WORLD CUSTOMS ORGANIZATION

GUIDELINES FOR THE PROCUREMENT AND DEPLOYMENT OF
SCANNING/NII EQUIPMENT

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DEFINITION

Scanning/NII equipment

For the purpose of this document, scanning/NII equipment means equipment/technology that is deployed to inspect all types of cargo and conveyances, such as a road vehicle, train, aircraft or ship, in a non-intrusive manner.

Container

For the purposes of this document only, the term container includes maritime containers, aircraft containers and any portable compartment in which freight is placed (as on a train, truck, aircraft or ship or any other means of conveyance) for transportation.

GUIDELINES FOR THE PROCUREMENT AND DEPLOYMENT OF SCANNING/NII EQUIPMENT

I. INTRODUCTION

Members are looking at the potential of inspection equipment, particularly X-ray or gamma ray equipment, to help detect threat materials while increasing the efficiency of Customs controls. Scanning/NII equipment can increase the number of consignments which receive Customs attention without causing undue delay, and it can help to identify illicit goods. The equipment requires a large capital outlay and the process of introducing it, from conception through to operation, impacts on both control and intelligence sectors and may entail changes to Departmental infrastructure and procedures. To justify the outlay cost, and to ensure maximum return for the investment, it is necessary to ensure that scanning/NII equipment is used effectively and is fully integrated into the risk assessment regime. The experience of Customs administrations that currently use scanning/NII equipment emphasizes that planning at an early stage for the introduction of the equipment is essential.

One of the key objectives and principles of the SAFE Framework is to promote the seamless movement of goods through secure international trade supply chains. The SAFE Framework consists of four key elements

- Harmonisation of advanced cargo information requirements
- Employment of a consistent risk management approach
- Outbound inspection of high risk containers and cargo, preferably by using non-intrusive inspection equipment
- Definition of benefits that Customs will provide businesses that meet minimal supply chain security standards and best practice

SAFE Framework has identified in standard 3 of the Customs to Customs Pillar that non-intrusive equipment and radiation detection equipment should be available and used for conducting inspections, where available and in accordance with risk assessment. The equipment is necessary to inspect high risk containers or cargo quickly, without disrupting the flow of legitimate trade.

While these guidelines focus largely on scanning/NII equipment, modern Customs administrations deploy a range of additional inspection equipment as outlined in the EU "Threats and Technology Solutions" document which is annexed at ANNEX 2. This document provides an overview of types of threats encountered by Customs together with suggested technology solutions. It is intended to provide support to those involved in the decision-making process involved in the purchase and deployment of detection equipment by providing the relevant technical information.

Given the complexities involved in the procurement, deployment and management of NII equipment. The sharing of experiences in this area plays a critical role in the development of the expertise required by Members. The Customs administrations of Australia, Hong Kong and China, have shared their respective experiences of NII, including the associated benefits, in the document which is annexed at ANNEX 3.

II. OBJECTIVE

These Guidelines assist Member Administrations which are considering the procurement of scanning/NII equipment (including the upgrading of existing equipment) by detailing relevant administrative issues. These Guidelines do not necessarily reflect all national needs (e.g. legislation or regulatory requirements). Crucial to the effective deployment of this equipment is the integration of the scanner into Customs controls as part of a risk management process. This equipment requires that a proper infrastructure exists to ensure efficient delivery of selected containers to the scanning unit.

These Guidelines cover the various ionizing radiation detection technology applications but do not include nuclear and radioactive material detection equipment including radiation portal monitors (RPMs); nonetheless, radioactive and special nuclear material detectors may be considered as optional extras when procuring container scanners.

The International Atomic Energy Agency (IAEA) has produced suitable technical guidance for nuclear and other radioactive material detection equipment entitled “Technical and Functional Specification for Border Monitoring Equipment [IAEA Nuclear Series no.1]”

III. DEFINING NEEDS

Customs administrations are faced with increasing volumes of traffic and greater expectations from business for faster clearance times without a corresponding increase in resources. At the same time, governments and society expect Customs to provide an effective control of imports, exports and transit traffic. Global terrorist attacks have also raised the expectations placed upon Customs administrations in respect of border security. To cope with this situation, many Members are looking at the potential of technical equipment, particularly X-ray or gamma ray NII equipment to help meet their objectives by increasing efficiency in inspections.

It is important to understand the operational and business environment and other factors that need to be taken into account. Some important issues to be considered at the outset are:

- Why do we carry out NII inspections?
- What do we need to inspect? (types of cargo and transport modes)
- What are the risks/threats to be identified? (e.g. drugs, explosives, tobacco, fiscal)
- Where do we carry out the inspections? (is enough space available and at what cost?)
- What type of technology and resources do we need for inspections?
- Does existing equipment need to be upgraded?
- What research do we need to carry out into commercially available and emerging inspection systems?
- What budget is needed both in terms of capital outlay and future ongoing cost?
- Have future needs, including traffic flows and international scanning requirements been taken into account?
- How will NII equipment fit into existing Customs operational procedures?

