

cost.

2 - Active Systems - These systems use tags with power and allow the storage of information in a dynamic way, in other words, you can record information such as points of reading, number of passengers on board the device, during the process.

Radio Frequency: This system processes the position information from information acquired by terrestrial systems, bidirectional communication through a radio network with unique frequency. It consists of a network of radio antennas, a communication unit installed in the vehicle or charge and a processing unit. This system has as main advantages, the precision, using the same communications channel for finding and exchanging information between the central and the device and a greater availability on GPS (*Global Position System*) as the main disadvantage shows the cost of implantation of the antennas.

Mobile network: better known as LBS (*Location Based Services*), has its operation based on the use of the infrastructure of mobile telephony.

The main technologies used in this system are: **Cell ID (cell identification)**. This is the simplest method of location and also the least accurate, since it is based on information coming from the identification of the cell to which the user is connected, and these cells can vary in size from 500m to more than 10 km in rural zone.

Timing Advance: This method allows to establish the location from time spent in the signal path between the antenna and the device.

AOA (Angle of Arrival): from *the* angle of arrival of the signal from the device into two or more receiver antennas is calculated its position. The advantage lies in the simplicity of mobile devices and the disadvantage is the high cost of the infrastructure of antennas directional.

TOA (Time of Arrival) is the location method based in the time of arrival of the signal from the device to the receiving antenna. May be posted two main methods:

TDOA (Time Difference of Arrival): This method measures the arrival time of the signal transmitted by the mobile device to the equipment called LMU (*Location Measurement Units*). From a user's request, the base forces the device to transmit a request of time measuring that is processed by the central SMLU (*Serving Mobile Location*

Center), determining its location. The advantage of TDOA is the use of the existing base, but its performance will depend of network traffic.

E-OTD (Enhanced Observed Time Difference): This method also uses the calculation time of the signal between the device and antenna, but who does the calculation is the device. The location is determined by the signal processing of at least three antennas, located in neighboring cells. It is recommended for areas with high concentration (density) of antennas and requires adaptations in the devices.

GPS - Global Positioning System: is a global positioning system that uses a network of 24 satellites orbiting the Earth. These satellites send signals with accurate information from their position / elevation and time of departure of the signal at specific frequencies that are processed by devices allowing to calculate the specific location on the globe. The calculation is done by the device with the information from at least four satellites. Thus, from the information received from the satellite (position, elevation and time of arrival of the signal) is fixed the first radius of location; from the second are assigned an area of intersection and so on, until the attainment of the location by triangulation.

Its main advantage is its global coverage and low cost device. Its disadvantage is the influence of shadow zones such as mountains and signal interference, such as those in urban centers.

Hybrid Systems / A-GPS (Assisted GPS) are systems that combine the technologies of GPS and LBS and are recommended for large urban centers. In this system a station receives, handles and transmits the information received by the satellite via the cellular network, reducing the cost of the embedded device, because it reduces its processing. Another advantage is the possibility of combining other technologies such as "Cell ID" or triangulation of antennas, if the GPS signal is unavailable.

Figure 4 shows a comparative summary of positioning systems presented, with their main characteristics:

<u>Método</u>	<u>Célula</u>	<u>Tempo de propagação</u>		<u>GPS</u>	
		<u>TDOA</u>	<u>E-OTD</u>	<u>GPS</u>	<u>A-GPS</u>
<u>Precisão urbana média</u>	50 a 500m 500m a 10Km	250m	75m	15 m	5m
<u>Terminais especiais</u>	Não	Não	Sim	Sim	Sim
<u>Custo</u>	Menor custo de implementação	Necessidade de pesados investimentos na rede e em servidores	Necessidade de investimentos na rede, servidores e terminais	Necessidade de investimento em terminais	Necessidade de investimentos em terminais e processamento na rede
<u>Obs.</u>	Precisão dependente do tamanho da célula	Precisão vulnerável à carga de tráfego da rede	Dependente de grande densidade de estações	Não tem cobertura indoor e sofre severas limitações com multipercursos e obstáculos (prédios)	Restrições à cobertura indoor

Figure 4. Comparative summary of positioning systems.

