

# Rapiscan Eagle<sup>®</sup> M60 Mobile Cargo Inspection System



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## Revisions

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# 1 OVERVIEW

The Rapiscan Eagle® M60 (“Eagle M60”) is a member of Rapiscan’s M-Series of mobile cargo and vehicle inspection systems capable of driving on public roads. The Eagle M60 is designed to scan trucks and cargo containers to verify the contents and to identify the presence of hidden contraband, such as weapons, explosives and narcotics. Optional capabilities to help find low density contraband and radioactive material in cargo are available with the Eagle M60. The unit is fully self-contained with all of the equipment and features required to perform inspections at locations, such as seaports, border crossings and roadside checkpoints.

The Eagle M60 has a 6 MV X-ray imaging system with the detector array mounted in an L-shaped boom. The boom is stowed for transport and then deployed to form the inspection tunnel. The Eagle M60 scans by driving past one or more unoccupied stationary objects in the forward or reverse direction. It also has optional drive-thru scan modes that scan trucks as they drive through the stationary inspection tunnel. The Eagle M60 is available with an inspection tunnel option to enable scanning up to 5 m tall objects.

The Eagle M60 produces a high-quality X-ray image of a vehicle or cargo container and its contents, which is immediately displayed on a monitor in the onboard Inspector Cab. The onboard inspector then evaluates the image using the comprehensive features of the Rapiscan Cargo Viewer software. Images can also be sent wirelessly to a nearby inspection office for review by off-board inspectors.

The Eagle M60 has a unique combination of features:

- **A 6 MV X-ray imaging system.** The Eagle M60 has the most powerful X-ray inspection system available on a mobile scanner. Its 6 MV X-ray imaging system penetrates and creates an image of dense and densely-packed cargo, which would otherwise have to be manually inspected.
- **Rapiscan’s material separation technology.** The Eagle M60 is the only Rapiscan M-Series mobile product with optional material separation technology, which helps the inspector find low density contraband, such as explosives and narcotics. These low density materials appear differently in the X-ray image than high density materials, such as steel. The material separation capability requires the optional 6 MV dual-energy X-ray generator available with the Eagle M60.
- **Large object scanning capability.** The Eagle M60 is available with the largest inspection tunnel of all Eagle scanners. The inspection tunnel enables scanning of objects up to 5 m tall.

The Eagle M60 offers best-in-class X-ray inspection and operational features in an easily-deployable mobile system.

- Mobile unit meets local road regulations
- All needed inspection capabilities onboard
- Two onboard inspectors
- Drive-by scanning of stationary, unoccupied vehicles
- Continuously scan multiple objects
- 6 MV X-ray imaging system
- Industry leading X-ray imaging quality
- Easy-to-use Rapiscan Cargo Viewer software
- Meets radiation safety standards
- Easy to maintain

Options available with the Eagle M60 include

- Drive-thru portal scan mode

- Third onboard inspector station
- Operator assist tools to increase inspection efficiency
- Material separation technology with the optional dual-energy X-ray generator
- Gamma or gamma and neutron radiation detection integrated with the X-ray scan
- Automated capture of the license plate and/or container number
- Radiation exclusion zone infrared fence
- Shore power operation
- Cold and/or hot weather package for expanded operational environment

### 1.1 Rapiscan Eagle M-Series Products

Rapiscan Eagle M-Series mobile cargo and vehicle inspection systems include

- Eagle M45 – 4.5 MV X-ray imaging system deployed on a heavy-duty truck chassis for scanning moderate to dense and densely-loaded cargo
- Eagle M60 – 6 MV X-ray imaging system deployed on a heavy-duty truck chassis for scanning the largest objects transporting up to dense and densely-loaded cargo

