Secure and Smart Container Development for Intermodal Transport

--Study on the Concept for Secure and Smart Container

SSC: functions, technical solutions and standards (project phase I and II)

(FINAL REPORT)

APEC Transportation Working Group

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1. Introduction

1.1 About the project

With the huge container transport volume nowadays, two major issues related to the sustainable development of container intermodal transport are recognized:

a. Container logistics efficiency. This is a common issue with special concerns on port operations, collection and delivery systems, transport organizing and other trade/logistics related activities including customs inspection.

b. Container safety and security. After the "9/11 attacks", the security issue became a hotspot in many domains, include the transport sector. The mass trading containers are thought to be highly venerable to terrorism activities. Special treatments for securer container transportation are needed.

To address these issues, the concept of "secure and smart container" has been put forth, yet it needs to be carefully studied before its successful application. In this regard, the Secure and Smart Container (SSC) development for intermodal transport is an APEC funded project, proposed and now undertaken by the Waterborne Transportation Institute, MOT of China.

The key objectives of this study are: to study the CONCEPT, APPLICATION MODE and some feasible development SUGGESTIONS for the SSC, finding a practical way for intermodal transport to meet the challenges under the new circumstances of international trade and container intermodal transportation.

1.1.1 The necessity for this study

A global supply chain links the Asia and its economy to the rest of the world. The unit of measure of the supply chain is the shipping container: a sturdy steel box of standard dimensions that carries most freight. Millions of containers circle the earth on specialized ships, railcars, and trucks. However, the problems of theft and smuggling demonstrate the relative ease with which criminal elements have capitalized on the use of containers as conveyances. Anonymity of contents, opaque ownership arrangements for vessels, and corruption in foreign ports have all facilitated the efforts of those who are inclined to use container shipping for illegal purposes. So "secure and smart container" concept was put forth.

For the understanding of secure and smart container trade, there are gaps between the government policy-making and the industry's actuality, and between the security devices developers and the real demand of the container transport business. Therefore to gain a common understanding is the most important thing at the beginning.

This research project study the demands for secure and smart container transportation not only from the government point of view, but also from other parties within the intermodal transportation networks, such as the shippers, the liner companies, the container terminals and the trailer companies etc, in different countries, by extensive consultation to container transport practices and relevant projects, the study try to provide a systematic picture of the concept of SSC.

Based on the common understanding of SSC, the project can then analyze the proper application mode for SSC, which is vital for the success of SSC.

1.1.2 Review on related studies

Related APEC Fora
In 2002, the APEC leaders launched "Secure Trade in the APEC Region" (STAR) designed to enhance security while increasing trade. The STAR initiative commits APEC economies to accelerate action on screening people and cargo for security before transit; increasing security on ships and airplanes while en route; and enhancing security in airports and seaports. The STAR conference was held in Australia in 2007. The APEC has taken a series of plan of actions and the

US has made the Container Security Initiative and other efforts to promote the secure trade initiatives. The STAR project is one of the important references for this project.

Counter Terrorism Task Force (CTTF) has also been consulted. It is understood that its role is to identify and assess counter-terrorism needs, coordinate capacity building and technical assistance programs, cooperate with international and regional organizations and facilitate cooperation between APEC fora on counter-terrorism issues in the APEC region.

The previously APEC funded projects such as "Enhancing Secure Trade and Efficiency in the APEC Region with Intelligent Transportation Systems (ITS) And Electronic Commerce Technologies" have also been referred, which include the following contents:

1. Analysis of Container Track and Trace Technologies
2. Initial Planning and Concept Development
3. Research, Coordinate and Develop Evaluation Plan
4. Develop Detailed Test Plans, Collect Data and Begin Analysis
5. Execute Analysis and Finalize Evaluation Report

Research of this project also considered other related APEC projects, and some further studies based on the informed research and the new developments within the industry are made.

1.2 Methodology

As the first step to gain the extensive professional opinions from different parties in the container transport related industries, a questionnaire has been designed according to our project planning, and was then uploaded onto a special questionnaire survey website in China. The questionnaire can be found and answered in the following address, and questionnaire can be found in Annex1:

http://www.sojump.com/jq/107863.aspx?source=qq

These links to our questionnaire, as well as the same questionnaire in other forms (such as electronic version sent via emails, or hard copies) are distributed to different professional receivers in China and other countries from June 2009 onward. Until the completion of this report, 57 effective feedback copies have been received by the project team, which were used as the basic data for survey analysis in this project. Participants come from a good variety of organizations: government agencies (30%), logistics companies (19%), research institutes and universities (16%), container lines (9%), technical companies (7%), container ports (5%), shippers (5%), and others. 70% of the participants are male while 30% are female, no substantial correlations were found between genders and the answers.

1.3 Summary of the findings

1.3.1 Concept of SSC

Through research, we think the containers which have automatic identification module, information storage module, transport security monitoring module and communicate module are secure and smart containers. Of course, functional modules of SSC are not only above modules, it also has track & trace functional module and transport status monitoring functional module etc.

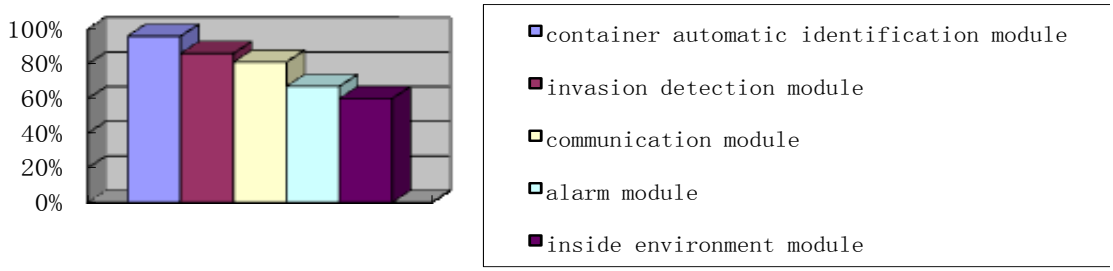
1.3.2 Functions

For the functions of the SSC, our survey shows a relative high agreement, among the participants, on the functions：

- Container automatic identification
- Ensuring container intermodal transport security
- Container track & trace
- Container intermodal transport information service
- Others

For the function modules of SSC, 96% of the participants agree that a SSC should have a container automatic identification module, 86% think it should have an invasion detection module,

81% think it should have communication module, 67% think it should also have an alarm module, and 60% think it should have the module for inside environment status detection.



1.3.3 Technical solutions

Website access or via management systems are mostly preferred to realize SSC data communication and information updates and sharing. Short Message Services via public telecommunication network should be taken as optional, depending on different business modes and customer requirements. On the other hand, “email” and “auto-notification telephone call” are far less preferred.

