

Electronic Container Tracking System as a Cost-Effective Tool in Intermodal and Maritime Transport Management

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Summary:

The amount of container goods that is lost due to theft, piracy, accidents and damage is unfortunately increasing. Real time remote containers tracking and monitoring can help prevent losing track of container and goods, as well as provide actionable information in order to retrieve goods or minimize damage. Moreover, the ability to determine responsibility in case of damage or theft leads to reduce insurance claims costs and lower insurance premiums. Thus, an effective container transport security and management system should include subsystems such as container tracking and container intrusion monitoring in real time. This paper is based on the AVANTE¹ Intermodal Real-time Container Tracking Solution and STARCOM Systems² TRITON Real-time Container Tracking System used in order to achieve benefits in supply chain security and management. The main aim of this article is to provide a holistic analysis of possible benefits for various levels of potential users of such systems. Working hypothesis of this paper states, that combination of advanced software and hardware solutions can help

container owners to monitor their often global fleet of containers, additionally can help in reduce the unnecessary costs and determine economical and security benefits in container management. Practitioners can use the research results as they reveal opportunities to increase competitiveness for carriers, forwarders, logistics and IT companies.

Key words: freight security, electronic container and cargo tracking systems, supply chain security management

JEL Classification: L 910, R 410

1. Introduction

Almost 90% of the world trade is accomplished with the help of containers using different means of transportation. Due to process characteristic and complexity, container trade faces a lot of challenges during day-to-day business. Comprising of container tracking, real time monitoring and intrusion detection, and real time theft reporting mechanism as well as status reporting of shipment items the container monitoring system seems to be the one of the most important tools for intermodal transport managers.

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¹ AVANTE is a US Complete Tracking Solutions Company, headquartered in Princeton, New Jersey, with subsidiary operations in Hong Kong, China and the Philippines and associated operations throughout Asia, South America and Africa.

² STARCOM Systems is a UK global technology company specializing in automated systems for remote tracking, monitoring and management of fleets of vehicles, containers and people with affiliated offices in Argentina (South America), Kenya (Africa) and UAE (Middle East).

Globally over 16 million maritime containers are in transit throughout the logistic processes on any given day regardless time and weather condition - at sea, on rail, over the road, or waiting on stuffing, pick-up, delivery and stripping. From economical point of view misplaced container results in financial and operational risk and any delay in delivery leads to increased transaction costs, production disruptions, missed sales opportunity and finally higher costs of goods being sold (Miler and Bujak, 2014).

According to Peters (2001) the syndrome of the "Needle-in-a-haystack" appears additionally in logistic processes of handling millions of container trips yearly around the world, in which only a small percentage of handled containers is inspected. What is more, each inspection causes additional challenge – how to secure the supply chain without stopping the flow of world commerce.

The cargo monitoring and tracking solution has to facilitate the flow of accurate and timely information across all involved parties including supply chain partners and government agencies. That is why integrated monitoring solution includes tools for (Mahlknecht and Madani, 2007):

- Optimization logistics processes in container handling,
- Improvement supply chain efficiency and reduce costs,
- Achievement of more efficient and individual container traceability,
- Deterioration theft, diversion and counterfeiting,
- Receiving notifications when an exception occurs in a given business process,
- Integration the RFID/GPS technology into existing business processes.

To achieve more information during a supply chain process in direct connection with any mobile business still remains the main objective of a container tracking service.

2. Conceptual Background – research problem and task

The main goal of this paper is to provide a holistic analysis of possible benefits for various levels of potential users of container tracking services. Working hypothesis of this paper states, that combination of advanced software and hardware solutions can help container owners to monitor their often global fleet of containers, additionally can help in reduce the unnecessary costs and determine economical and security benefits in container management.

This leads to the necessity of identification of the most advanced and cost-effective container transport security and management systems which should include subsystems such as container tracking and container intrusion monitoring in real time. For holistic comparison and analysis two representative systems have been chosen - the AVANTE Intermodal Real-time Container Tracking Solution and STARCOM Systems TRITON Real-time Container Tracking System. The research problem that needed to be resolved concerns the method of economic benefits definition for potential users of container tracking services.

In order to resolve the research problem the following tasks were identified:

- Define the area of knowledge necessary to solve the research problem;
- Determine the main criteria for identification of possible economic benefits for potential users of container tracking services;
- Propose a holistic analysis for benefits identification;
- Recommend further development and a model for verification.