Easily deployable Rapiscan Eagle M-Series mobile cargo and vehicle scanners provide operational flexibility. A unit drives to an inspection site on local roads and within 30 minutes is ready to scan. Everything required to perform the scan and evaluate the resulting X-ray image is onboard the unit. In drive-by scan mode, unoccupied objects are scanned as the unit moves past them. In the optional drive-thru portal scan mode, trucks are scanned as they drive-thru the stationary deployed unit. The X-ray beam automatically turns on after the driver cab passes, so that only the cargo is scanned

### 1.2 Application Scenarios for Rapiscan Eagle M-Series Products

**Inspection at Border Crossings.** One Eagle M-Series mobile scanner is randomly deployed at different border crossings with no advance warning. This approach multiplies the effectiveness of a single scanner to counter smuggling because the unit can be located at any of the border crossings.

**Inspection at a Seaport.** At a seaport where space is at a premium, it may not be feasible to dedicate a site for inspecting cargo containers. However, a suitable site, such as an unused dock, may become available for short periods of time. An Eagle M-Series mobile unit can be set up temporarily at an available site and then quickly moved to a different site to rapidly respond to changing conditions.

**Variable Throughput.** In some cases, the inspection throughput may vary from a steady rate to a much higher peak rate. For example, at a seaport there is a steady stream of containers throughout the day with much higher traffic when a ship arrives. A single Eagle M-Series mobile unit offers a range of throughput capabilities from 20 containers per hour in drive-by scan mode to 100 containers per hour in drive-thru scan mode.

### 1.3 Rapiscan Approach to Cargo and Vehicle Inspection Products

All Rapiscan cargo and vehicle inspection products reflect our corporate commitment to excellence in imaging performance, design, ease-of-use and quality. This commitment results in products that have best-in-class imaging, low cost of ownership, high reliability and high operator satisfaction. Rapiscan offers its customers the largest selection of cargo and vehicle inspection products that share a common design philosophy.

- Modular common design elements across multiple products – Common design elements, such as the operating software, enable operating and maintenance staff trained on one product to quickly move to a different product. It also simplifies operation, training, service and spares.
- Multiple operation modes for one product – One product is able to inspect in different ways to respond to changing operational requirements. For example, an Eagle M-Series mobile scanner can also be used as a drive-thru portal scanner when high throughput is required. This capability provides operational flexibility and maximizes the effectiveness of each scanner.
- Products available to meet the full range of inspection requirements – Rapiscan’s unmatched range of cargo and vehicle inspection products enables us to work with customers to define a solution that meets their inspection requirements. We can choose from products capable of scanning occupied vehicles to dense cargo in mobile, gantry, portal and fixed deployment configurations, which can be used alone or in optimal combinations.
- Minimize cost of ownership – Rapiscan recognizes that a customer’s price for a scanner must include the cost of ownership over the unit’s lifetime as well as the cost of acquisition. Therefore, we are constantly working to reduce cost of ownership, such as by improving fuel efficiency and offering shore power operation for our Eagle M-Series mobile products.

## 2 FEATURES

The Eagle M60 (Figures 1-3) is a mobile cargo inspection system consisting of a 6 MV linear accelerator X-ray generator and deployable X-ray detector boom mounted on a road-mobile truck. The system is built on a heavy duty commercial truck chassis, either a Mercedes Benz or Mack truck, which meets local road worthiness standards. The detector array is stowed while the system is being driven to an inspection site and then quickly deployed at the site. The system is fully self-contained and requires no civil works, external utilities or infrastructure, although shore power operation is an available option.

The system scans by driving past an object which fits in the inspection tunnel between the X-ray generator and the detector array (Figure 3). The boom is deployed on the passenger side at 90° to the inspected object. The Eagle M60 scans one or more objects up to 5.0 m tall x 2.8 m wide x any length. The optional drive-thru scanning mode scan trucks as they drive through the stationary inspection tunnel. The resulting X-ray image is immediately displayed on a workstation in the Inspector Cab, which houses two onboard inspectors. Optionally a third inspector can be accommodated.