For short distance wireless communication of the SSC system, RFID and WIFI among other communication technologies are currently the most popular choices. Nevertheless, we may still see possible changes as some technologies have great potentials and are developing very fast.

For long distance wireless communication of the SSC system, the survey suggests that public mobile phone communication networks are good choices, such as GPRS/GSM. Satellite communication is also suitable for long distance communication; this is especially true for long-haul transport such as shipping, users can get the information on board in real time by chasing the vessel sailing information.

Over 2/3 of our participants support that SSC information service platform should be run by an independent third party.

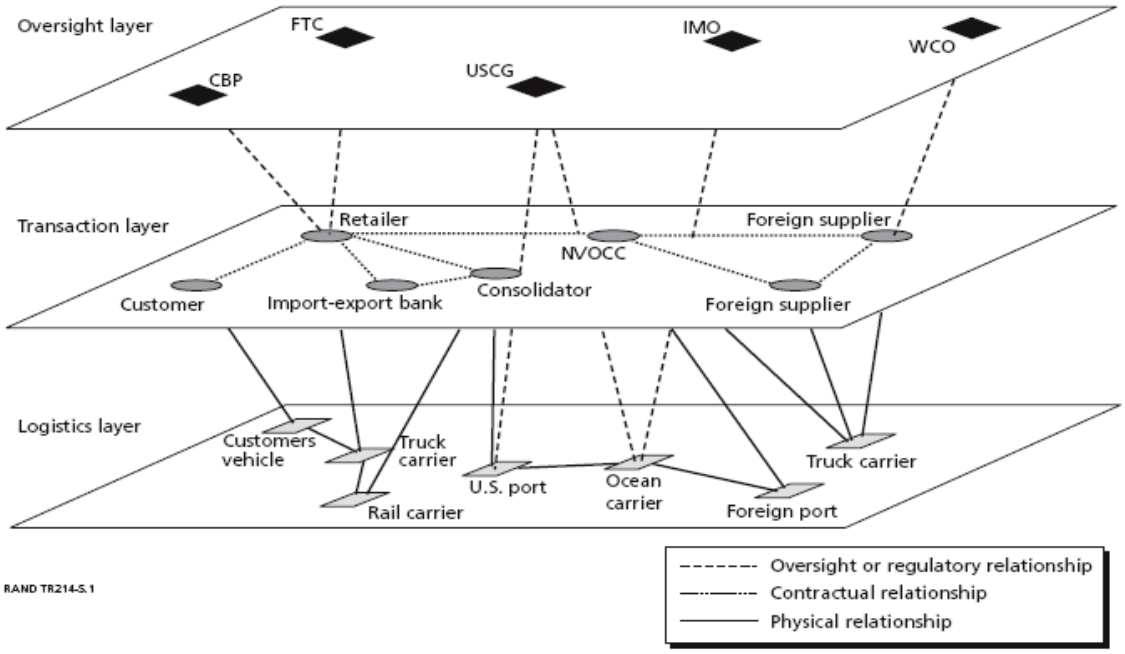
1.3.4 Standard framework

Standard research is one of the crucial driving forces and guarantee for development of Secure and Smart container, survey shows 88% of the participants think that the SSC should have a uniform standard. As an emerging direction of container intermodal transport development, SSC as a system concept is very complex, its standard to be established will involve many subjects, such as communication, mechanics, electronics, software system and management etc. In this report, research of standard framework will just set up a system framework, which needs to be enriched by follow-up studies in the future.

2. Study on the concept of SSC

Study on the CONCEPT of SSC is based on both security policy requirements and smart operation requirement within the container intermodal transportation networks. Ideally, the concept of SSC should meet the need of improving safety and security in container intermodal transport and the efficiency of seamless connections among different transport modes. In order to do such a job, a good understanding of container transport system is essential. Generally, it includes three layers, i.e. the logistics layer where containers are transported and handled, the transaction layer where business take place, and the oversight (administration/regulation) layer. Interactions among the Logistics, Transaction, and Oversight Layers of the Supply Chain can be explained by the figure below (Source: RAND).

Figure 1. Interactions between the Logistics, Transaction, and Oversight Layers of the Supply Chain



(Source: RAND).

The three points of view each form a layer of the supply chain, each of which depends on the others; we begin with the transaction layer. In the transaction layer, the movement of raw materials, work-in-progress inventory, or finished goods represents the fulfillment of an order. Figure 1 depicts a retailer, who contracts with a foreign supplier and a common carrier to deliver the goods. The carriers in the logistics layer move freight across sea, rail, and road networks. Interacting with the other layers is the oversight layer, which sets the rules under which the lower layers operate. The regulatory network specifies actions that should be taken to secure the supply chain, levies fines, and sets standards. Note that the oversight functions are diffuse: The national and regulatory agencies evolved with specific industries but are now called on to ensure security of the supply chain. For example, U.S. Customs and Border Protection is responsible for enforcing U.S. trade law in addition to ensuring the security of the containerized supply chain.

2.1 Requirement for higher security level on container transport

2.1.1 Supply chain management after 9/11

Due to the invisible of the cargo inside it, containers have been used to smuggle contrabands. The stowaways itself is estimated to cost the industry more than $20 million a year. The vast majority of containers are never subjected to scrutiny due to the large number of containers in use.

After 9/11, supply-chain security has been redefined as preventing terrorists from targeting the containerized supply chain or transporting a weapon in a shipping container. The change in focus raises questions about the effectiveness of proposed security efforts and the consequences they may have for supply-chain efficiency[1].

In recent years there have been increased concerns that containers might be used to transport terrorists or terrorist materials into a country undetected[2]. The U.S. government has advanced the Container Security Initiative (CSI), intended to ensure that high-risk cargo is examined or scanned, preferably at the port of departure. Besides anti-terrorism concerns, food safety and hazardous cargo transport are also important issues that ask for better container transport security.

Besides anti-terrorism concerns, special cargo such as food and pharmacy supply chain safety and hazardous cargo transport are also important issues that ask for better container transport security assurances. So does Events & Exhibition logistics, which generally have high standards for container transport safety and security among other service quality standards.

2.1.2 Proposed measures on policy level

Customs-Trade Partnership against Terrorism (USA)

The goal of Customs-Trade Partnership against Terrorism (C-TPAT) is to push responsibility for cargo security onto stakeholders in the supply chain. C-TPAT is a voluntary program that shippers and carriers can enter to assure CBP (US Customs and Border Protection, the largest law enforcement agency within the Department of Homeland Security) that they have put into place the best security practices for the packing, tracking, and distribution of all containers and goods en route to the United States. In return, shippers and carriers are rewarded through quicker processing and reduced probability of inspection delays (CBP, 2004).