The underlying consideration is whether container scanning/NII equipment is a justified acquisition. It should be emphasized that prior to investment in NII equipment a full business case, including a cost-benefit analysis, should be conducted to determine whether the use of scanning equipment would be more beneficial than manual intervention.

In preparing the business case, the following issues should be addressed:

1. Ensure that budgetary provision is made for annual operational and maintenance costs bearing in mind that annual maintenance costs will be significant over the life time of the NII equipment. (It may be financially attractive to negotiate a long term (10 year) maintenance contract at the outset).

2. A programme manager should be appointed to manage the implementation of the project.

3. A procurement group should be formed to include expertise from the following areas: Customs policy, radiological issues, technical issues, procurement procedures, Customs operations and financial issues. This procurement group will be responsible for writing the delivery contract, the maintenance contract and the formulation of the programme of requirements.

4. A Radiation Safety programme should be developed to ensure the safe operation of the scanning system in accordance with national regulatory requirements, as well as the training of Customs officers.

Procurement of equipment and scanning sites (where necessary) are major costs for Customs administrations. The potential returns against this investment will vary according to traffic volumes and associated revenue risk. The deterrent factor, although not quantifiable, is also an important consideration, especially in the areas of drugs and explosives detection.

For the most effective and efficient use of this equipment input from trade groups, other relevant authorities and Customs administrations must be considered. It is important to address concerns of the trade and other relevant stakeholders from an early stage. Trade bodies and relevant stakeholders must be kept informed of intentions and progress and should be involved in planning to minimize delays in the flow of legitimate trade.

The effect of the deployment of NII equipment on trade patterns and whether traders will divert their goods to other ports or border crossings (“port shopping”) should be considered. To address this concern, it will be necessary to show, through consistent application of procedures, that traders wishing to avoid a port with a scanning facility will not obtain material benefits in alternative locations.

IV. USER REQUIREMENTS and TECHNICAL SPECIFICATIONS

Before deciding on technical specifications, the purchaser should carry out sufficient research into technology solutions which are currently available, as well as new and emerging technologies. Existing users should be consulted to identify best practice and also limitations of existing systems. Every effort should be made to ensure that requirements can be achieved within the available budget.

An in-depth understanding of operational constraints on deployment of a particular imaging system, e.g., availability of sufficient space, national radiation requirements, (a license to hold and use equipment will be required, usually involving a series of conditions), must also be taken into account. One of the most important considerations that an administration must address is which of the commercially available technologies best meets the user requirements within financial constraints. If no such technology application is currently available, Customs should discuss potential solutions with suppliers, including their willingness to carry out research and development.

Listed below are the specific considerations an administration must address, both in contract with a vendor and within its own operational environment, throughout the procurement process.

- It is recommended that potential suppliers should be ISO 9001 certified
- Necessity for all systems that use ionizing radiation to meet national and IAEA standards/regulations for radiation equipment [1]
- Local health and safety requirements, e.g. shielding, exclusion zone, personnel safety programme including maximum radiation exposure limits (in consultation with the national regulatory body)
- National transportation requirements (when NII equipment is required to be transported)
- Maximum and minimum dimensions of scanning tunnel and targets to be scanned
- System footprint dimensions (to include equipment and safety exclusion zone, for NII systems that use ionizing radiation, as well as container/vehicle marshalling areas).

1. Technical Specifications

Scanning indicators

- *Penetration capability*: the maximum thickness of steel through which the orientation of a specified test object can be determined in an X-ray/gamma-ray image. An average penetration of 330 – 350 mm of steel is suggested for X-ray systems.
- *Spatial resolution*: the minimum separation between the features of a test object can be distinguished in an X-ray/gamma-ray image. Spatial resolution of 4mm (horizontally) and 3mm (vertically) should be achieved.

- *Contrast sensitivity*: the ability to distinguish a thin sheet of metal behind 100, 150 and 200 mm of steel. X-ray systems should be capable of achieving contrast sensitivity of 1mm (1%) behind 100mm steel, 3mm (2%) behind 150mm steel, and 8mm (4%) behind 200 mm steel.

- *Wire detection*: to determine the smallest diameter wire that is visible in the x-ray or gamma-ray image. Systems should be capable of detecting a steel wire with a cross section of 1.3 mm behind 100 mm steel in both horizontal and vertical planes.

- (Note: The methodology for testing for these requirements is set out in ANSI Standards : ANSI N42.46.2008)

- *Material discrimination*: the ability to distinguish between organic and inorganic materials, steel and lead in the X-ray/gamma-image.

- Throughput

- Scan speed (Most suppliers offer a range of scanning speeds)

- Potential interference with any existing radiation portal monitors

- The ability to scan the complete transport including the wheels, where appropriate, in one single action. Where scanning of vehicle wheels is required, a ramp or platform may be required to raise the vehicle to a suitable height.

- Maximum and minimum dimensions of scanning tunnel and targets to be scanned

- Suitable electrical power availability

- Communications availability; between scanner /other operational staff/remote image analysis station.