Figure 1. The Eagle M60 – Stowed Configuration



Figure 2. The Eagle M60 – Deployed Configuration

## 2.1 Imaging System

**X-ray Generator.** The Eagle M60 uses a linear accelerator to generate a 6 MV X-ray beam. The X-ray generator is heavily shielded and the beam tightly collimated into a fan shape, which minimizes radiation dose while maximizing beam intensity at the center of the object being scanned. The fan beam (Figure 3) is oriented to inspect from the axle to the top of a truck or container on a truck without corner cutoff. A dual-energy linear accelerator is used with the optional material separation capability

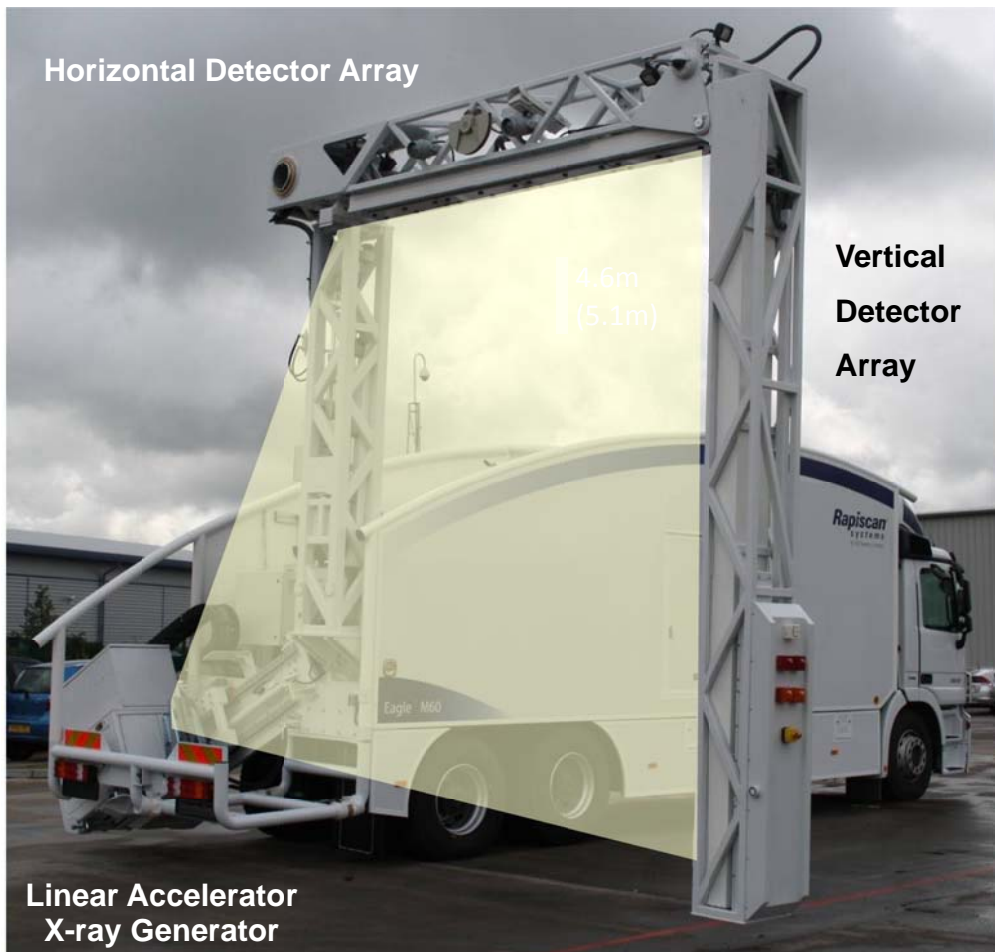


Figure 3. The Eagle M60 – X-ray Imaging System

**Detector System.** The Eagle M60's detector system uses scintillating cadmium tungstate crystals mounted to a silicon photodiode to detect transmitted X-rays. The detectors and their electronics are organized in modules arranged in an L-shaped array. This design minimizes the X-ray generator-to-detector distance while still enabling 100% inspection of a truck or cargo container on a truck. The detector housing protects the detectors from environmental degradation. Doors provide easy access for servicing individual modules. The output from the detectors is sent to Rapiscan proprietary imaging electronics and then to the Image Analysis Workstation for display.