Identification of possible economic benefits, under the condition that the demand for containerized maritime transport must be satisfied and the entire process must obey to a certain port calling

rule, aims at minimize the total cost of the ship route system with multiple hub ports, multiple feeders and multiple port/terminal operations. Finally, as an effect of additional in field research, a numerical example might be provided to illustrate the effectiveness of the identified solutions, and the impact on the total cost of a complex transportation system might be deeper analyzed.

3. Existing container tracking solutions and ideas

At multimodal container transport, including shipments, it is vital for a consignor to know the exact position and situation of goods (regardless whether being transported or in storage). Recently, the Container Tracking Service (CTS) scheme using Low Earth Orbital (LEO) satellite and Internet Service Provider (ISP) has been introduced to enhance regional and

even global visibility of almost all aspects of container status. This provides shipping companies or freight forwarders as well as consignors with more robust information such as door status, container-inside condition e.g. temperature etc. (Ahn, 2005).

Figure 1 shows the diagram of the entire container tracking process with use of GPS. Containers equipped with GPS receivers are carried by ship through ocean, and then unloaded at terminal, temporary stored on container yards and finally headed to their inland end destination. Simultaneously all activities and status of containers are reported by LEO, and ISP transmits the information to all parties involved, including shipping company and consignors.

The CTS scheme is a part of Intelligent Transportation Systems (ITS) concept, which deals with the introduction and further application of advanced IT in

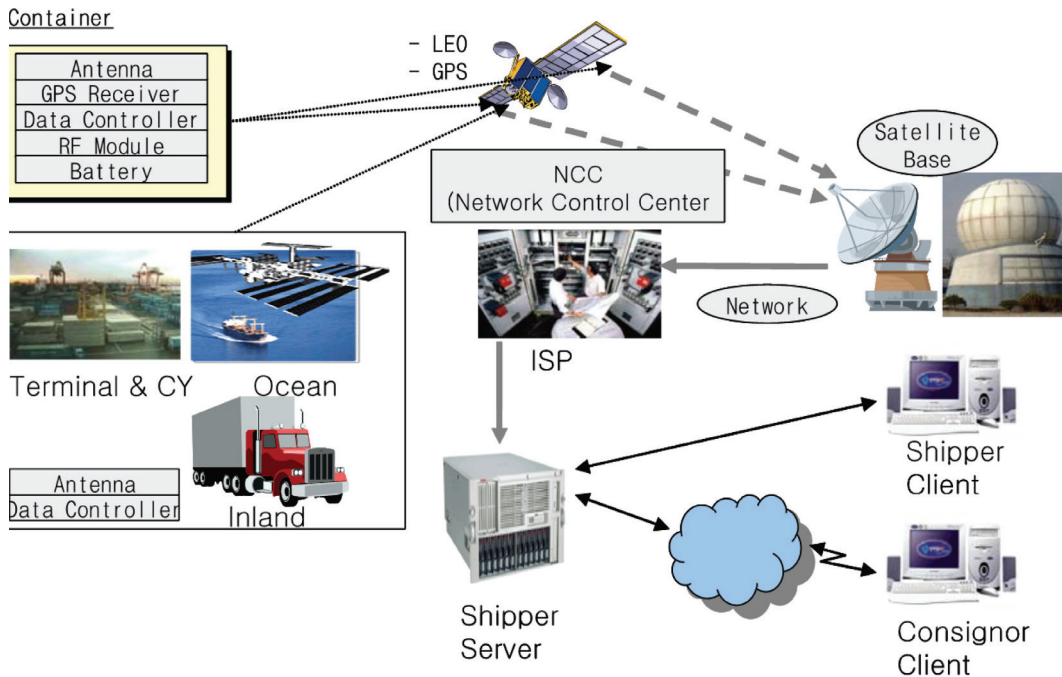


Fig. 1. Scheme of Container Tracking Service

Source: Ahn S-B., Container Tracking And Tracing System To Enhance Global Visibility, Proceedings of the Eastern Asia Society for Transportation Studies, 2005 Vol. 5, p. 1722

Articles

transportation processes in general. In the US, the Commercial Vehicle Operations (CVO) system was subsequently introduced as a subsystem of ITS and was followed by the implementation of ITS technologies to the monitoring of freight movement. In recent years ITS/CVO has become the important and powerful services in logistics

For electronic seals and tracking services a new technology of Radio Frequency Identification (RFID) has been already introduced. In addition in intermodal transportation, tracking and tracing issues are dealt with in ISO/TC204 WG7 regulations (van Hoek, 2002). Figure 2 shows ISO documents related to SCM tracking abilities.