In order to have interoperability and interconnectivity capabilities between NII systems, and to have a global view of the database of vehicles inspected, systems may be connected to a dedicated central server

<u>Radiological</u>

- It is recommended that potential suppliers should be ISO 9001 certified.

- Necessity for all ionizing radiation systems to meet national and IAEA standards/regulations for radiation equipment Local health and safety requirements, e.g. shielding, exclusion zone, personnel safety programme including maximum radiation exposure limits (in consultation with national regulatory body)

- Personal certification in field of radiation safety where required

- Appointment of radiation safety advisor where required

Financial

- Port authority charges (i.e. rent for the land where the system is deployed and scanning handling charges)

- Future upgrades can lead to additional investment in the re-design of existing NII equipment

- Other costs to be taken into account: radiological license fee, radiation detection monitoring costs (dosimeters and analysis costs etc), radiation training costs, support vehicles, additional staffing costs, fuel and electrical power costs, maintenance costs, including scanning vehicle maintenance in the case of mobile systems.

Logistical

- National transportation requirements.

- Indoor/outdoor usage issues

- Minimal logistical impact including traffic/cargo flow on port operations

- Suitable site access for maintenance personnel

- System footprint dimensions (to include equipment and safety exclusion zone as well as container/vehicle marshalling areas,)

- Parking areas before and after scanning

Environment/ weather

- Minimum and maximum temperatures at which the equipment may operate

- Other environmental factors such as wind, moisture, sand, dust, sea salt

- Geological considerations

- Environmental impact

Other regulatory requirements

- Planning, permits and requirements (permits required for developing and building the site, and for the use of the NII equipment)

- Comply with requirements of national Road Transport Department in the case of mobile scanners

- Appropriate category of driving license

- Compliance with national digital tachograph road safety requirements

10.

Other requirements

- Provision for adequate training for operators including image analysis training
- Ensuring compatibility with existing systems

2. Maintenance

The importance of providing for suitable maintenance of equipment cannot be overstated. While the average life expectancy of scanning equipment is about 10 years, many supply contracts only contain warranty/maintenance provisions for up to 2 years in duration. Additional maintenance contracts following on from this initial period can prove to be expensive and can lead to much higher than anticipated running costs over the lifetime of the system.

It is advisable therefore, when issuing a Request for Tender, to request bidders to quote, on a year by year basis, for a comprehensive maintenance service for the anticipated lifespan of the system. The purchaser should have the option of choosing the duration of any such service and paying the cost annually if desired.

Drawing up a Service Level Agreement with the service provider should also be considered, to allow for monitoring of the service provided, and to impose penalties where the standard of service falls below agreed levels. Regular review of the maintenance service is an important element in managing the system which may provide the opportunity to make appropriate amendments.

The maintenance service should include routine preventive maintenance in addition to corrective maintenance. Where mobile systems are involved, the maintenance of the vehicle chassis should also be covered. Depending on levels of use etc., certain important components such as the linear accelerator and detectors may require to be replaced in the course of the lifetime of the system. The terms of the maintenance contract should be clear as to whether such costs are covered.

Other factors to consider concerning maintenance:

- Local service organization with maximum response time
- 24/7 helpdesk with maximum response time
- Guarantee of delivery of spare parts during contract period
- On-site storage of spare parts
- Spare parts and maintenance required from a third party (e.g. accelerator supplier)
- Does maintenance cost include spare parts, all relevant duties/taxes and other associated costs?(e.g. travel, subsistence, accommodation, car hire)

3. Types of technology

The various technology applications commonly in use include;

a) X-ray

An X-ray is an electromagnetic wave of very short wavelength. X-rays are polychromatic and have a larger spectrum than gamma rays. The power source for X-ray systems is electrical. This means it can be turned on and off. It also means that in a site where the electricity supply is not certain, it is essential to have a back-up generator. The energy level of X-ray systems is measured in mega-electron volts (MeV). The MeV rating varies between fixed, mobile and re-locatable systems; these are discussed in detail below. For the purpose of container scanning the maximum X-ray energy is 9 MeV. X-ray systems are considered to provide better image quality, but are more expensive and, in general, are physically larger than Gamma Ray systems.

b) Gamma Ray

Gamma rays are monochromatic electromagnetic waves of shorter wavelength than X- rays. Gamma rays are produced from natural isotopes such as ^{137}Cesium and ^{60}Cobalt. These are radioactive sources and the energy emission is continuous. Because of this, the isotopes must be kept in a shielded cabinet at all times. Over time, the radioactive isotopes decay and ultimately require replacement, usually every 5 years. Some Members that operate these systems have included within their contracts a provision for periodic testing to ensure that energy levels remain sufficiently high. Contracts should include supplier “take back” provisions for spent sources.

Gamma ray systems are cheaper to purchase and to operate but the images produced may be more difficult to interpret. A gamma ray unit is, in general, smaller than an X-ray unit which gives such systems a higher degree of mobility. Gamma ray units are more likely to be mobile or re-locatable than fixed.