**Computer Hardware.** The Eagle M60's computer system is used to acquire the X-ray data, create the X-ray image, display and process the image and store and retrieve images from the database. It utilizes commercially available Windows PC workstations, which run the Rapiscan Cargo Viewer software. High-resolution, color flat-panel monitors display the X-ray image, the user interface controls and the cargo manifest. There is a hard drive for data storage and a CD/DVD drive for data archiving. Images are displayed on the flat panel color monitor and printed on a color printer. The images can also be sent via wireless transmission to a nearby office for review and evaluation.

**Computer Software.** Rapiscan's Cargo Viewer software used on the Eagle M60 supports the entire cargo inspection process, including check-in, scanning and image evaluation. The inspector uses Cargo Viewer to view, process, evaluate and store the X-ray images. Cargo Viewer includes a comprehensive suite of image processing tools, including contrast and brightness adjustment, magnify/demagnify, edge

enhancement, filters, and histogram functions. Features of interest in the image can be highlighted and annotated for future reference. Each of Rapiscan's cargo and vehicle inspection products uses the same Cargo View software, so that trained inspectors can operate different Rapiscan scanners.

### 2.2 Vehicle

The Eagle M60 is built on a commercially available, heavy-duty solid frame truck chassis, which supports the X-ray imaging system, onboard Inspector Cab and electric generator. The Eagle M60 uses a Mercedes Benz truck chassis designed (Figures 1-2) for rugged applications, which comes standard with a manual transmission or an optional automatic transmission. A Mack truck chassis with an automatic transmission, shown in Figure 4, is optional. This model meets the US Customs and Border Protection requirements for a mobile cargo scanner. The Eagle M60 can easily be driven to a border crossing, to different inspection sites at a seaport or from a storage location to a deployment site. The vehicle is designed to meet the requirements for operation on public roads in the country where the unit is installed, including conformance with local emission control standards and road regulations. The chassis is also selected to ensure availability of in-country service.



Figure 4. Eagle M45 with the Mack Truck Chassis

## 3 OPERATION

The Eagle M60 scans an object, such as a truck or a container on a truck, in a single pass from approximately the axle to the top of the object. The resulting transmission X-ray image shows the entire object and its contents. The boom is automatically deployed on the passenger side of the vehicle perpendicular to the inspected object. During a scan, CCTV cameras are used to monitor the inspection tunnel and the area around the unit. The optional Identification Number Capture capability automatically captures a license plate and/or cargo container number. The X-ray image is immediately available to the onboard inspectors riding in the Inspector Cab. Images can also be wirelessly transmitted to additional inspectors at a nearby office.

The Eagle M60 is operated in road mode (boom stowed) for transport and scan mode (boom deployed) for cargo and vehicle inspection. When operated in road mode, the truck is propelled by the diesel motor and is capable of highway speeds. This allows rapid redeployment of the Eagle M60 in response to



changing operational requirements. After arriving at an inspection site, the boom is deployed and the unit is ready to scan in less than 30 minutes in the standard operating environment. Start-up takes longer in colder temperatures. The unit is powered by the onboard generator or optionally on shore power.

### 3.1 Scan Modes

The Eagle M60 can scan in the following modes:

1. Drive-by Mode - The unit scans by driving past one or more unoccupied stationary objects at a nominal speed of 0.4 m/s in the forward or reverse direction. It is propelled by a scan drive and is capable of regulated low speed operation, which enables uniform scanning and optimal imaging. The Eagle M60 scans one object at a time or continuously scans a line of several objects.
2. Optional Drive-thru Portal Mode - Trucks are scanned as they drive through the inspection tunnel at speeds up to 5 km/h. The high-energy X-ray beam automatically turns on after the driver cab passes, so that only the cargo is scanned.