Free and Secure Trade program (USA, Canada)

The Free and Secure Trade (FAST) program is a United States-Canada-Mexico joint program. The FAST initiative offers pre-authorized importers, carriers and drivers expedited clearance for eligible goods, building on what Canada previously implemented under their Customs Self Assessment (CSA) program. Initiated after 9/11, this innovative trusted traveler/trusted shipper program allows for expedited processing for commercial carriers who have completed background checks and fulfill certain eligibility requirements.

More than 87,000 commercial drivers are currently enrolled in the FAST program nationwide. (The FAST program is open to enrollment by U.S., Canadian and Mexican truck drivers.) FAST processing exists at 55 of 105 northern and southern land border ports that process commercial cargo. The majority of FAST processing occurs at dedicated FAST lanes in key northern border ports in Michigan, New York and Washington State and at southern border ports from California to Texas. Participation in FAST requires that every link in the supply chain, from manufacturer to carrier to driver to importer is certified under the Customs-Trade Partnership Against Terrorism (C-TPAT) program.

Operation Safe Commerce (USA, Canada)

Operation Safe Commerce (OSC) is a technology-development and -deployment program intended to improve the ability of customs agents to detect illicit cargo on its entry into a port. According to TSA (Transportation Security Administration) in 2004, “OSC is a collaborative effort between the federal government, business interests, and the maritime industry to develop and share best practices for the safe and expeditious movement of containerized cargo.” Through a set of grants, OSC is promoting the testing, evaluation, and fielding of container scanning and tracking technologies.

The Container Security Initiative (USA)

The Container Security Initiative (CSI) aims to establish working bilateral partnerships with foreign authorities to identify high-risk cargo containers originating at ports throughout the world before they are loaded on vessels destined for the United States. It inspects and clears containerized cargo before shipment to the United States (CBP). Through this program, CBP has deployed inspectors at almost the world’s all major seaports in Europe, Asia, Africa, and North America. There are currently 58 foreign ports participating in CSI, accounting for 85% of container traffic bound for the United States. The goal of CSI is to make it more difficult to transport illegal shipments to the United States by implementing inspections at ports of origin, thus increasing U.S. security.

The Maritime Transportation Security Act of 2002 (USA, IMO)

MTSA dictates that domestic ports and carriers with US-flagged vessels develop and institute port, port area, and vessel security plans, and register these plans with the USCG (MTSA, 2002). These requirements establish standards and protocols for port security, inspections, and emergency response. MTSA is the U.S. version of the IMO's International Ship and Port Security Code (ISPS Code, IMO, 2004).

EU: CSP (Customs Security Program)

CSP offers the benefit of prioritized and simplified processing of customs clearance for freights of export companies that meet a certain level of safety and security.

2.2 Requirement for smartness

2.2.1 Consistent efficiency improvement

Facing an ever increasing container handling volume, capacity limit is another problem bothering the port and logistics industry. The industry needs to take every measure to improve the container handling efficiency. Innovation on transport operation modes is preferred to conventional infrastructure capacity expansion activities. Examples relating to this point include bigger vessels, two TEU container handling gantries and new management systems, etc.

Environment protection and fuel consumption reduction also ask for higher efficiency and less idle/waste work for transport and port operations.

2.2.2 Control of supply chain and seamless connections

Supply chain management requires better planning, organizing, coordinating and controlling of every activity of the supply chain. Traditionally it relies on the forecasting for future market and business planning. With the development of computerization, Management Information Systems and especially the internet application, different parties within the supply chain can share the real time information, thus they can have a much better agility to be more flexible to react in the ever changing market environment.

To have the good control is the most challenging issue for supply chain management, which involves many parties in different transport links and nodes in different transport modes, all make it difficult to achieve synchronized logistics activities. As the result of globalization, intra-firm trade between different countries is becoming more and more popular[3]. Multinational companies often organize their productions in a global picture to gain the benefit of comparative advantages of different regions. This makes logistics and supply chain management become ever more important for the big shippers. At the same time, it brings further challenges for the transport sector as a service industry for the customers.

For the interconnection points (transport nodes such as the port), it is often considered as the bottleneck of the whole supply chain system, since low connection efficiency easily happens here between different transport modes. So to improve the seamless connections in intermodal container transportation is an important object of the whole industry to better satisfy their customers.

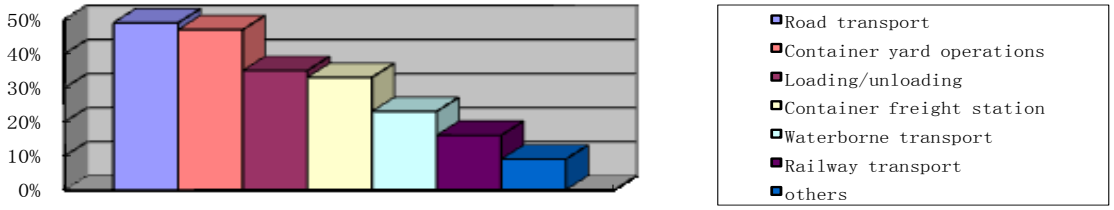
2.3 Questionnaires analysis

2.3.1 About the existing problems within container transport

All the participants to the survey have the understanding that there are safety/security problems and efficiency problems in container intermodal transportation.

For the security issue, a multi choice question on the vulnerable points in container intermodal transport systems was brought up. According to the survey results, the vulnerable points were identified and ranked as follows:

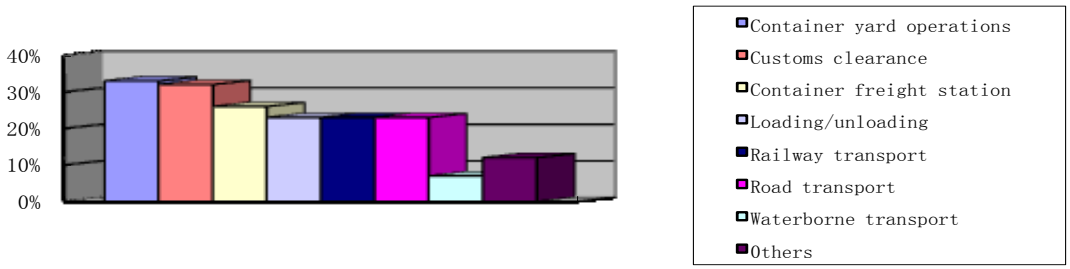
Road transport (49%);
Container yard operations (47%);
Loading/unloading (35%);
Container freight station (33%);
Waterborne transport (23%);
Railway transport (16%);
Others (9%)



From the above result, it can be seen that nearly half of the participants hold the opinion that road transport and container yard are the most vulnerable points within the system, followed by loading/unloading operations and container freight station operations. This goes in accordance with the container transport practice, because in general, road transport is under the weakest monitor compared to other parts of container logistics activities, and container yard is the place where most smuggling/stowaway accident happens.