A common comparative method for systems is to refer to steel penetration capability. In general, the higher the energy of the system, the higher will be the penetration. The need for penetration will depend on the cargo types being scanned and the operational environment involved. A gamma based system using a ^{60}Cobalt radioisotope, which has greater penetration capability than one based on ^{137}Cesium, is said to penetrate up to 165mm of steel. Manufacturers of X-ray equipment show 180mm penetration of steel for a 2.5 MeV mobile X-ray system, over 200 mm for a 3.0 MeV mobile unit and up to 350mm for a 6.0 MeV relocatable unit. Fixed X-ray systems of 9 MeV are able to penetrate up to 450 mm of steel. Some currently deployed mobile systems have energy levels as low as 300/450 KeV and are inadequate for the effective screening of typical container traffic. Members who currently use X-ray systems are of the view that 3 MeV is the minimum energy level required for effective cargo penetration.

However, for gamma ray and X-ray systems, steel penetration is not the sole criterion to achieve high quality images. Spatial resolution and contrast sensitivity are other important factors to be taken into account.

c) Backscatter X-ray

Backscatter X-ray systems operate by directing X-rays at a target object and capturing the resultant scattered, or reflected, radiation using detectors on the near side of the target. Because the detectors are located on the near side, no boom or archway is required, thereby increasing the versatility and mobility of the scanning system.

The ensuing image has a more photographic appearance than that of a transmission X-ray system, and backscatter systems are particularly suited to imaging organic materials. However, as backscatter imaging is confined to relatively low energy systems, generally having a maximum energy of 450 KeV, the penetrative capability of such systems is quite limited.

Backscatter systems may operate with single or multiple views, or in combination with transmission X-ray sources. Backscatter technology can be used in a variety of configurations, some examples of these include:

- In conjunction with a transmission x-ray system, with one, two or three sided backscatter x-ray.
- Backscatter van, which is suitable for detecting organic materials such as explosives, plastic weapons and drugs in cargo, (private) cars, airplane bodies and wings, airfreight containers- and (ULD) pallets, sea containers (for objects close to walls or doors).

4. Available Features

a) Dual view

Early X-ray systems used a single energy source normally scanning the target in the horizontal plane. However, dual view scanning, which incorporates a second energy source scanning in the vertical plane, is also available. Typically, similar energy levels are used for both sources. The advantage of dual view scanning is that it provides an additional dimension to the image analysis information (depth, positioning etc).

b) Dual Energy

Interlaced linear accelerators using dual energy systems have been available since 2006. When operating, these accelerators alternate between 2 different energy levels, making it possible to achieve material discrimination. The most commonly used energy combinations are 6 and 3 MeV or 9 and 6 MeV respectively. Best results are achieved with low density homogeneous cargo. Current dual energy systems do not always provide reliable results when scanning mixed high density cargoes on account of their inability to always differentiate accurately between organic, inorganic and metallic materials.

c) Combination of backscatter and transmission X-ray

Backscatter x-ray can be combined with transmission x-ray. In addition to the transmission x-ray image, one, two or three sided Backscatter x-ray images (left, right and top down) may be added.

d) Material discrimination

Different methods are available to achieve material discrimination:

- A single accelerator using one energy level together with multiple arrays of detectors placed behind each other. The higher energies of the spectrum are captured by the first detector row, with the lower energies being captured by the second row of detectors. Only one run is necessary

- An interlaced linear accelerator, alternating between high and low energy levels. Only one run is necessary

- One accelerator capable of operating at two different energy levels, or two accelerators each operating at a single energy level. Two runs are necessary, one run operating at the high energy level and the second operating at the low energy level.

(Note: Using a system of algorithms, the resultant images are combined to produce a single image which differentiates between organic, non-organic and metallic materials on a colour- coded basis)

5. Types of NII systems

a) Fixed (Stationary)

Fixed units are the most expensive and the most powerful, typically with an energy level of 9 MeV. This high energy level provides a clearer image and deeper penetration of cargo than systems of lower energy. However, due to the high energy of the system there is a possibility that X-rays may “blow through” less dense cargo without forming a proper image. To mitigate against that phenomenon, some supplier are offering the possibility to scan such less dense cargo with a lower energy, for example at 3 MeV instead of 6 MeV, in order to obtain a suitable image. Most fixed scanners tend to use X-ray. A fixed unit may permit a “dual view”, i.e. both horizontal and vertical profiles of the cargo can be imaged. The permanent nature of the site allows for better links between the scanner’s computer system and the main Customs control network.

A fixed unit consists of more than just the scanner. Due to the high energy of the systems and possible scattering of X-rays, the entire system must be housed in a purpose- built building with concrete walls of sufficient thickness to provide adequate shielding. The building may also require safety doors for the entrance and exit. The entire construction of this unit must also include the facility for the computer equipment and image interpretation and may also include ancillary office accommodation. The system is quite expensive in terms of actual unit purchase including the facility that must be constructed to house it.

A major consideration for fixed units is that, by definition, containers must come to them. This means there must be sufficient space for vehicles waiting to enter the facility to park and to maneuver. Furthermore, there must be satisfactory access roads to and from the unit that must accommodate both import and export traffic. Due to these constraints it has been found that fixed units are better suited to areas such as container ports where there is a constant flow of traffic which can be directed along a single channel or choke point.