**Drive-thru Scan Mode.** For the optional drive-thru scan mode, a Traffic Control and Monitoring System (TCMS) is added to the Eagle M60 unit to support a safe, continuous flow of vehicles through the deployed boom. The TCMS typically has the following components:

- Traffic control light to signal when it is safe to enter the facility
- Vehicle speed measurement device. Measured speed through the inspection tunnel is used to adjust the linear accelerator pulse rate and the X-ray image, if necessary.
- A “beam control” sensor that detects the front and back of the truck and the end of the driver cab. It also is used to turn the X-ray generator(s) on and off at the appropriate time.
- An “approach” sensor that senses a vehicle approaching the inspection tunnel, controls the traffic light and prepares the X-ray generator to turn on.
- CCTV cameras for monitoring the facility and its vicinity.

Inspection of a truck in drive-thru portal mode typically consists of the following sequence of events:

1. If there is no truck in the facility, the traffic control light is green signifying that it is safe for the truck to proceed.
2. The truck proceeds into the facility at a target speed of 5 km/hr. When the truck enters, the traffic control light turns red to prevent another truck from entering.
3. The truck drives through the inspection tunnel formed by the deployed boom.
4. The beam control sensor detects the back of the driver cab. The X-ray beam subsequently turns on and remains on until the back of the truck is detected.
5. The truck drives out of the facility to a parking area and waits for the inspection results.

### 3.2 Throughput

In drive-by scan mode, typical maximum scan throughput is 20 vehicles per hour when scanning one vehicle at a time and with an immediate supply of vehicles ready to be scanned. Scan throughput of up to 100 vehicles per hour is achievable in the optional drive-thru scan mode assuming a continuous flow of trucks through the scanner.

### 3.3 Crew

The crew of the Eagle M60 consists of the driver and up to two onboard inspectors. A ground guide can help to stage trucks for inspection. An optional third onboard inspector station is available.

### 3.4 Operating Environment

The Eagle M60 is designed to operate in a wide-range of weather conditions.

- Operating Temperature range: -10°C to 40°C
- Optional Cold Weather Kit extends the low temperature range to -40°C when cold weather operating requirements are followed (see below)
- Optional Hot Weather Kit extends the high temperature range to 55°C.
- Humidity 5% to 95% non-condensing
- Wind gusts up to 20 m/s
- Altitude up to 2000 m.

The design draws on Rapiscan Systems' experience deploying cargo inspection systems at a wide variety of locations. The Eagle M60 units are designed to perform in all deployment environments, including seaside, dusty and sandy sites and tropical conditions and various weather conditions, including rain and snow. The unit must be operated in accordance with the Operator Manual and maintained in accordance with the Maintenance Manual. Design features, including paint and finishes, are intended to prevent corrosion in a marine environment. Floodlights are located on the unit to support scanning operations after dark or in poor visibility conditions.

**Cold Weather Operation.** The optional Cold Weather Kit is required for operation at sites where the minimum temperature is -10°C to -40°C. At these temperatures, the following Eagle M60 cold weather operating requirements must be followed:

- Use specified low temperature fluids, including hydraulic oil and grease
- Allow for an extended equipment warm up time prior to operation
- Store the unit in a garage out of the weather on shore power when not in use

## 4 SAFETY

The Eagle M60 is designed and manufactured to applicable international safety standards and regulations. The safety system includes X-ray warning lights, alarms and signs; emergency stops and safety interlocks; CCTV cameras; anti-collision system and fire extinguishers. The emergency stops and interlocks immediately stop scanning and X-ray production and must be in the required configuration for the unit to scan. The status of the safety system is displayed on the onboard monitoring and control system.