For the efficiency issue of container intermodal transport system, the most inefficiency points for choice are relatively evenly spread, ranked as follows:

Container yard operations (33%);
Customs clearance (32%);
Container freight station operations (26%);
Loading/unloading (23%);
Road transport (23%);
Railway transport (23%);
Waterborne transport (7%);
Others (12%)



The above result shows that the most concerned issues are yard operations and customs clearance, in terms of efficiency. In fact, there are inefficiency problems existing almost everywhere in the whole system, that's why the opinions are spread evenly among different participants. An interesting finding is that although waterborne transport is the slowest transport mode among others, only 7% think it's inefficient. An important reason for this is container shipping is a highly developed global industry and is relatively better organized than trucking or railway transport etc. The implication of this finding is that container shipping (include port operations) may be the starting point for the possible global application of SSC in the future.

2.3.2 About the concept of SSC

According to our survey, among all the participants who are from container transport related industries, 72% of them have heard of “Security and Smart Container” in contrast to 28% who have never heard of it before. This provides a good foundation for our further questions since more than 70% of the participants have been exposed to the concept of SSC before. So it’s reasonable to take the results of this survey as valuable to the study.

For the form of a SSC, two thirds (67%) of the participants think it must not be an absolute answer, in other words, either removable or fixed devices to the container should be fine, given that the secure and smart functions would not be affected. We also see 25% of the people think the SSC should be an entirely new type of container that made with special materials with sensor functions etc.

For the functions of the SSC, the survey shows a relative high agreement that 91% of the participants think it should have the functions of container automatic identification, container track & trace and container intermodal transport information service. 82% think it should be able to ensure container security, followed by the compatibility/extensibility functions (chosen by 77% of our participants) such as compatibility for sensor devices, intelligent operation management, logistics organizing, and other applications like container maintenance management or overload alarm etc.

All the above results provide the ground for defining the concept of Secure and Smart Container, which is discussed in the next step.

2.4 Concept of SSC

From questionnaire, we can find SSC is considered to have automatic identification function, ensuring security function, track &trace function, information service function, recording environmental information function and intelligent management function, etc. We think if the container has automatic identification module, security monitoring module, information storage module and communication module, which can be called as secure and smart container. Of course, SSC does not only have above mentioned functional modules, it also can have track & trace module and transport status monitoring module etc.

Automatic identification function is precondition to realize secure and smart container, which ensure the uniqueness of container in transit. Information storage and exchange function is the basic condition to realize secure and smart container, which can realize the storage of container transport information and safety information, and provide the information communication ability of people and container. Transport safety monitoring function is necessary condition to realize secure and smart container, which can make the common container have the safety monitoring ability.

The concept of SSC also should be understood as combining the related systems, integrated with all kinds of intermodal container transport facilities and resources, business operation systems and container security devices and their supporting IT systems by applying different technologies. Without the support of related systems, the container itself will not be able to ensure its secure and smart functions.

Within the system, one can organize and monitor all the container logistic activities and resources needed along the entire supply chain, analyze and optimize the overall container transport operations with the decision support functions of the system. The functions are discussed later on.

To achieve these functions, various technologies are integrated in the SSC system. By adopting electronic tag (RFID) technologies, containers can be automatically identified in real-time with related information needed by different management information systems to achieve better efficiency and accuracy; by adopting sensor technologies, the open/close status of the container and its inner environment data can be detected and recorded to improve the security level and reliability of container transport; by adopting positioning technologies such as GPS system, container track & trace can be realized.

3. Functions of SSC

The container transportation involves in the interests of different parties, and different users could have different requirements and impacts on container transport and standards. The project aims at the combination of technical options and management systems and operation practices to summarize the security and intelligent functions for SSC. The research result is also expected to provide some suggestions for the standard framework of SSC, which is also very much needed to conform to the increasingly high safety and security standards in intermodal container transportation.

The functions needed for SSC are summarized in this chapter, with consideration of different technical options. This include the security functions needed for ensuring the transport security, and the smart functions needed for improving the seamless container intermodal transport chain.

3.1 Functions

For the functions of the SSC, the survey shows a relative high agreement that 91% of the participants think SSC should have the functions of container automatic identification, container track & trace and container intermodal transport information service. 82% think it should be able to ensure container security, followed by the compatibility/extensibility functions (chosen by 77% of our participants) such as compatibility for sensor devices, intelligent operation management, logistics organizing, and other applications like container maintenance management or overload alarm etc.

3.1.1 Container automatic identification

Container automatic identification is the very basic function to realize seamless connection for intermodal transport, and to improve container transport safety and security, as well as container automatic management level and informationization level. With this function, when a container goes into/out of the portal of rail, road and port, its identification number will be automatically identified and input into corresponding application system, at the same time, its related information of container will be updated in the central database. Container information mainly includes: container inherent information, container transport information and cargo information. Container inherent information just like a person's ID Card, should contain container number, weight, manufacturer, produce date, spec, owner information, maintenance record and schedule etc. Container transport information contains container location, place and time of departure and arrival, environmental information (temperature and humidity), conveyance etc. Cargo information contains cargo owner, type, weight, volume etc.

So far, container information is input into application system mainly by manual work, in many cases, this work would be done several times within one single shipment. Mistake of missing and inputting fault container information often happens, and at the same time, manual work can also cause lots of waiting time, leading to logistics resources waste. For example, when a truck carrying container goes into checking bridge of port, the driver of truck has to stop the truck, and walks to the booth of portal to run procedure of entrance, the officer will input the container number and related information of container to management system of port, this process will spend average two minutes at least. If in rush hour, there is a long queue waiting out of the portal, which strongly affects the efficiency of transport. Container automatic identification can deal with this situation easily, which does not need the truck to stop at the checking bridge, the container information will be input to management system of port automatically when the truck passing the check bridge at the normal speed. Automatic identification function not only reduces the error caused by manual input and working intensity, but also saves cost of labor force.

