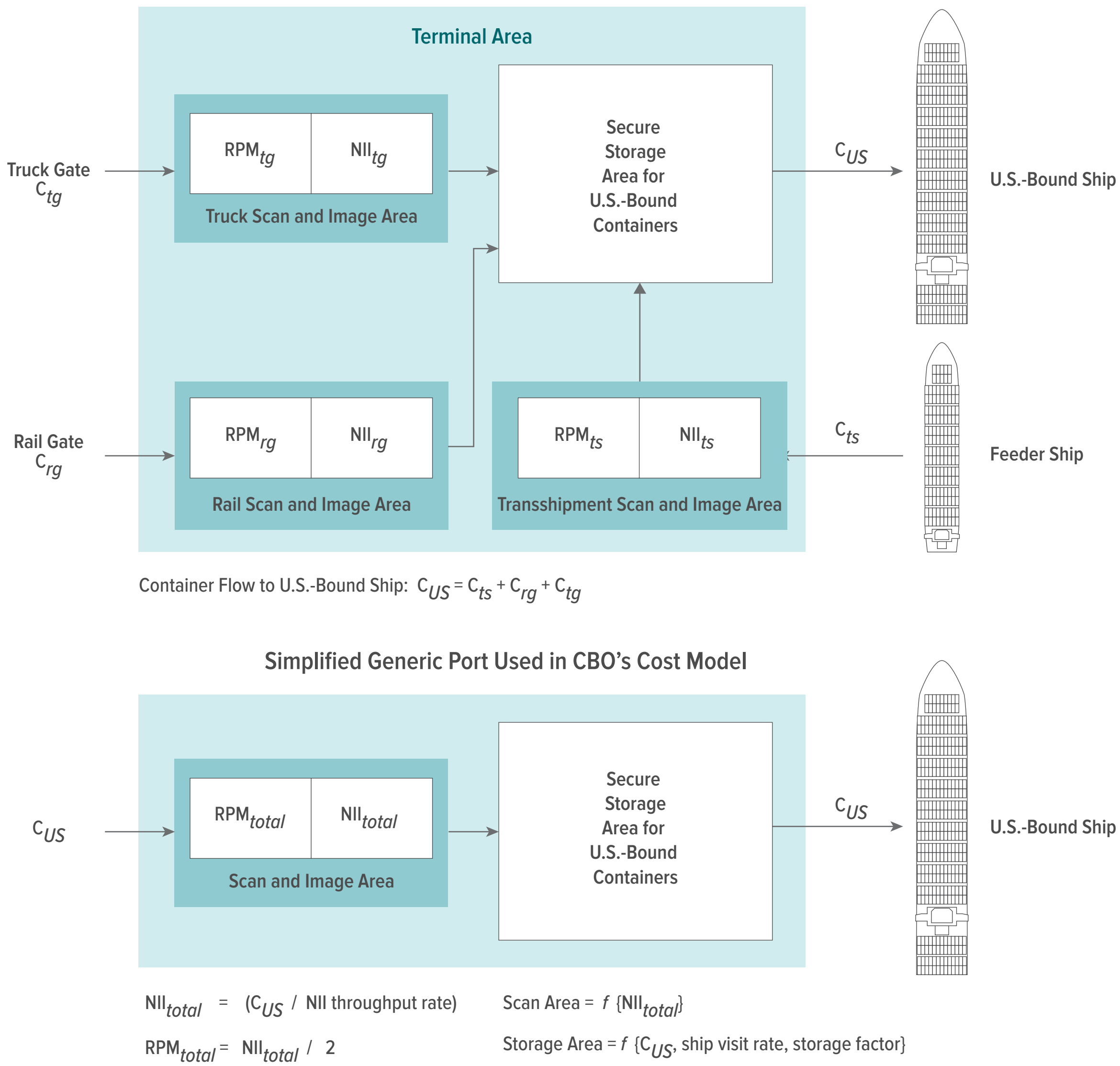


Source: Congressional Budget Office, using data from Customs and Border Protection.

Figure A-1. n to Reference 1,

Generic Port Used in Cost Model With 100 Percent Scanning and Imaging

Container Flow in a Generic Port With 100 Percent Scanning and Imaging



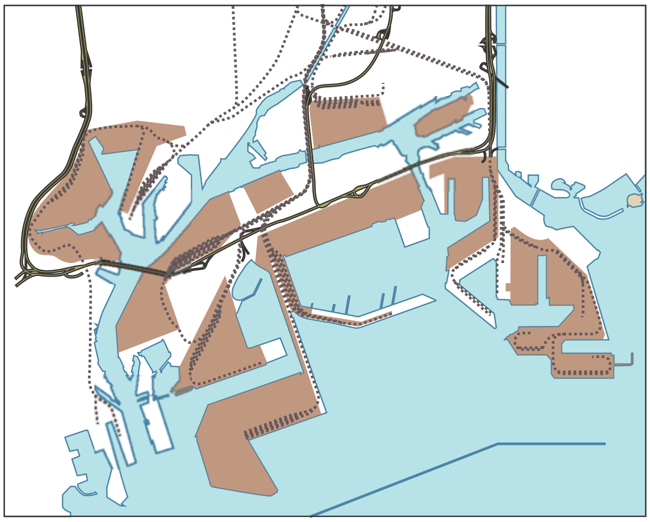
Source: Congressional Budget Office.