**Radiation Safety.** The Eagle M60 is designed to be radiation safe for the onboard crew, vehicle occupants and bystanders, in accordance with international and local standards. As with all Rapiscan products, the principle of ALARA (As Low As Reasonably Achievable) is fundamental to the design.

- Crew – Onboard crew members in the Driver Cab and Inspector Cab are protected from radiation. The radiation dose in these areas does not exceed allowable levels in the drive-by and drive-thru scan modes
- Bystanders - To protect nearby personnel and prevent unauthorized access, the Eagle M60 includes warning lights and alarms and radiation controlled area warning signs. The radiation dose at the radiation exclusion zone boundary does not exceed the maximum allowable.
- Vehicle Occupants - When scanning in an optional drive-thru scan mode, the Eagle M60 is designed to be radiation safe for occupants of the truck driver cab. The radiation dose from

scattered radiation in the drive-thru portal mode does not exceed the maximum dose allowable.

**Radiation Exclusion Zone.** To protect bystanders during a scan, a radiation exclusion zone surrounds the Eagle M60 unit. The radiation dose at the exclusion zone boundary does not exceed the maximum allowable. The size of the Eagle M60 controlled area depends on factors, including the X-ray penetration, truck length and scanning throughput. An optional infrared fence at the exclusion zone boundary automatically turns off the X-ray beam when it is violated.

## 5 IMAGES

Representative examples of Eagle M60 X-ray images are presented in Figures 5-6.

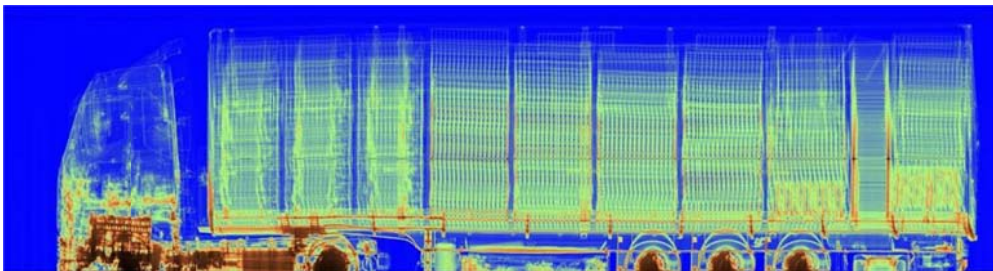


Figure 5. Representative Eagle M60 Pseudo-color Image

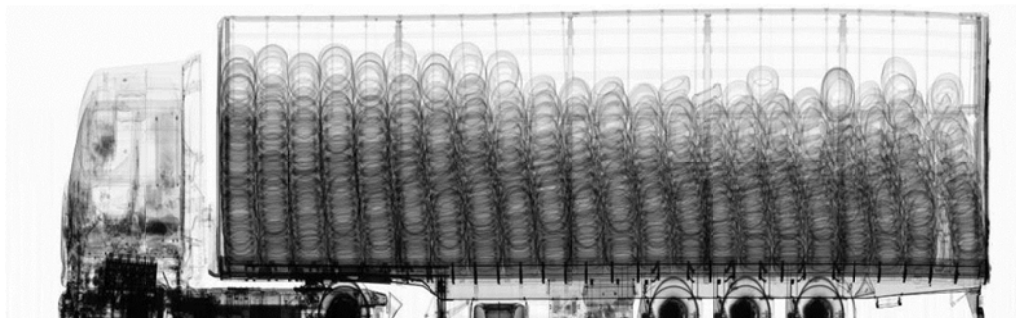


Figure 6. Representative Eagle M60 Grayscale Image

## 6 EAGLE M60 OPTIONS

Options available with an Eagle M60 unit are listed in Table 1. Unless specifically noted in the table, each option can be ordered separately with any other option.