RF Tag

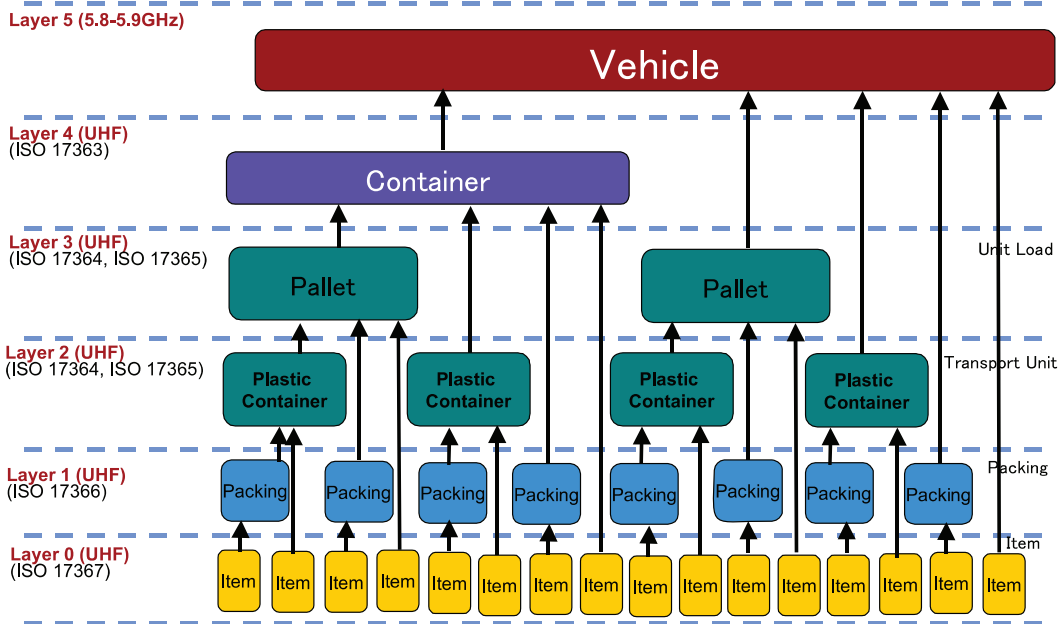


Fig. 2. Layer Structure of Supply Chain and ISO Documents in CTS operations

Source: Ahn S., *Container Tracking And Tracing System To Enhance Global Visibility*, op. cit., p. 1720

and especially in freight transportation. Bujak et al (2014) states that such as system may include electronic monitoring, screening, weigh-in-motion, border-crossing, credentials administration and automatic equipment identification. Global activities covered by Supply Chain Management (SCM) expand ITS/CVO services to other areas of activity, such as intermodal transportation and logistics information systems, warehousing, ports, rail stations and airports operations, etc. (Ahn, 2005, Lechner and Baumann, 2000).

According to Mahlkecht and Madani (2007) the clue of the Electronic Container Tracking System (ECTS) is to ensure end-to-end supply chain security and safety. For this reason monitoring and integrated management begins at the consolidation and packaging centers, follows road transportation and delivery to the port, includes storage at the port and (where applicable) terminal yards, offers optional ship deck monitoring, goes through drayage, and finishes with the de-consolidation and unpacking monitoring at the shippers or

end users warehouse. In principle the above mentioned end-to-end functionalities can be provided by state of the art industrial monitoring systems, however such system does not necessarily provide the advantages in flexibility and low cost of intermodal supply chain security and management as can be achieved by integrated commercial solutions such as AVANTE and STARCOM's Triton.

4. The AVANTE End-To-End Supply Chain Security System and Tracking Solution

AVANTE Supply Chain Security Monitoring Services, as an example of CTS services, provides a full spectrum of container security monitoring and tracking abilities throughout the supply chain (including cold chain) to all stakeholders, including shippers, consignors, logistics providers and customs authorities.