C = number of containers; NII = nonintrusive imaging; rg = rail gate; RPM = radiation portal monitor; tg = truck gate; ts = transshipped; US = United States.

Figure A-2.

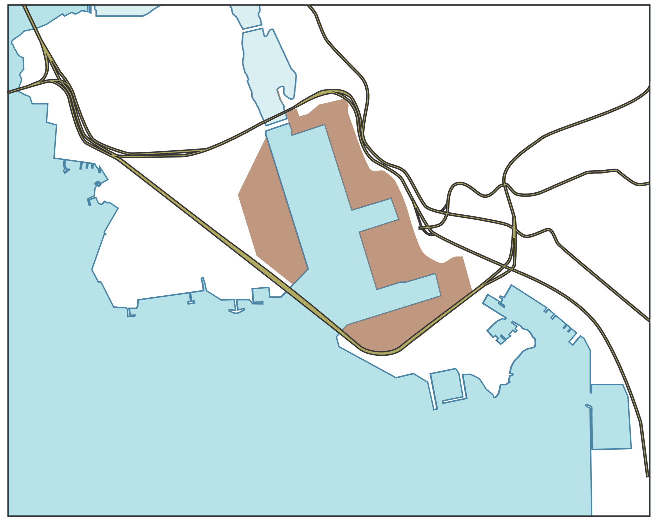
n to Reference

Selected Container Ports Compared by Size, Number of Terminals, and Annual Container Flow