Table 1. Eagle M60 Options

Option	Standard
<b>Vehicle</b>	
Mack truck chassis	Mercedes Benz truck chassis
Automatic transmission (Mercedes Benz chassis)	<ul style="list-style-type: none"> <li>Manual transmission (Mercedes Benz chassis)</li> <li>Automatic transmission (Mack chassis)</li> </ul>
Three onboard inspectors	Two onboard inspectors
Two driver cab passenger seats (Mercedes Benz chassis only)	One driver cab passenger seat
Inspector cab amenities <ul style="list-style-type: none"> <li>Microwave Oven</li> <li>Small Refrigerator</li> </ul>	Standard inspector cab
VHF radio set	Standard radio set
<b>Inspection</b>	
6 MV dual-energy linear accelerator – required for material separation capability	6 MV linear accelerator X-ray generator
Field of View 0.4 m - 5 m tall x 2.8 m wide	Field of View 0.4 m – 5 m tall x 2.8 m wide
Drive-thru portal scan mode – drive-thru high-energy cargo scan	Drive-by scan mode – scan entire unoccupied object in drive-by mode
License plate reader	Photo of inspected object
Container number reader	Photo of inspected object
Gamma radiation detection	X-ray imaging system
Gamma and neutron radiation detection	X-ray imaging system
Material separation, including dual-energy 6 MV linear accelerator X-ray generator	High quality greyscale and pseudo-colour image
Shore power operation	Powered by onboard diesel generator

Radiation exclusion zone infrared fence	High visibility cones to mark controlled area
<b>Operating Environment</b>	
Cold weather package – extends operating temperature to -40°C	Operating Temperature Range: -10°C to 40°C
Hot weather package – extends operating temperature to 55°C	Operating Temperature Range: -10°C to 40°C

### 6.1 Material Separation

With the optional Rapiscan material separation technology, low atomic number and high atomic number materials appear differently in the Eagle M60 X-ray image. This capability enables low atomic number (low density) contraband, such as explosives, to be distinguished from high atomic number (high density) materials, such as steel. The example material separation X-ray image in Figure 7 displays on the left a steel test fixture and on the right different thickness plastic test samples, which serve as explosive simulants. Notice that the test fixture appears in blue and the plastic test samples are green. The optional material separation capability also requires a dual-energy LINAC X-ray generator. With this approach, the material separation capability applies to the entire scanned object.

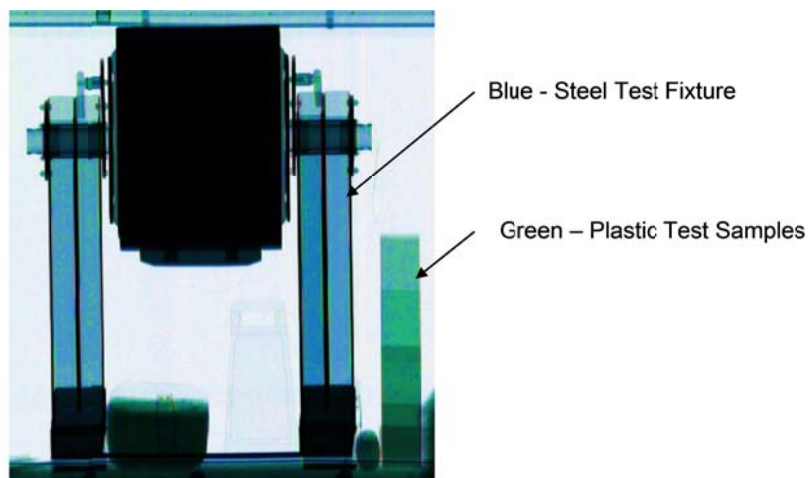


Figure 7. Material Separation Image

## 6.2 Radiation Detection

The Eagle M60 is available with an optional onboard radiation detection capability, so that radioactive materials in the cargo are detected during a scan. The system is available with gamma radiation detection or gamma and neutron radiation detection. The longitudinal location of the alarm is shown on the X-ray image. The radiation detection system is integrated with the X-ray imaging system, so that they do not interfere with each other.