The AVANTE End-To-End Supply Chain Security System and Tracking Solution

consists of three important elements (www.avantetech.com/products/shipping, 2014):

- Electronic Cargo Tracking System and Solution,
- Intermodal Real-time Container Tracking,
- Rail Car Transport Security Tracking System

Electronic Cargo Tracking Solution (ECTS) is fully effective when the entire history of any given transport process is monitored and tracked in conjunction of two modes - real-time mode and end-to-end mode with a holistic approach. AVANTE solution provides these functionalities using patented active RFID container security tracking technologies (Miler and Bujak, 2014). General overview of the AVANTE ECTS architecture is presented on Figure 3.

Entire system consists of several important functionalities (www.avantetech.com/products/shipping, 2014):

- Real-time container intrusion and tampering detection based on multi-mode

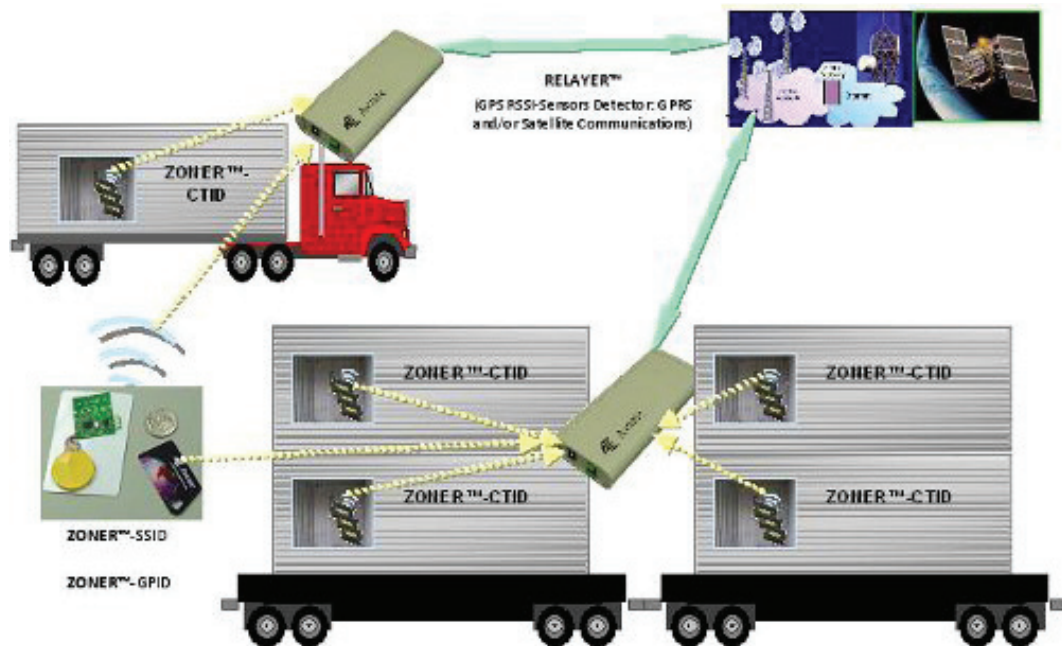


Fig. 3. AVANTE ECTS architecture and main tools
Source: <http://www.avantetech.com/products/shipping/>

Articles

sensors and tags placed inside the intermodal container securing all of the six container surfaces. Additional container security seal using optical continuity is available for container and trailer door intrusion tracking.

- Transportation workers and staff are equipped with badges that include a "transportation worker identification card" (TWIC), beaconing every second to provide real-time location and proximity to the container for personnel safety and container security. In case of emergency, to call for assistance, the driver and staff can press on the panic button.
- Carriers including trucks, rail trains, aircrafts, and vessels utilize devices based on GPS, GPRS and SATCOM technology to provide real-time locating of container and cargo. Unauthorized intrusion into a container and exceptions such as temperature excursions beyond normal ranges, excessive mechanical shock, absence of driver, etc., are reported in real-time.
- A cost-effective real-time locating system and reader-monitor network is installed in

ports, terminals, and yards to provide real-time visibility during temporary storage or while in transit. The same network is installed onboard vessels requiring real-time visibility.




- Containers and/or pallets or boxes of high value can use a device that is embedded with GPS-GPRS-SATCOM to provide independent real-time reporting status during scheduled times and exceptions or tampering information in real-time.

To achieve expected level of compatibility between all kinds of sensors, actuators, transducers, programmable controllers and data processing equipment, there are three types of devices vital for the system. The key elements of the AVANTE system are presented in Table 1.