Due to the fact that the purchase of a fixed unit may require acquisition of land for the site and will involve substantial buildings to be erected, the process may take years from initial conception to final installation. Planning application procedures must also be complied with.

b) Re-locatable/Gantry

Re-locatable scanning units are designed as a compromise between fixed and mobile systems by providing better performance than mobile units while overcoming the expense and land requirements of a fixed unit. Re-locatable scanners typically operate at levels of approximately 6 MeV and require a lighter construction and shielding structure than fixed units. The latest re-locatable systems are capable of operating in the open air, without additional shielding walls for radiation protection. They are less expensive to procure and operate than fixed units but must, as with fixed units, have suitable access roads and parking facilities. Re-locatable units also require a dedicated and prepared operating area at each location in which they are used.

While re-locatable units may be dismantled and moved to a new location, they should not be considered to be mobile. The process of dismantling, transporting and reassembling them can be time-consuming and labour intensive and can take between one day and eight weeks, depending on the nature of the construction and location of the system. A re-locatable unit might be the preferred choice if trade patterns indicate that traffic might shift significantly from one port or border location to another in the foreseeable future. Due to cost and size implications some administrations have opted to deploy re-locatable units in the same manner as fixed units with some modifications involving an upgrade of energy and penetration levels.

All re-locatable X-ray and gamma ray scanning systems require a clear area surrounding them for health and safety reasons during operation, known as an ‘exclusion zone’. In theory the space required for this zone increases relative to the increase in equipment energy levels. Improved shielding/attenuation techniques in the latest systems, however, have contributed to significantly reduced exclusion zones. It is important to establish the land requirements of the exclusion zone for these re-locatable units. If the necessary land is not available within the port or close to the Customs station, the scanning unit will have to be deployed at a remote location. Planning application procedures may also apply.

Portable scanning versions must also be included in this section. A portable unit is a combination of a mobile and a re-locatable system. A portable unit is deployed on the ground and consists of a scanning section, usually comprising of an X-ray system in a container, an electricity supply (generator) and an office for the image analysis. This type of scanner can be readily loaded onto a lorry (truck) using 4 hydraulic feet, and can be transported quickly to a new inspection location. The installation and de-installation, including unloading and loading on the lorry, can take 30 to 45 minutes and can be carried out with a maximum 3 people. With an energy range of 2.5 to 3.5 MeV, an operational and security area of approximately 18 x 18 m. is needed. Portable units are somewhat less expensive than other re-locatable systems because they require no specific construction or site preparation work.

c) Mobile

Mobile units are less expensive than fixed units but operate at lower energy levels, typically 3 - 6 MeV. Mobile scanners equipped with an interlaced accelerator, alternating between high and low energy levels are becoming increasingly prevalent. If the cost of a mobile system (including delivery and maintenance) is the most important consideration, then a gamma ray system could be a viable option, even though the image quality may not match that of a comparable X-ray system. The latest Mobile scanners Mobile scanners can compete with the performance of fixed 6 MeV scanners in terms of penetration, contrast, spatial resolution and wire detectability. Prior to purchase, a full review of the operation must be performed to make certain that the unit is fit for its function. Mobile scanners should require no more than 15 minutes to be ready for operation after their arrival on location. For example, they are particularly useful for land borders where traffic may cross at a number of points and smugglers are searching for the weak points in the border inspection sites. The fact that they can move to different locations at very short notice makes it more difficult for the smugglers to avoid scanning controls by shifting border entry points. They also permit the possibility of sharing costs with neighbouring administrations that could jointly purchase and operate a mobile unit. Mobile systems are subject to greater downtime and require more frequent maintenance.

Mobile scanners usually comprise of an X-ray or gamma ray scanner built onto an integrated chassis cab vehicle or, they may be constructed as articulated units which will be towed by independent tractor units. In any case, particular attention must be paid to the suitability of the vehicle when moving between locations on public roads. It must comply with national transport and road traffic regulations especially in terms of height, length, overall weight, and weight distribution. Right/Left hand drive formats, automatic/manual transmission, and any speed limitations should also be taken into account. A license for a heavy goods vehicle (HGV) and for transport of a live gamma source (radiological license) may also be required to move the vehicle between operations.

Consideration should be given to using separate fuel tanks to fuel chassis/generator where the possibility to fuel the generator with tax-free/ rebated fuel exists. Large capacity tanks may be desirable where the scanner is operating in remote locations for prolonged periods. The scope for using large/separate fuel tanks may be limited by factors such as available space, Gross Vehicle Weight (GVW) limitations and local road transport regulations.

Unlike fixed and re-locatable units, mobile scanners do not require a network of access roads to be constructed because they are able to move with the traffic flow. However, like re- locatable scanners, they do require an ‘exclusion zone’, a size of which is dependent upon the energy level and amount of shielding of the unit. Exclusion zones vary according to the models and must be specifically measured on a unit by unit basis. A rough estimate would be to assume that between $500m^2$ and $1500m^2$ will be needed as an exclusion zone for these units.