3.1.2 Ensuring security

In the last decade, losses through cargo theft have soared. In the beginning of the eighties average global cargo theft statistics show losses to the tune of 20 to 30 billion USD annually. In 2001 losses reached 300 billion USD, and at present they grow with an average of 20 to 30 billion

per year. Cargo theft is a serious threat to products in transit, the supply chain and ultimately, shareholder's value. Organized criminal gangs account for a fair percentage of the thefts, especially in Eastern Europe, Russia and the CIS[4]. However, the vast majority of all cargo theft is caused through pilferage by drivers, customs, handling personnel and amateur thieves which are 'at the right place at the right moment'.

Illegal emigration and smuggle by furtively intruding into containers are becoming serious problems that puzzle the customs. In this case, traditional lead seal can not completely ensure security, for example, Seattle Times reported that the USA Washington customs found 22 illegal emigration hidden in 40ft container on April 4, 2007. Another report came from Europe Daily said that in Thailand, 54 Burman illegal emigrations were found stifled in the container on April 9, 2008. After research and investigation, it was found that when traditional lead seal was cut, the same duplicate would replace cut lead seal or they would agglutinate the cut lead seal from breakpoint.

Therefore secure and smart container needs the function of ensuring the security. Once the container is invaded without authorization, it will record and alert automatically. Authorized opening and closing, such as loading/unloading, customs random checking, will also be recorded. This function will reduce loss of cargo, and effectively stop illegal emigration and smuggle events.

3.1.3 Track & trace

Track & trace is another very important function for secure and smart container, which is the key element for ensuring security and providing logistics information.

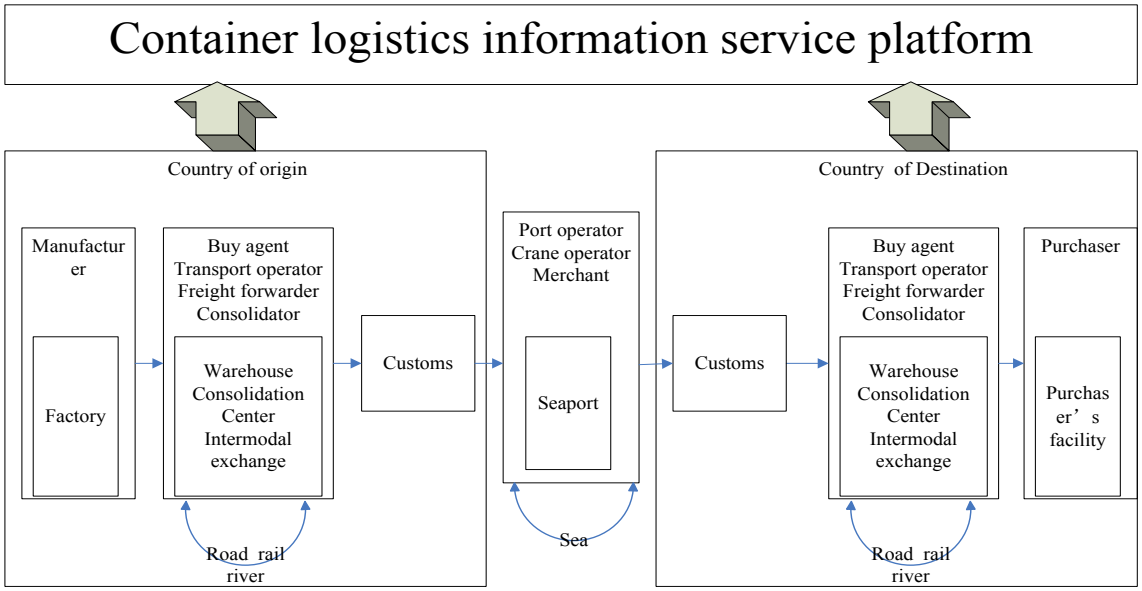
The location and time of container in the whole transit process are recorded; the tracking function enables users to track the current status of their shipments online by using Booking Reference Number, Bill of Lading Reference or Container Number. The system is continuously updated, and should not display any commercially sensitive information to the public.

The tracking information can also be combined with other information, such as container open/close status, temperature, etc, and these container information should be synchronized. For example, when trace transit process of smart and secure container, we need to record location, door open/close status, environmental information at the same time, these container information should be correlated, not be isolated existence, which are convenient for track and track. When the route is different from the preset transport route, or the container door is opened or environment information is beyond the normal range, smart and secure container should be able to send alarm and record the detail data for tracing the whole transit process.

3.1.4 Information services for different parties

While secure and smart container has the function of automatic identification, ensuring security and safety and track & trace, it can realize the transparency of container logistics chain, figure 2 depicts the whole process of container transport. When secure and smart container passing transport nodes, secure and smart container information will be automatically identified and uploaded to container logistics information service platform. Container logistics information service platform serves objects contain: Manufacturer, shipper and consignee, buy agent, transport operator, freight forwarder, consolidator, customs, etc.

Figure 2 Container logistics information services platform



As for manufacturers, they wish to know accurate transport information of material and components, such as time of departure and arrival, etc. In real life, transport information of material and components often is notified to manufacturers by sellers, however for some reason, transport information provided by sellers is always inaccurate that will affect efficiency of production. If manufacturers know container number carrying the material and components, Container logistics information service platform can provide manufacturers accurate transport information by short massage or website query.

As for cargo owners, buy agent, transport operator, freight forwarder and consolidator, they can not only gain the accurate transport time, but also monitor the container state, such as location, container safety state and environment information, to prevent cargo theft stealing. Specially for fresh food and hazardous goods, environment information is very important.

As for customs and government administration, on the one hand, they can gain more container information, information data of these containers record details of most national economic activity clearly, which will help government analyze current economic situation and setup solid base for policy making-decision. On the other hand, customs agents equipped with reader device could scan the secure and smart container to obtain its electronic manifest, thereby facilitating the container-inspection process. As long as the secure and smart container does not send a signal indicating it has been damaged or broken, a customs agent would know that container has not been opened, and that its contents have thus not been altered. Secure and smart container not only improves the efficiency of passing, but also improves the inspection level and quality.

3.1.5 Recording environmental information

For cargos that are sensitive to temperature and moisture, tiny temperature and humidity sensor can be added to packaging. If sensors record temperature and moisture out of tolerance, the sensor signal information will be written to the RFID Tags on the container to alert someone later in the supply chain.

For fresh food supply chain, this is very important, for example, 'dumpling toxic event' happened in Japan on January, 2008 is a typical case. Some Japanese people who eat dumpling transported via container from China got food poisoning, both exporter and importer insisted that they have no responsibility in their quality control. However there was no evidence and monitoring data, people can not know in which node this event happened. So it is hard to ascertain the responsibility, in the end most experts deduced that high temperature and high humidity made dumplings deteriorated during long distance transport.