Table 1. Key elements of the AVANTE End-To-End Supply Chain Security System and Tracking Solution

The AVANTE container and cargo tracking system (in end-to-end mode) and security monitoring services (including intermodal transportation) are much more compatible to requirements of the "Smart Box" concept

Table 1. Key elements of the AVANTE End-To-End Supply Chain Security System and Tracking Solution

<ul style="list-style-type: none"> • ZONER™CTID TAGS with temperature, motion, shock, light, sound, humidity and other optional sensors <ul style="list-style-type: none"> - Detect intrusions through any of the six sides of the cargo area - Can be located directly on the goods to provide localized status information or mounted on walls for general conditions. 	
<ul style="list-style-type: none"> • ZONER™SSID BADGES with panic button <ul style="list-style-type: none"> - Associates personnel and staff with goods for accountability - Active (433MHz ISM) RFID technology 	
<ul style="list-style-type: none"> • RELAYER™RFID COMMUNICATION DEVICE <ul style="list-style-type: none"> - Communicates with and monitors the ZONER™tags and badges - All data is stored and sent to a central server via GPRS or SATCOM - Relays the exceptions and intrusions to stakeholders via SMS, email and phone 	

Source: <http://www.avantetech.com/uploads/pdf/AVANTEBooklet.pdf>

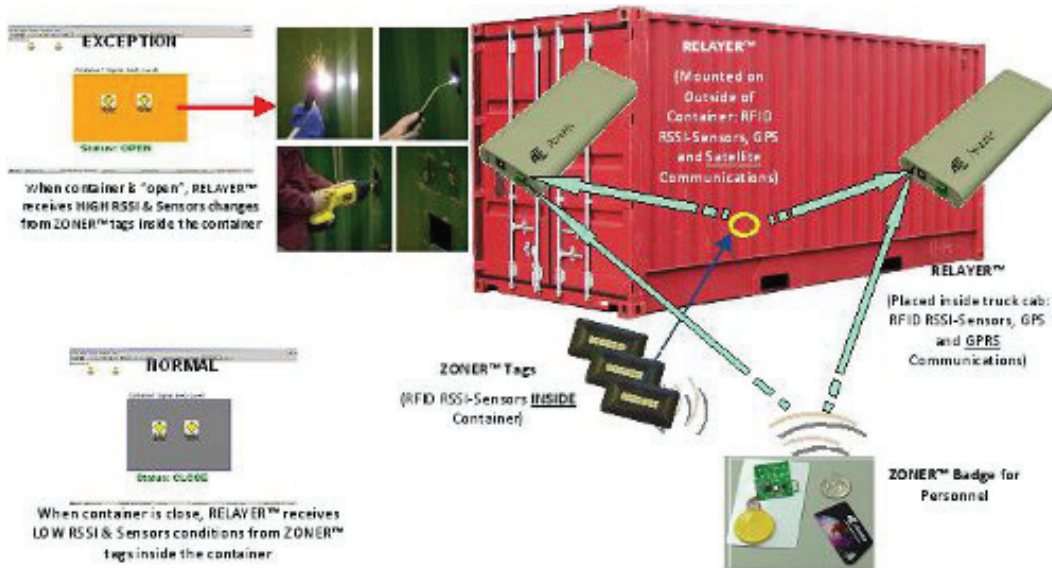


Fig. 4. AVANTE container security device solution

Source: <http://www.avantetech.com/products/shipping/>

than any other solutions. By utilizing new technologies using Automated Data Processing (ADP), Radio Frequency Identification (RFID) and embedded temperature, shock, sound, and light sensors AVANTE solutions can detect all known in containerisation intrusions and tampering giving practically no false positives (Miller and Bujak 2014).

The general idea of the system is provided on the Figure 4.

AVANTE multi-mode sensors and RFID devices detect exceptions from the defined rules and intrusions during the transportation process inside the container. All anomalies are reported via SMS, email and other communications channels in real-time to all predefined parties, including shippers, buyers as well as authorities including customs, insurance companies and 3PL providers (Miller and Bujak, 2014).



Fig. 5. AVANTE container security device information flow

Source: <http://www.avantetech.com/products/shipping/>

Articles

Information flow is shown on the Figure 5.