Source: Technical report of the “Central de Operações e Vigilância” – COV (Central of Operations and Surveillance – Plano Nacional de Segurança Aduaneira da Secretaria da Receita Federal.

3.3 Non-Intrusive Inspection

The non-intrusive inspection uses equipment that enable examining and analyzing contents, without requiring the removal from where they are stored. The major equipment currently used are the scanners, which may use X-ray or gamma-ray technologies. This article only covers the X-ray equipment.

This equipment is divided into three types:

- ✓ Mobile equipment;
- ✓ Fixed or relocatable equipment, where the equipment moves and the target is fixed;
- ✓ Fixed or relocatable equipment, where the equipment is fixed and the target moves.

All the types support the installation of radioactivity detectors, identity capture devices, via OCR systems and external images. Other equipment, particularly mass and infrared spectrometers, is frequently used together with X-ray apparatuses for cargo examination.

Thus type of technology is being increasingly used in containers and trucks, and thus article will focus on this utilization.



Figure 5: Large Stationary System
Source: From author



Figure 6: Scanner
Source: EBCO SYSTEM LTDA

The triplet: Penetration, Spatial Resolution and Flow

To better understand the functioning of an equipment of non-intrusive inspection, you can compare it with the mode of actions of the human eye.

For example, in a dark place, lit by a stroboscopic light, the identification of objects is done through the shadows on the wall opposite the light. If the object is very thin, the relation that as higher the energy as better the identification of the object may not be true.

Likewise, the amount of energy released by the x-ray device is not indicative of any object crossed by it will be seen in the radiosopic image.

Therefore, is necessary to concern which is the adequate amount of energy to observe specific material. In the human case, the eye is the instrument that captures the signal and generates the image, in the case of the non-intrusive inspection equipment, the diodes have this function, with the advantage that there are several types that can be used, depending of the target.

Besides the intensity, if the light flashes at a too fast frequency, the eye may not recover in time and if the object passes very fast, it will not be seen. Similar results were obtained with the non-intrusive inspection equipment, where the diodes have the function of capturing x-rays; if the chosen diode were not appropriate, failures in the distinction of details can be happens. Therefore, the diodes must be developed to recover its capacity to act in a compatible time with the speed of the object.

The non-intrusive inspection equipment, as well as the human eye, have affected his performance due to several factors, that cannot be treated separately. The main factors that should be considered in a non-intrusive equipment: penetration, resolution and flux. The penetration is linked to the observation of objects, the resolution to image quality and the flow speed of processing.

3.3.1 Principle of Operation

The principle of operation of X-ray equipment for inspection is relatively simple. An X-ray generator, which is usually an electron tube in conventional small-size equipment and a particle accelerator in large-size equipment, is energized by a power circuit, thus generating X rays. The X-rays generated are aligned by a collimator and form a fan-like beam with small thickness, usually around 1 mm. The object to be inspected passes across this beam – with fixed X-ray apparatus and moving

object, or vice-versa. This object is then traversed by the X-ray beam, and in function of its content density, it absorbs more or less energy from the beam, and the X rays that traversed this object hit a column of photosensor diodes, sensitive to X rays, which will emit an electric pulse. Analog to digital converters change these pulses in signals that are processed and finally converted in a digital image on a monitor. This radiosopic image shows the content of the object inspected.

3.3.2 Mobile Equipment

These are autonomous apparatuses, mounted on a truck chassis, which enable their displacement. They are manufactured to be quickly started up in use or prepared for a new displacement.

This type of equipment is primarily used by repression units, which must use the surprise element as a primordial factor for cargo examination.

3.3.3 Fixed Equipment with Fixed Cargo and Mobile Apparatus

Also known as “Gantry”. The truck that carries the cargo stops, the driver leaves the cab and this equipment, usually mounted on rails, moves alongside the object to obtain the image.

In addition to provide a good speed control, which provides more uniform images, it is possible to examine, in addition to the container or box that carries the cargo, the truck driving cab.

3.3.4 Fixed Equipment with Mobile Cargo and Fixed Apparatus

Also known as Portal (or Pass-Through). This is a piece of equipment where the X-ray apparatus is fastened to the ground and the trucks are driven by their drivers across the portal. The safety devices wait for the cab passing through the portal and trigger the X-ray beam on the cargo container or box.