Pharmacy products have the similar supply chain safety requirements as foods. Due to the specific characteristics of such cargo, logistics service providers have to ensure the absolute safety of the entire supply chain. In this regard, the secure and smart container would play an important role to make the whole supply chain transparent to the customers.

Along with the development of globalization, business and cultural communications domestically or internationally become more and more frequent, which brings a lot of business opportunities for the events/exhibition organizers. Further, the logistics demand of this business is growing very fast. Noting that this is a kind of high-end logistics, the requirement for punctuality, safety and security as well as environment control is at a relatively high level. Considering these requirements, secure and smart container can be helpful for better events/exhibition logistics service quality.

For hazardous goods, such as fireworks products, environmental conditions like the temperature inside the container are important elements for logistics safety, hence should be monitored carefully. For liquefied goods like LPG (Liquefied Petroleum Gas), LNG (Liquefied Natural Gas), and liquefied chlorine and so on, inside pressure of tanker container, liquid location, obliquity, acceleration and velocity also should be monitored and recorded. Real-time monitoring data would help people master the related information in time, reduce the possibility of transport accidents.

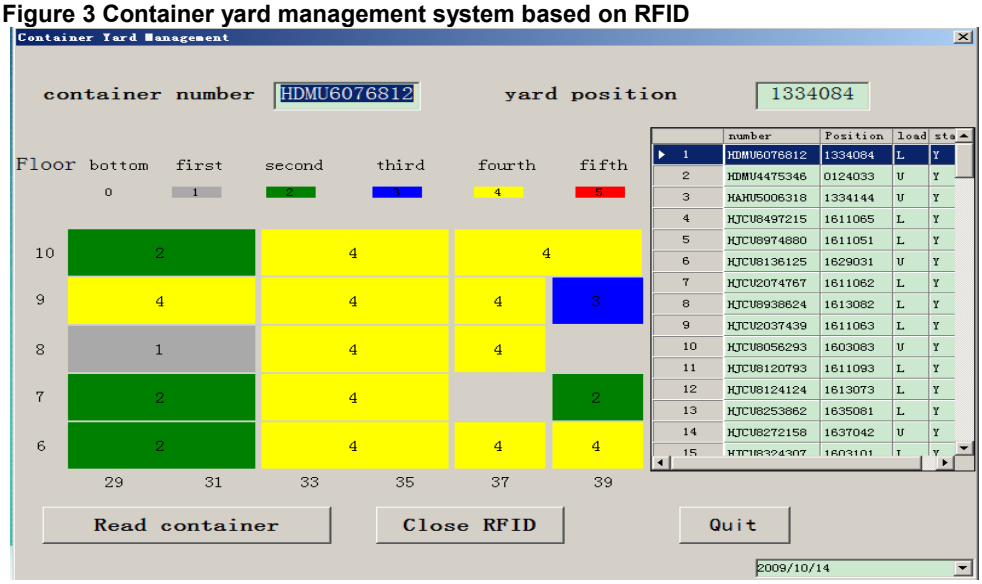
3.1.6 Intelligent operation management

Secure and smart container can effectively improve container yard operation efficiency based on automatic identification. Conventionally, container operation at the yard is mainly conducted by worker, who tells the driver of gantry crane where the container should be placed according to the operation plan. However, this operation mode often causes mistakes; the driver may put the container at a wrong place after several times of container transposition.

For example, there are four containers stacked together, if the container at the bottom is going to be loaded, the driver should carry away the other three containers above at first, after taking the right container, the driver needs to replace the three containers back, but their position information is actually changed, mistakes of such kind often happen in this container transposition process.

If reader devices of secure and smart container are fixed on the spreader of crane, combined with intelligent management software run on the mobile computer of crane cab for driver, when crane spreader holds the secure and smart container, the management software will read the container number and yard position of the container, to check its operations. Figure 3 displays an interface of the container yard management software as a part of pilot project which was developed and applied in container yard by waterborne transport institute of MOT, P.R.C.

Figure 3 Container yard management system based on RFID



From figure 3 we can see that container number can be read into management software, stacking position information of the container will be searched from the right planning list and displayed as the left 2-D top view, which can display the current container position and surrounding container stack status. The different color represents different floor, for example, the container number being read is HDMU6076812. According to this container number, it will automatically search the planed position in the container yard, which is 1334084, it means its position is in the 13th district of the yard, '34' is an even number, here it means the size of the container is 40ft, and its column coordinate is between 33 and 35, '08' means it is in row 8, '4' means it will be placed on the fourth layer. The indicated coordinate position will flicker ceaselessly until the driver places the container at this position. If the driver places the container on a wrong place, it will alarm warning the mistake, and at the same time, the system will record the details of operation, such as time, operator, loading or unloading status. It is easy to know dynamically how much containers in the container yard and where they are.

Secure and smart container can also realize container management itself. Through survey, we noticed that there are lots of old containers which have been stacked in the container yard for a long time, and there is nobody admit these containers (maybe their owners have forgotten or lost control of these containers, or they think it is not worthy to spend so much on storage fee to take these containers back, so they decided to abandon them instead). However, for container port, it is hard to deal with this problem: if container ports keep these containers for long time, which will hold much space to cause resource waste; if ports dispose of these containers, they may worry that one day, the owners of the containers will ask for them. Because ports do not know much about the container inherent information, it is hard to get in touch with the container owners. Container automatic identification can deal with this problem, secure and smart container will tell the port who it is and where it comes that will help the port find its owner and maintenance.

It is obvious that secure and smart container can improve the automation management level and working efficiency.

3.2 Technical solutions available today

3.2.1 Radio Frequency Identification

Nowadays, bar coding technology, Radio Frequency Identification (RFID) technology and optical character recognition (OCR) technology are three major auto-identification technologies being used.

Bar coding technology are being used widely nowadays. Printed labels with standardized black bar and human-readable numbers at the bottom are being scanned almost every where with hand-held readers to read the SKU number on the bar-code label. Due to its cost saving and efficiency improvement, it is widely applied on the manufacturing, packing and retailing industries. However, bar-code labels can realize auto-identification function only within a very short distance, which is not suitable to be placed on the side of a container, but "smart" RFID tag can capture the every movement of that container.