AVANTE system is unique and provides real-time alerts and notifications of any theft or damage to a container's contents from any of its six sides as well as all possible security breaches of the container in whole. System provides to the stakeholders the ability to check the predefined conditions of the goods including temperature, moisture

are provided with a specific documentation (certificate) of end-to-end tracking and monitoring for each container shipment. This report may be used for various purposes e.g. as a valid document for insurance rate negotiation, adjudication, and possible "green lane" inspection qualification and compliance (Ruiz Garcia *et al*, 2007). Additionally, the AVANTE services provide

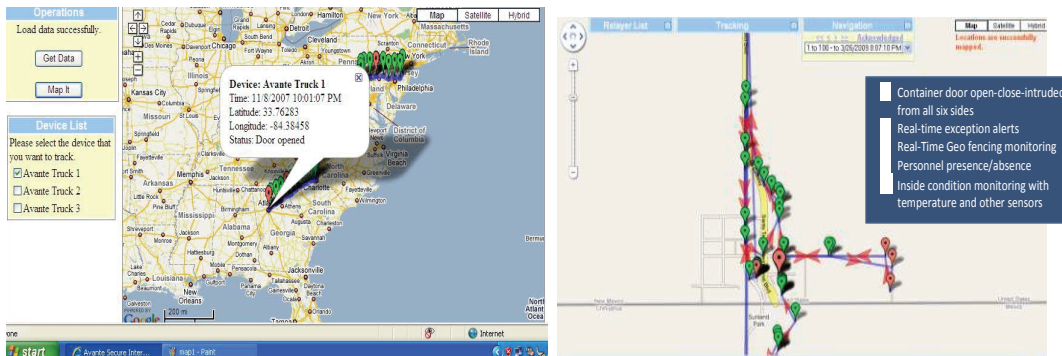


Fig. 6. AVANTE container security device information display

Source : <http://www.avantetech.com/products/shipping/>

and other sensor-based status anytime and anywhere in the supply chain.

Example of the AVANTE interface (with selected information displayed) is depicted on Figure 6.

Users and subscribers of the AVANTE Supply Chain Security Monitoring Services

any contraband detection. Worth mentioning are: optional real-time reporting of threats arising from smuggled radiological and chemical devices (achieved by additional direct sensor detection) as well as strategic end-to-end monitoring of stuffing points, transportation patterns and storage places



Fig. 7. AVANTE container location tools

Source : <http://www.avantetech.com/products/shipping/>

(Bujak *et al*, 2014). Location tools and display are presented on Figure 7.

The capability to report tampering and exceptions in real-time along with monitoring the transportation workers and staff in all phases of the supply chain execution helps to provide accountability, efficiency and deterrent of theft and tampering, what increasing dramatically the efficiency of container management and planning. The similar abilities are presented by STARCOM systems.

5. TRITON Real Time Containers Tracking System

STARCOM offers real time tracking systems for fleet management and security applications of the vehicle and driver (Helios), containers monitoring (Triton), merchandise tracking and management (Kylos), and a personal locator for the protection of individuals (Rainbow) (www.starcomsystems.com/products, 2014).

The Triton containers tracking system provides ongoing monitoring of a container through all the stations and checkpoints on its journey, from the factory to its destination, including:

- Container management (tracking and monitoring)

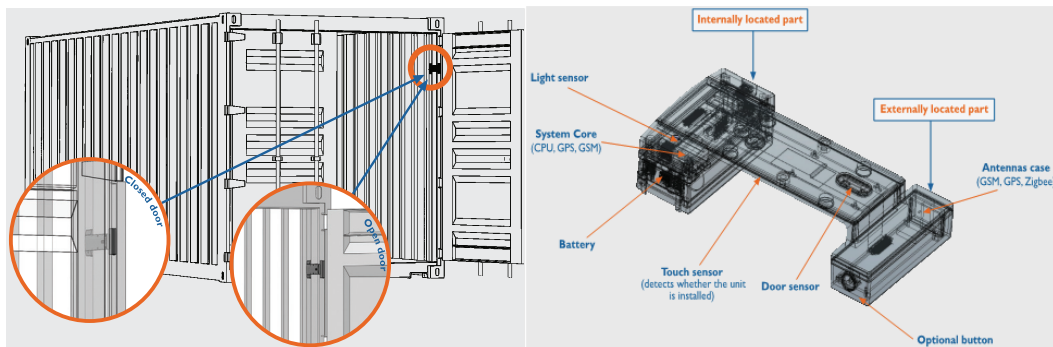


Fig. 7. The idea of the Triton Container Locator

Source: <http://www.starcomsystems.com/wp-content/uploads/2013/02/TRITON.pdf>

³ Monitoring only door locks for container security management is widely acknowledged as hardly effective. There are just too many ways to tamper with an intermodal container without touching or destroying the e-seal on locks during the transit.