Some mobile scanners may also be deployed in drive-through/gantry mode. The image quality may suffer some degradation when the system is used in this mode. It should also be borne in mind that different safety exclusion zone dimensions may apply in this case.

d) Drive-Through

In the earliest fixed scanning systems the emphasis was primarily on the quality of the X-ray systems. The X-ray systems were built in central locations in the ports and containers were transported from the terminals to the scanning facility. Because of the ever increasing numbers of containers to be handled, the throughput limitations resulting from relatively slow scanning speeds became a problem in busy seaports and other border crossing point (BCPs).

For this reason the drive- through scanning systems were developed. Drive- through systems deliver a much higher throughput, by increasing scanning speeds and allowing truck or terminal vehicle drivers to remain in the cab of the truck while a container is scanned. These systems incorporate many safety precautions to ensure that the driver is not exposed to direct or unacceptable levels of radiation. It is estimated that drivers may pass through such scanners at least 10,000 times annually without exceeding permitted radiation dose levels. However, national radiation regulatory bodies should be consulted in this regard before the commissioning of systems. The disadvantage of drive- through systems, however, is that the driver`s cab is not normally scanned.

The investment required for a drive- through scanning system is comparable with that of a re-locatable system. Drive- through systems can operate in the open air, although the effects of wind, snow, sand, rain etc. should be considered. Drive-through systems operate with X-ray energy level typically between 3 and 6 but 7.5 MeV is also available. Dual energy versions, providing material discrimination, are also available.

Drive-through systems are capable of scanning between 150 and 180 containers per hour, with a drive- through speed of around 11 kilometers per hour. In practice, throughput may be lower due to local logistical considerations. This higher speed, relative to traditional scanning systems, will have consequences for the specification requirements as the speed will influence the penetration, resolution etc. capabilities. This factor must be taken into account, therefore, within the programme of requirements, although the quality of imaging at high speeds continues to improve.

In some countries, it may be permissible to scan vehicles containing occupants, in accordance with ANSI norm N 43.17-2009.) In such cases, warnings should include information regarding annual dose thresholds and should offer an alternative route through the checkpoint which does not involve exposure to ionising radiation. Similar warnings may be posted for infant and elderly travellers, pregnant women, and those suffering from serious illness.

A good quality reliable optical character recognition (OCR) system, for recognizing and recording container numbers is a very important part of a drive- through system. It is necessary to make a good match between the container and the saved image.

As in the case of fixed and re-locatable systems, drive-through scanners require access roads. Drive-through scanners can operate with a relatively small exclusion zone. The high passing speed results in a shorter period of radiation exposure for each scan. In some cases an exclusion zone of 20 X 5 meters will suffice,

e) Train Scanning

Train scanning is a relatively recent development. A train scanning system is comparable to a drive-through system. The difference is that train scanning systems are specifically built for scanning cargo/ tank wagons, or containers loaded onto trains. First generation train scanners were only capable of scanning at a very low passing speed. Scanning systems with a passing speed of 30 kilometers per hour are now commonplace.

Train scanning systems are used in various situations, most commonly at BCPs between two countries. The most recent variation operates with the passing speed of up to 60 kilometers per hour.

A good quality reliable optical character recognition (OCR) system, for recognizing and recording container numbers is also an important requirement for a train scanning system. It is necessary to make a good match between the container and the saved image.

Train scanning systems using either an X-ray source or a live (gamma ray) source are available. Gamma ray operates well when the passing speed is no higher than a few kilometers per hour. For higher passing speeds an X-ray system in the range, 6 to 9 MeV is required.

Where high energy X-rays are used to cope with high passing speeds, additional radiation safety requirements may apply, depending on national radiological legislation and requirements.

f) Radiation and Nuclear Material Detection System

While many ports/border crossings may already use dedicated Radiation Portal Monitors (RPM's) to detect illicit trafficking of radioactive/nuclear materials, some scanner suppliers offer the option of a radioactive/ nuclear material detection system together with their X-ray scanning systems. Passive detectors are incorporated into the scanning process, providing an integrated cargo scanning solution. These are not intended to replace RPM's, but can allow for a more informed analysis of radioactive/ nuclear material alarms by using the information provided by the X-ray image, to provide additional information on the location of the source within the container.

6. New and Emerging Technology Applications

Despite recent advances in the area of sensor detection, the number of new technologies, suitable for large scale inspection of container/vehicle traffic, to reach the market is quite limited. The following technologies, although not in widespread use, have demonstrated a potential to detect a range of threat materials, either in stand-alone mode, or as part of a multi-level inspection system.

a) Neutron

Neutron scanning is an emerging detection technology application which has the capability to identify specific materials in cargo. For the purpose of cargo screening, neutrons with an energy level of 14 MeV are produced by means of a neutron generator. When neutrons collide with the atoms of a given material characteristic gamma rays are emitted. These gamma rays provide information which allows certain constituent chemical elements to be detected and identified, particularly those present in threat materials such as drugs and explosives. Because of the high energy involved and the high penetration capability of neutrons, extensive shielding and radiation safety precautions are required.