A RFID system consists of tag, antenna, and transponder (reader). Data information can be stored in tag, data information can be read from tag and be written into tag, RFID tag can be divided into passive tag and active tag. Passive RFID tags are powered wirelessly by the reading device and have the potential to provide the information at low cost. Active RFID tag is powered by itself battery which has longer distance of reading and writing than passive RFID tag. For active RFID, According to different situation of supplying power by battery, active RFID tag is further divided into active RFID tag and semi-active RFID tag, if semi-active RFID tag is out of radiation range of transponder (reader), it will be in the state of dormancy and almost not consume power, when semi-active RFID tag is in the radiation range of transponder (reader), semi-active RFID tag will be incentive, working power is mainly supplied by transponder (reader), itself battery is just supplement for power while the tag is in the place where radio field intensity is deficiency.

Presently, main UFH RFID frequency is used in Korea, China, Japan and USA (see chart 1)

Chart 1 UFH RFID frequency in Korea, China, Japan and USA

classification	Korea	China	Japan	USA
Tag frequency	860~960MHz	840~845MHz and 920~925MHz	860~960MHz	902-928MHz
Reader frequency	908.5~914MHz (expects to relocate 915~923.5MHz by June 2011)	840~845MHz and 920~925MHz	950~956MHz	902-928MHz

RFID technology can be applied in the container identification, there are two main reasons: first, feature of this technology is suit for identifying the moving container. Under certain speed and angle, accuracy of identifying moving container can reach 99.9%, because identification capacity of active RFID tag is stronger than passive RFID tag, if passive RFID tag can be identified successfully, active RFID tag also can be identified in the same situation, we have done some experiments to research RFID technology applying on the container, related research introduction can be found in Annex 2. The research proved availability of automation identification by applying RFID on container. Second, RFID technology has been proven to work normally in extreme temperature and weather conditions, which can realize auto-identification in fog, dark day and night.

Optical character recognition technology is that picture captured by camera will be input to computer, the character on the picture gets recognized by computer arithmetic. The RFID technology has a big advantage over a bar code and Optical character recognition when there is no line of sight. Bar codes need a line of sight to shoot out the red light, capture and read the bar code. Optical character recognition needs plenteous light to capture picture for camera, so it is hard to realize auto-identification in fog, dark day and night. Another big differentiating advantage is that RFID can read multiple items for one time, whereas bar codes just scan one for one time.

As it is so often the case, a technology's biggest strengths are also its biggest weakness, without needing the line of slight, RFID sometimes causes conflicts to determine what you are reading, because any container with RFID tag in the antenna field could be read, if containers with RFID tag go through the portal abreast, they will be read by reader. So when trying to read the information of Tag, you have to ensure that you are not reading multiple tags. However, the times of reading RFID tag in a fixed period are determined by the distance from reader, this case gives us possibility of using software to distinguish different RFID tag.

3.2.2 Sensor monitoring technology

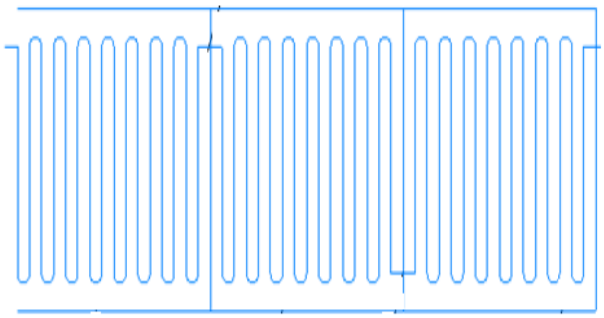
Container monitoring system consists of controller, sensor, power and related signal circuit. Controller is like a person's brain, sensor is like a person's eyes, and sensor can detect and collect the container environment information, and tell the controller what he feels. Temperature and moisture sensor can detect inside the temperature and humidity of container, optical sensor and magnetic sensor can detect open and closed statement of container door, velocity sensor can detect the speed of container, acceleration transducer can detect the acceleration of container, pressure transducer can detect the inside pressure of container, container monitoring is restricted by three main factors: first, condition of container transport is extremely harsh, it brings great challenge for monitoring system stability and reliability. Second, container transport has a very long cycle, power supply is challenge that requires low power dissipation of monitoring system. Third, space of container is occupied mainly by the cargo, the space for monitoring hardware is limited which requires the hardware is as possible as small.

MEMS (Micro-Electro-Mechanical Systems) can deal with above problems, which consists of micro-sensor, micro-controller, and related signal circuit, the sensors such as temperature and moisture sensor, optical sensor, velocity sensor, acceleration transducer, pressure transducer and others can be packaged into chips, these chips can be welded on the electronic board, this way can not only reduce the power dissipation, but also save the hardware space.

Magnetic sensor is used for monitoring the open and closed statement of container, which is made into the E-seal, when container door is open, the magnetic field power of magnetic sensor will change, this way can realize to monitor container door statement, but container has six sides; only monitoring the container door is not enough. In order to monitor the break of six sides of container, a layer of safety pad can be fixed on the inside surface of container (except bottom plate), this safety pad is made of electricity sensor network, safety pad divides every side (container roof, container side plate) as a big unit, every unit is divided into small standard pieces, conductive net is laid on the standard pieces, connectors connect the small standard pieces as figure 4.

When some small standard piece is broken, we can change it with new piece, the standard piece is made of something of hardness insulated materials which can be folded pending, conductive electricity net can be laid inside of glue plate, this kind of glue plate will placed on the bottom of container, which need to have the capacity of bearing the forklift weight, at this time, the electricity net of six sides of container will connected as a whole, when some break happens on the container, the electricity through the break will change, different extent break will cause different electricity change, destroyed the balance of electricity sensor net, the controller will analyze the electricity change comparing with the pre-value, and can find the precise broken position of break.

Figure 4



(source from: CIMC)

3.2.3 Positioning technology

GPS (Global Positioning System) is playing an important role in our lives. Almost all current navigational systems are based on GPS, and the security industry makes thankful use of this technology as well. Truck companies manage their fleet movement and cargo location with it, and sea / land transported cargo alike is tracked, traced and secured with GPS equipped units. The fundamental basis of the GPS system is a triangulation process where a GPS receiver measures its distance from three satellites using the travel time of radio signals broadcast from the satellites to provide precise location information. The GPS receiver uses the signal from a fourth satellite to remove any errors in its local clock, allowing for very accurate timing, this timing process allows for the highly precise measurement of distances that gives GPS it accuracy. Along with distance, the exact location of the satellite in space is also needed. Constant monitoring by ground based radars allow for very precise position updates to be sent to the satellite for this purpose. The satellites broadcast a signal, which contains information on its location, velocity and the time of transmission based on very accurate atomic clocks. A GPS receiver that can access signals from three satellites for triangulation and a fourth to correct the receiver's clock, can locate its position on the globe with excellent accuracy, from 15 to 30 meters. In fact if you use a differential GPS system, one that removes the built in error placed in the system by the military, to prevent malevolent use, by using an additional fixed land based signal you can achieve accuracy in the 3 meter range. Europe has recently launched its own GPS system allowing for even greater accuracy, and it is bound to be operational soon[4] .