Electronic Container Tracking System as a Cost-Effective Tool in Intermodal and Maritime Transport Management

- Insurance risk management (decreasing insurance premiums)
- Customs operations management (accelerating processes)
- Security regulations (supporting compliance with different country's legislation)
- Container operation management (cost and time reduction)
- Temperature Monitoring (log the history of temperature readings throughout the voyage)

Alerts can be triggered on various situations by a wide spectrum of single events, such as door opening, breaking-in bypassing the door, breaking-in if forcing the door or container suffering an impact. What is more, a trigger may be also set as a combination of events, such as the container door opening outside a defined area.³ Alerts can be transmitted, according to previously stated preferences, to the cell phone as a text message or to any given email address (Giannopoulos, 2004). The idea of the Triton Container Locator is depicted on the Figure 8.

The Triton system tracks the location of the container and provides useful information on its condition during entire transportation and handling process, whether going through customs inspections

or when harboring at the port, or if the container is now heading towards its final destination. Automatically triggered are all predefined exceptions such as unauthorized doors opening or container breaking-in, any deviation from a predefined route and all anomalies detected in temperature.

For better and more sufficient management, information from monitoring and tracking system should be available electronically. That is why the Triton containers tracking and management system produces a wide variety of reports that assist in efficient management. All events and reports are easily defined in a user-friendly multi-lingual application. The application is web based and can be accessed using either the PC in the office, mobile phone or tablet (Bujak *et al*, 2014).

The customs authorities, in order to control illegal or dangerous acts and collect taxes on imported goods, are obliged to inspect containers passing through ports or container terminals at least one time during their travel route (Bujak *et al*, 2014). Triton Container tracking device can allow a more efficient and more correct reporting to the customs and tax authorities. It is achievable by presenting reports on the containers route and on every opening of the container's door, ensuring container integrity and accuracy of reporting (www.starcomsystems.com/products, 2014).

In international and multimodal chain of supply security plays a central role. Security is impacted by different country's legislation and rules introduced in order to enhance supply chain security across various countries (van Hoek, 2002). Triton remote tracking container device can play an important role in helping to comply with regulations by sending direct information on container past and present location as well as cargo information. Possessing in advance information about a possible delay or mishap enables any managing staff

personnel to find an alternative solution or simply to notify in time the next links in the chain of supply about possible problems (Miler and Bujak, 2014). This allows providing a stable, reliable and qualitative service, which should not be underestimated when, came to economic and managerial benefits for users.

6. Economic Benefits Of Real Time Containers Tracking System

Taking into account all above-mentioned operational and technical features of the containers tracking systems it allows defining some of the most important benefits for potential users in economic and management field leading to achieving a competitive advance:

- Web-based 24/7 end-to-end real-time container tracking and security monitoring services optimize supply chain security management. This standard is achievable thanks to use of container security devices, carrier-based and yards based fixed site communication links, and association of personnel badges in real time through entire process.
- The ability to determine responsibility in case of damage or theft, thanks to end-to-end container monitoring leads to reduce insurance claims costs and lower insurance premiums.
- The container security tracking and monitoring services using RFID technology dramatically minimizes false alarms that have plagued the e-seal technology earlier.
- The first RFID technology for tracking and tracing personnel and assets over multiple locations and IT networks provides true end-to-end visibility to secure the supply chain in terms of personnel (human) mistakes (errors).
- This network technology provides complete coverage of a ship's deck

Articles

and port terminal yard. The resulting intermodal container security system is dramatically affordable and lower in cost over other current offerings.

- Knowing in advance about a possible delay or mishap enables any managing staff personnel to find an alternative solution or simply notify next links in the chain of supply in time. This allows providing a stable, reliable and qualitative service.
- The capability of real-time reporting of any exception (temperature, humidity) and intrusion (unauthorized opening, damage) provides the ultimate intermodal container security management and supply chain security management solution.
- The tampered carrier can be inspected away from the destination port to prevent potential negative impact and potential destruction (when high jacked by terrorists).