Neutron scanning is not currently seen as a replacement for X-ray and Gamma ray screening; rather it is seen as a tool for providing an additional level of information when used in conjunction with X-ray scanning, whether in an integrated system, or interoperating with an existing X-ray scanner.

b) Cosmic Ray Tomography

Cosmic Ray Tomography is a recently developed technology application. It exploits naturally occurring charged particles, such as muons and electrons, to produce a 3-dimensional image of the scanned cargo without using ionizing radiation. Cosmic Ray Tomography systems have a very high penetration capability in comparison with X-ray systems. This technology application has been shown to be capable of detecting radioactive sources within dense cargoes e.g. scrap metal. It also offers an automatic threat detection facility.

c) Vapour analysis

This technology involves the extraction of a sample of vapour from a closed container, either through the door seal or an air vent. The sample is introduced to an adjacent analyser which, following a short period of analysis, can identify the presence of certain threat materials. While this technology application remains at the developmental stage for the most part, it has demonstrated a capability to detect threat materials such as explosives, drugs and their precursors.

d) CT-scanning

This technology is not yet in use at the moment in the field of containers scanning. However comprehensive investigation is going on to design a model which can be used in the cargo inspection process.

V. PROCUREMENT PROCESS

Every country has its own procurement procedure but some common guidelines can be established in order to ensure the procurement process is transparent, fair and comprehensive.

The Request for Proposal / Tender (RFP/RFT)

1. A request for proposal/tender (RFP) is an early stage in a procurement process, issuing an invitation for suppliers, often through a bidding process, to submit a proposal on a specific commodity (e.g. equipment) or service.

2. The RFP is your "official" statement to suppliers about the equipment and/or services you require. Suppliers typically try to respond, point by point, to your RFP when they make their proposals. Therefore, the RFP "leads" suppliers by focusing their attention on certain issues. Most importantly, the RFP is the foundation upon which the supplier's relationship with you is built.

3. The RFP process brings structure to the procurement decision and allows the risks and benefits to be identified clearly upfront. The following information should be considered when preparing a proposal.

   Overview - when sending out a Request for Proposal document it can be very useful to provide a high level overview of some key points

   Background - as part of the proposal it is useful to provide some background information to ensure that the prospective suppliers understand what it is you are trying to achieve and to ensure that you get the right ultimate solution.

   Requirements - this highlights your specific requirements both in terms of supplier relationship and the solution and configuration you are seeking. RFP Terms and Conditions (Instructions**)** - identifies the elements of terms and conditions or instructions that you may want to specify in your proposal as to how the process will be managed.

   Evaluation - ensures the procurement process is transparent and documenting how the proposals will be evaluated.

   Response – specifies what information is expected back from the responder, in what format and to what level of detail

Further details of the elements identified above and examples of what you might include can be found in Annex I.

VI. FACTORY ACCEPTANCE TEST

Factory acceptance tests can act as an important part of the validation process as they allow for the correction of any identified faults prior to delivery. The scope of such tests will vary according to the format of the system being purchased.

Mobile Scanners

In the case of mobile scanners, it should be possible to test the performance of the X- ray system, certain mechanical and other vehicle specifications, and the dimensions of the safety exclusion zone.

Other scanning systems

In the case of re-locatable and fixed systems, it will be possible to test only those parts which are fully assembled e.g. linear accelerator. However, an inventory of the constituent parts, which will be assembled on site, may be carried out.

Shipping

It should be borne in mind that the transportation of the equipment to its destination may have some effect on the system's performance, which will be required to be addressed during installation and commissioning. As a precautionary measure, therefore, the supplier should ensure that the equipment is adequately protected by protective packaging etc. during shipment. The supplier should also ensure that adequate marine, or other, insurance is in place.

The responsibilities for Customs clearance procedures and payment of Customs duties/other taxes as well as costs relating to the discharge, carriage to installation site and unpacking at site, should be clearly defined. These issues also apply to any spare parts supplied.

VII. DEPLOYMENT

As soon as is practical following the signing of the contract, it is important to ensure that all necessary measures are put in place to facilitate a smooth deployment of the scanning system when delivered/constructed. These include:

- Preparation of scanning site and associated buildings,
- Provision of suitable accommodation to store spare parts, and to carry out maintenance, in the case of mobile scanners. Application to the regulatory body for radiological licenses, including submission of justification to use ionizing radiation equipment
- Suitable methodology for selecting targets for scanning
- Arrangements for transporting target containers/ vehicles to/from scanning site
- Design of a traffic management plan
- Provision of adequate facilities for any resultant manual inspections
- Recruitment and training of scanner operators
- Compatibility of scanner computer systems with existing systems.