This apparatus type enables higher cargo flow, and is capable of examining, with good image quality, near 120 trucks per hour.

4 Proposed Model

The key idea behind the model is tracking the vehicle and cargo and assuring its inviolability.

Shown below are the services to be used in the secure logistic chain model.

4.1 Physical Inspection of the Container

The physical inspection of the container is a procedure to be carried out upon truck arrival and

departure, aiming at checking the container status and its conditions at the analysis time.

First, the container seal will be inspected for any eventual violation. Then, the container inspection starts, according to a predefined checking routine made by an operator properly trained.

All these stages are followed by photographic records.

4.2 Inspection Level 1

Initially, the special equipment that will perform the cargo inspection must enable:

- ✓ Radioscopic image (X rays) of the cargo compartment (container);
- ✓ Automatic recognition of the presence of any radioactive material;
- ✓ Automatic cargo and truck identification;
- ✓ Obtainment of external images of the container and truck.

First, a so-called inspection level 1 will be performed, where the truck runs at an approximate speed of 7 km/h through an equipment, which enables processing approximately 120 trucks per hour per equipment installed.

The data achieved are digital, thus forming a file that will be transmitted in real time to a remote server. This information will be then available to any intervening authority (Tax Authority, Federal Police, Sanitary Surveillance, etc), and also other interested parties (importer, exporter, etc), which will be able to access it.

4.3 Inspection Level 2

After inspection level 1, and when identified as suspect, the cargo is submitted to other inspection, called herein as inspection level 2, where the truck

with the cargo parks and the equipment moves and achieves data with higher accuracy than that in the previous inspection, in addition to scan the truck driving cab.

This inspection level employs explosive and narcotic trace detectors and spectrometers to identify liquid and solid substances.

Solid residues will be also scanned for analysis, classification and screening purposes.

The data achieved are digital, and similarly as for the inspection level 1, a file is formed and transmitted in real time to a remote server and made available for queries.

In case of suspicion after inspection level 2, the cargo will be removed from the container and submitted to a physical inspection.

4.4 Sealing and Tracking

Also, it will be developed a container sealing and tracking system, which will enable tracking displacements in the run and/or path from the dock to the customs premises, including areas outside the port facilities in order to monitor the route and term established, as well as to assure inviolability of security seals.

To support the proposed model, the optimal solution is the utilization of electronic seals, with satellite-based (GPS) or radio frequency identification sensor technologies, to provide accurate information on the geographical position of the cargo or container. Among the numerous existing solutions in the market, a monitored padlock-type electronic seal must be used, as shown in the sample illustration below, installed on the container locks, which shall provide the features below:

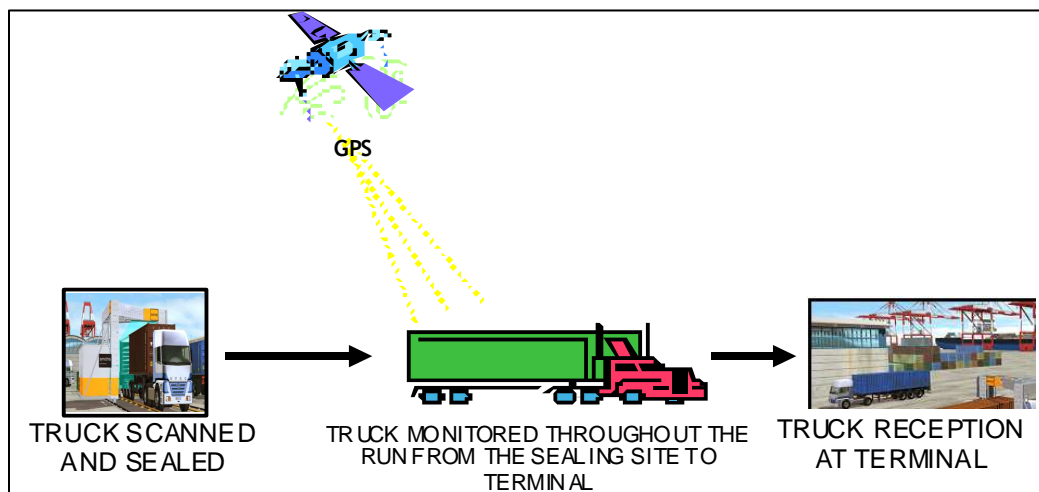


Figure 7: Tracking

- ✓ Physical security to prevent or alarm its violation;
- ✓ Physical or electronic non-repetitive alphanumeric identification;
- ✓ Active or passive transmission/reception of signals for run sensors or satellite; and
- ✓ Option for reutilization by undetermined time.

It shall be defined the specific place to install the sealing system to be used and routes and terms to be observed by the container carriers in the path between ship and warehouse, and vice-versa, also passing through the scanners' premises and including a solution for locking the container's door in order to assure its inviolability, as well as provide control information on the container, especially the one related to locking and opening times, and tracking, thus preventing the cargo displacement to more distant areas or on non-authorized runs.

4.5 Model Process Flow

When arriving to the location where the non-intrusive inspection will be performed, the driver will present the invoices for the goods carried, which will be entered in the system. This information may be sent in advance by the customer in EDI/XML format. Then, the truck shall be submitted to a physical inspection of the container in order to register its status, by checking that it was not violated. Next, the truck will pass by Inspection Level 1, and run to the place where the high-flow non-intrusive inspection equipment is installed. The images generated will be analyzed. In case of any suspicion or divergence with the goods information previously entered, the vehicle will be forwarded to Inspection Level 2. In Inspection Level 2, the non-intrusive inspection will be carried out by more accurate equipment. If the suspicion or divergence remains, the analysis information will be transmitted to the system users, and the parties involved will wait for the measures to be taken.

If there is no suspicion or divergence on the truck and goods, the vehicle will run to the sealing area. At this place, the vehicles to be tracked in the rest of the run will be sealed.

Upon departure, the container on the truck is inspected again.

We must highlight that all these stages will be monitored by electronic and photographic records.

4.6 Information Integration and Management

This model includes the development of a WEB Information System providing the container information and images, which will integrate:

- ✓ Scanner System;
- ✓ Physical inspection report;
- ✓ Electronic documentation;
- ✓ Tracking;
- ✓ Photographic / video system for the containers.

This portal will link the data proceeding from the systems described above, thus enabling the user to perform several queries.

5 Conclusion

The model presented, in spite of being focused on road modal transportation, can be adapted for railway, waterway, airway and port modal transports. This model will benefit the society as a whole in terms of greater and better control of drug and weapon traffic, and also goods smuggling. Other area benefited with this system is the control on pandemia proceeding from other regions and that may affect public health, fauna or flora, by the automation of non-intrusive cargo, solid residue, crew member and passenger inspection systems, aimed at controlling Severe Acute Respiratory Syndrome (SARS). Thus, there are numerous benefits from using the secure logistic chain by federal, state and local authorities, and we may highlight, among others:

- ✓ Inter-state tax control (ICMS);
- ✓ Sanitary controls;
- ✓ Environmental controls;
- ✓ Traffic control;
- ✓ Logistic control for exportation/importation cargoes;
- ✓ Information for systems that combat drug and weapon traffic and smuggling in general;

References:

- GARCIA, Valêncio. *Modelo de automação Colaborativa para aumentar a eficácia nos processos do gerenciamento da cadeia logística de suprimentos*, São Paulo, 2008.
- CALDWELL, Stephen L.. *Maritime Security – The SAFE port act and efforts to secure our nation's seaport*, 2007.
- SETCESP, Roubo de Carga, 2007. Site <
<http://www.setcesp.org.br/arquivos/seguranca/Ja>

n_Dez2007.pdf> access on 06/25/2008, at 11:34
AM

WCO – *World Customer Organization*.

Convenção de Kyoto,. 2006

U.S. Customer and Border Protection, *Container Security Initiative*, 2006.

BURROUGH, P. A.; MCDONNELL, R. A.

Principles of geographical information systems: Spatial information systems and geostatistics. 2. ed. New York: Oxford University Press, 1998.