Potential benefits of Intelligent Freight Technologies (real time containers tracking systems) on economical and management fields can be identified in three main categories (Miler and Bujak, 2014):

- Direct benefits to private sector, including:
 - Increased efficiency and productivity, often thought of as cost reduction benefits,
 - Improved service quality and reliability, usually thought of as tools to grow market share and revenue by the retain of good customers,
 - Improved container integrity during shipment built around a bench of security issues;
- Direct public sector benefits, including:
 - More efficient and more effective government operations,
 - Improved safety of entire logistic process,
 - Greater national security,

Electronic Container Tracking System as a Cost-Effective Tool in Intermodal and Maritime Transport Management

- Significantly reduced environmental effects of entire logistic process, including freight transport,
- Reduced congestion and expanded capacity for transportation infrastructure;
- Indirect freight network benefits, including:
 - Economies of scale and decreasing unit cost of network expansion,
 - Exponential increase in total benefits as costs drop and usage grows,
 - Derivative productivity benefits in industries that depend on freight transportation.

As a good practical example of direct economic benefits achieved after introduction of container monitoring systems for private sector companies a value created for Perdigão S.A Company⁴ may be pointed. The company has achieved significant gains by deploying container-monitoring solutions including (<http://www.intra.com>, 2015):

- 500% reduction in turnaround times with carriers through increased flexibility and clarity of information exchanged,
- Reduced costs by minimizing the need for 3rd party resources to process shipping documentation,
- Improved customer service by increasing transaction volume and providing real-time updates of shipping documentation status,
- Increased efficiency of existing staff enabled completion of over 25,000 shipping instructions in 2007

Conclusions

During the past 20 years world seaborne trade increased by almost 40%, accelerated by the liner shipping, which grew the fastest. Containerized cargo is widely recognized as the most dynamically developing sector of global seaborne trade. Thus, containerization has been a major and increasingly important element of maritime activity, world trade

² Perdigão S.A. is Brazilian food producer founded in 1934 in the state of Santa Catarina in the South of Brazil, in 2009 announced merger with competitor Sadia forming Brasil Foods

Articles

and entire global industrial transportation structure and scheme.

The growing significance of containerization is a reflection of the changes that have occurred in the international organization of manufacturing and production. Container lines have moved through several organizational phases in the search for profitability. Most of the advances in containership design have been associated with the upsizing of vessels, both to accommodate trade growth and to offer economies of scale in a highly competitive market (Peters, 2001).

Container handling in ports is another area where technical advance is more than noticeable. Increasingly larger tonnage, especially container ships, will have significant implications for ports. The launch of the biggest container vessel (triple E, 18T TEU –McKinsey Moller) is a good example. Massive investments and substantial productivity improvements are generally required to enable ports to meet the stringent service requirements of their customers efficiently. The speed of container handling and consequent vessel turnaround time is a crucial issue in terms of competition. Competition among international stevedores and between these parties and ocean carriers for port concessions has never been stronger (Wang *et al*, 2006).

Information technology is now seen as the great opportunity for further competitive features development of any carriers, forwarders, logistics-based integrators and, potentially technology companies, who may use their systems expertise to enter the industry at the expense of traditional players. Container security tracking and monitoring services must be treated as a part of information technology and intelligent freight

technologies. Such systems incorporate a secure onboard communication and immediately (automatically) report any in-transit container intrusion or tampering to the proper (prior defined) authorities.

The end-to-end intermodal container and cargo transport tracking and monitoring services provide many of the potential benefits that are critical in a containerized supply chain security, such as:

- Cargo theft from containers and trailers via any of the six sides of the container,
- Potential spoilage from unwanted temperature variations (high or low),
- Cargo damage due to shock during handling for insurance adjudication,
- Border and Customs concerns of contraband,
- Homeland Security concerns of radioactive devices (optional services),
- Geo-fencing and route conformance for potential diversion issues,
- Real-time alerts for any exceptions and tampering,
- Web role-based access to the conditions of goods.

All in all - the main thesis of this paper states, that combination of advanced software and hardware solutions can help container owners to monitor their often global fleet of containers, additionally can help in reduce the unnecessary costs and determine economical and security benefits in container management in author's opinion has been proved.

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Electronic Container Tracking System as a Cost-Effective Tool in Intermodal and Maritime Transport Management