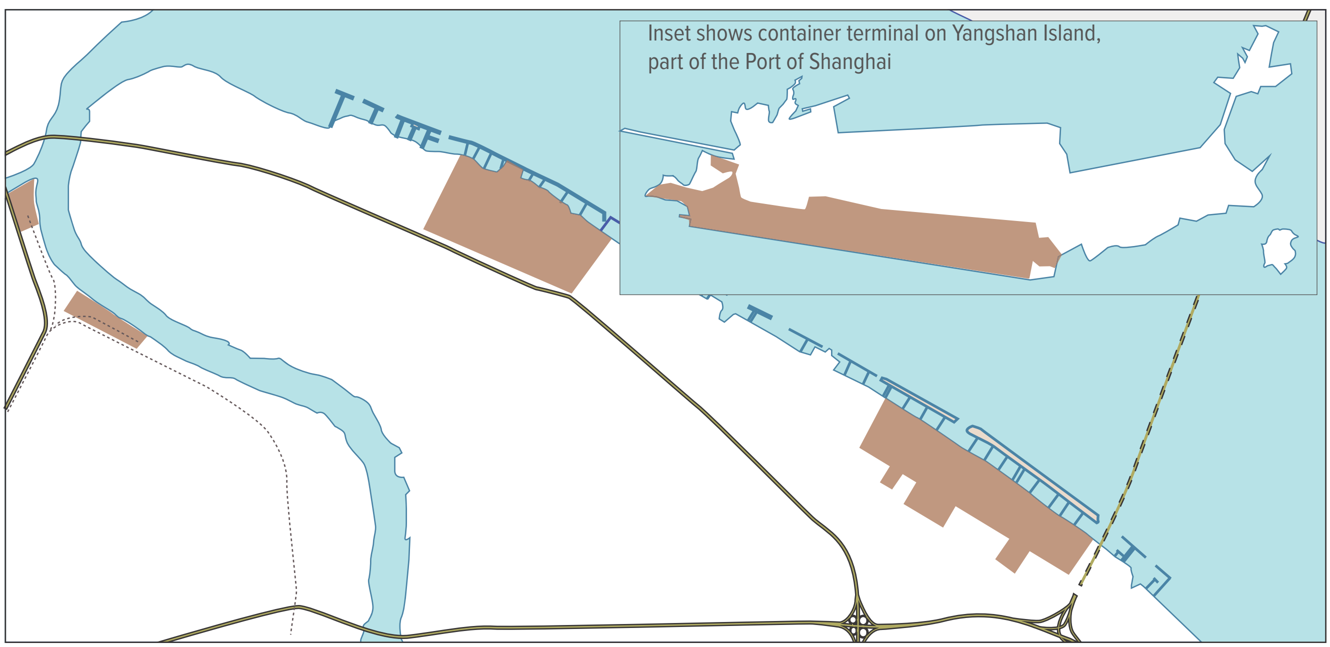
Port of Los Angeles Port of Long Beach

Approximately 13 Terminals With
4 Million Arriving Containers



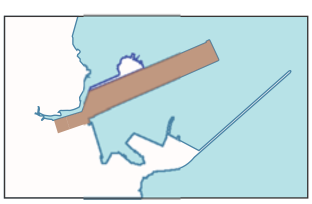
Port of Hong Kong

Approximately 9 Terminals With
0.5 Million U.S.-Bound Containers



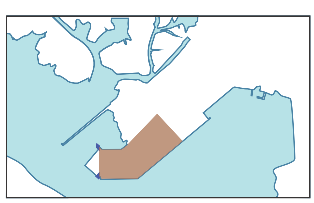
Port of Shanghai, China

Approximately 3 Terminals With
1.5 Million U.S.-Bound Containers



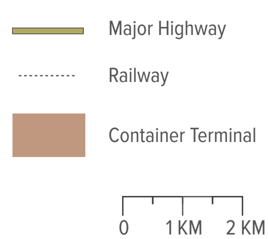
Port of Shalalah, Oman

1 Terminal With
94,000 U.S.-Bound Containers



Port of Qasim, Pakistan

1 Terminal With
32,000 U.S.-Bound Containers

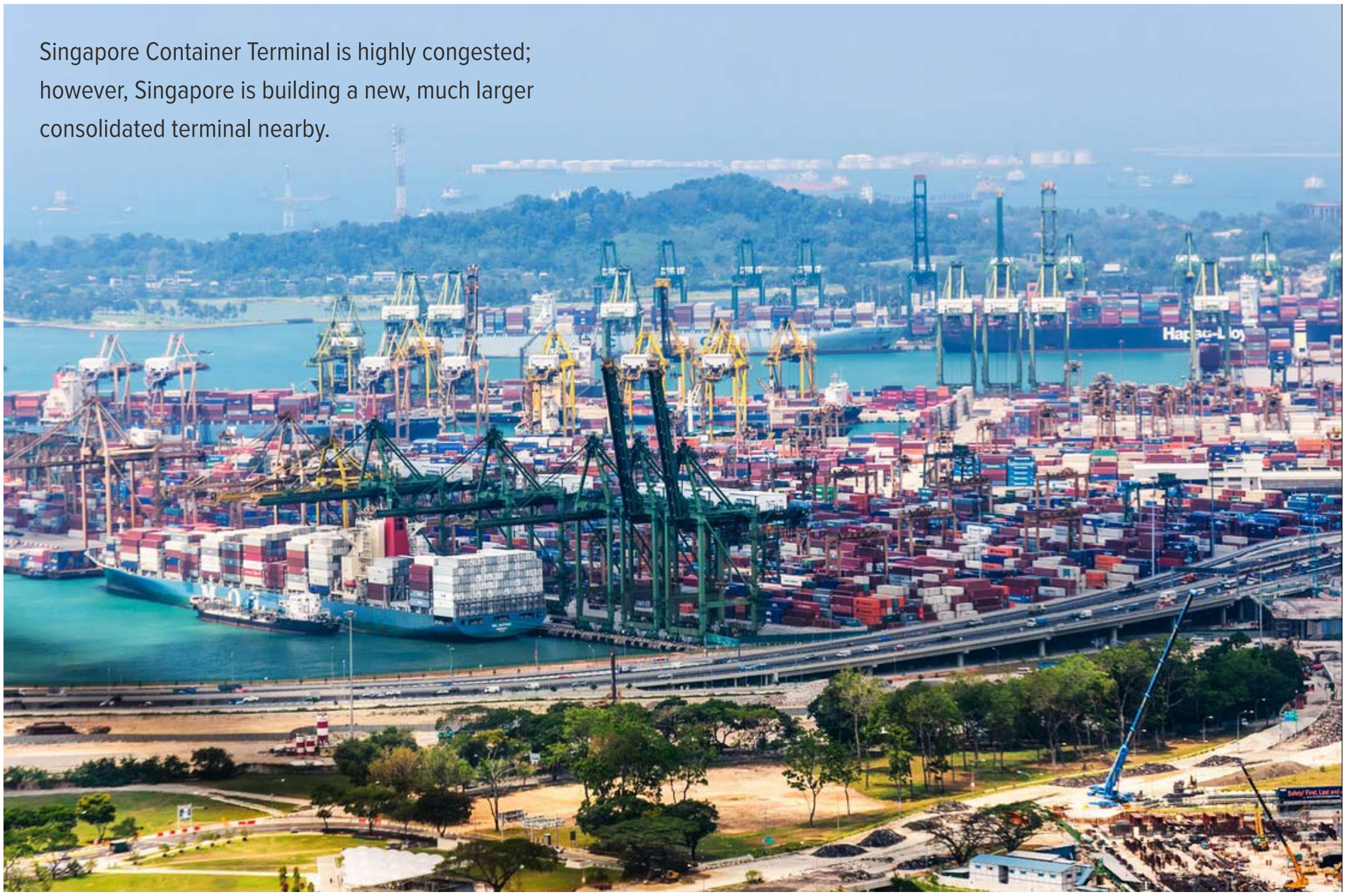


Source: Congressional Budget Office.

Figure A-3.

Return to Reference

Singapore Container Terminal



Singapore Container Terminal is highly congested; however, Singapore is building a new, much larger consolidated terminal nearby.

Source: Photo by Edwin Bundy (used with permission).