VIII. FIELD VALIDATION TEST

After installation, the performance of the entire system must be tested for compliance with contractual specifications at the purchaser's site by a specialized Customs team (which may include an external expert advisor), which is familiar with these systems and test regimes. Due to varying conditions of the site, and the possible effect of transportation, systems may not perform in the same manner as they did during factory acceptance testing. Additional modifications may be required to fully meet the specifications of the contract. In this case "a cure notice" will be issued to the manufacturer notifying him of the deficiencies identified in the course of the Field Validation Test.

The tests should be drawn up carefully and agreed with the supplier in advance and should form part of the contract agreement.

They should cover specifications such as throughput, overall imaging quality, imaging tools, image saving and retrieval, steel penetration, wire detectability, contrast sensitivity, scanning speeds, maximum dimensions of target to be scanned, operator environment, paintwork and general workmanship, as specified in the programme of requirement.

The dimensions of the radiation safety exclusion zone should be verified and radiation dose levels recorded at appropriate points at the perimeter of the exclusion zone, inside a laden scanned container, and in the operator cabin (in the case of a mobile system). These measurements should be made using a recently calibrated survey meter.

Field testing should include testing for radiological compliance in accordance with national regulatory requirements and any specific licensing conditions.

Many contract agreements now include the option of a short trial period which allows the system to operate in typical operational conditions and facilitates any necessary adjustments before final acceptance.

IX. FINAL ACCEPTANCE

If the systems are tested and meet the specifications of the contract, then the contracting unit may approve formal acceptance of the equipment according to the contract terms and relevant national requirements. Systems should not be formally accepted until any significant deficiencies identified in the field test are made good.

Final acceptance usually triggers payment of the final instalment of the equipment purchase price according to the payment schedule. It may be useful to include a contractual condition to provide for withholding a portion of the payment until any deficiencies noted in the field tests are remedied.

Operational support (establishing link with maintenance support; establishing spare parts inventory or accessibility to spare parts) should be clearly established.

X. POST DEPLOYMENT REVIEW

Periodic reviewing of the operation of the system forms an intrinsic part of the overall management of the project.

Initial review

Monitoring of the operation of the system should commence immediately after the system is installed.

It is inevitable that some teething problems will arise in the early stages of operation of the system. These may relate to technical problems within the scanner, as well as logistical or staffing issues.

The initial review should take the following into account:

- Effectiveness of system procedures (consider using personal log-in and password for each system operator)
- Quality of the system's images
- Quality of operational support (response times, adequacy of maintenance support; spare parts etc)
- Familiarity of operators with scanning functions

(Note: Early intervention in these areas may help to improve the overall efficiency of the system)

Long term review

As part of the long term management of the system it will be necessary to carry out periodic reviews. These reviews will rely heavily on good quality records maintained throughout the lifetime of the system. They should focus on the performance of the scanner, performance of the operators, maintenance issues, results achieved, and the benefits derived from the deployment of the system. Such reviews will also prove valuable when planning to purchase additional equipment.

The following issues should be considered:

- Overall system availability
- Any major maintenance issues
- Service response times
- Quality of maintenance support
- Quality of imaging performance
- Throughput
- Number of scans carried out
- Number of resulting physical inspections
- Number of detections made
- Radiological compliance, including monitoring of radiation dose readings
- Adequacy of operator training

Team leaders and local managers should be consulted in relation to issues such as:

- whether the equipment has performed in accordance with expectations
- whether operating procedures require alteration

- requirements for refresher training or advanced image interpretation training. (Generally the training courses provided by the suppliers are fairly basic, especially in the area of image interpretation)

XI. RADIATION SAFETY

All ionizing radiation equipment is subject to licensing by the national regulatory authority and must conform to national and international radiation safety regulations and requirements. Additional conditions may apply to systems using live sources including transport requirements, and replacement and "take back" conditions. It is advisable therefore, to engage a radiation safety expert, such as an accredited Radiation Safety Advisor, to deal with such issues at an early stage in the procurement process. This may be a regulatory requirement in a country.

Issues to be dealt with by this expert might include:

- Engagement with regulatory body
- Site assessment for radiological purposes
- Formulation of justification for practice
- Advise on relevant tender requirements
- Evaluation of relevant safety programme
- Implementation of radiation safety programme
- Compliance with licensing conditions
- Design of radiation safety awareness training
- Medical check-up for personnel

The radiation safety programme should include the following elements:

- Delivery of radiation safety awareness training to all operational staff before commencing operation of the system
- Appointment of Radiation Safety Officer
- Issue of Radiation Safety Procedures to all relevant operational staff
- Provision of personal dosimeters and monitoring of personal radiation doses
- Regular measurement of dose levels in scanner and at perimeter of exclusion zone
- Annual review of Radiation Safety Procedures

(Note: Notwithstanding any additional national requirements it is suggested that exposure dosage at the border of the exclusion zone be no higher than 1 micro Sievert (µSv) per hour (integrated)

In addition, the maximum radiation dose limit for operators should not exceed the limit for general public at 1 milli sievert (mSv) per year.

In addition, every effort should be made to minimise the accidental exposure to radiation of clandestine concealed within trucks and containers, especially at locations where they are regularly encountered. Additional resources, where necessary, should be provided to deal with such incidents.