3.2.4 Wireless communication technology

Wireless communication is very important link for smart and secure container; data communication contains short distant communication and long distant communication. Presently, the most popular short distant communication technologies have Bluetooth, Wi-Fi, Zigbee, UWB (Ultra-Wideband) and IrDA (Infrared).

Bluetooth uses 2.4GHz ISM common channel, mainly applying on speech information and data transmission of short distance, users can use the Bluetooth device without application, frequency hopping rate is 1600 per second, which makes the Bluetooth have very high capacity of

anti-jamming. The available communication distance between Bluetooth devices is about 10~100 according to the different emission power, providing wireless link of one point to another point and one point to multi-points, this technology is mature, but faces the biggest obstacle is the price is high and distance of data transmission is short.

Wi-Fi (Wireless Fidelity IEEE 802.11) uses 2.4GHz and 5GHz channel, transmission rate can reach 11Mbps (802.11b) - 54Mbps (802.11a), WI-Fi network can cover a radius of more than100 meters , Wi-Fi Protected Access and other WIFI productions rapidly develop, improves the safety of data transmission greatly, initial IEEE802.11 criterion is put forth in 1997,called 802.11b which provides WLAN access, and also is main technical standard of WLAN, application of WI-FI becomes more and more abroad with development of 802.11a and 802.11g, WI-FI is the wireless extension of internet, WI-FI data safety is not good as the Bluetooth, but transmission distance is better than Bluetooth.

UWB (Ultra-Wideband) is burgeoning high speed communication technology, which has obvious advantage under 13 meters, the highest transmission speed can reach 1GB/s, frequency range of UWB is from 3.1GHz to 10.6GHz, however UWB technology just is admitted by few countries, market production of UWB is on the initial stage.

Zigbee (IEEE 802.15.4) uses 2.4GHz ISM common channel, which has very low power and speed, speed can reach 10M-250kb/s, distance of transmission is about 10~75 meters. In the most time, zigbee technology is in the sleeping mode which is fit for the situation that data do not need real-time transmission; the character of zigbee is that activation time is short, power and cost is low, which will make it become much advantage in the field of auto-monitoring and remote controlling. A key component of the zigBee protocol is the ability to support mesh networking. In a mesh network, nodes are interconnected with other nodes so that multiple pathways connect each node. Connections between nodes are dynamically updated and optimized through sophisticated, built-in mesh routing table. Mesh networks are decentralized in nature; each node is capable of self-discovery on the network. Also, as nodes leave the network, the mesh topology allows the nodes to reconfigure routing paths based on the new network structure. The characteristics of mesh topology and ad-hoc routing provide greater stability in changing conditions or failure at single nodes. When container is transported by rail, because the train is long, RFID reader is hard to read the information of every container, however, zigbee technology can realize adjacent zigbee nodes retransmit information of container. At the same time, when container is transported by ship, the containers will be stacked together, if we choose WIFI or GPRS to transmit the information, the signal of monitoring container which surrounded the others will be sheltered, zigbee technology can deal with this issue, the surrounded container can transmit the monitoring information to adjacent container by mesh network.

IrDA (Infrared) is point to point communication technology using infrared ray, infrared wavelength is between 0.75um and 25um, because of short wavelength, IrDA has weak diffraction capacity for barrier, so it is fit for situation of no stumbling block.

Presently, the most popular long distant transmission technologies have the third generation (3G) of mobile transmission technologies, Microwave Access (WiMax) and GSM (Global System for Mobile Communications)/GPRS(General Packet Radio Service)/GPS(Global Positioning System). Worldwide Interoperability for Microwave Access (WiMax), a mobile technology, will be available to the user by the end of this decade. This advance in mobile telephony, still in trial phase, has a transmission rate of 70Mbit/s with a cell average of up to 50km given ideal conditions. WiMax will allow for provision of integrated CCTV, sensors, communications, GSM video streaming and more in area's where no data network is normally available. Another advantage is that the private nature of closed user group WiMax setups allow for individual security protocols and encryption with less risk of security breaches.

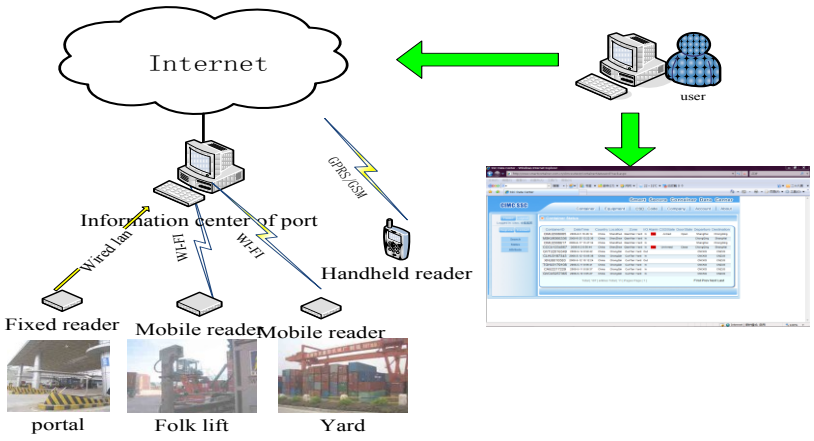
GSM/GPRS transfer modes often are provided by many companies to be tracking & tracing solutions. The advantages are clear, flexible implementation, reliable communications, low operating costs, and roaming between networks allow for SMS usage worldwide. This technology provides a large added value to the monitoring of low-cost goods in transit.

Satellite communication is another way of information transmission, Data distribution is provided via low earth orbiting satellites which circle the earth several times a day. Data information is uplinked/transmitted and subsequently downlinked/transmitted to the end-users operations center.

When SSC passing by the reader of SSC, SSC information is read by the reader, the container information needs to be transmitted by wire network and wireless network, Combined the current data transmission technology, we will put forth different technical solutions for realizing the data transmission of SSC.

When the reader is fixed at the gata or portal of port, if there is wired local area network in these places, the reader can connect the wired local area network to transmit the data information. If there is no wired local area network, WI-FI technology can be used to access into the local area network. Take the port for instance, Figure 5, there is wired LAN (local area network) at the portal of port, the fixed reader can transmit the SSC information via wired LAN directly, for mobile machine such as folk lift, crane etc. , WI-FI can be used for accessing to the local area network of port, handheld reader can read the SSC information and transmit to internet by GPRS/GSM directly.

Figure 5

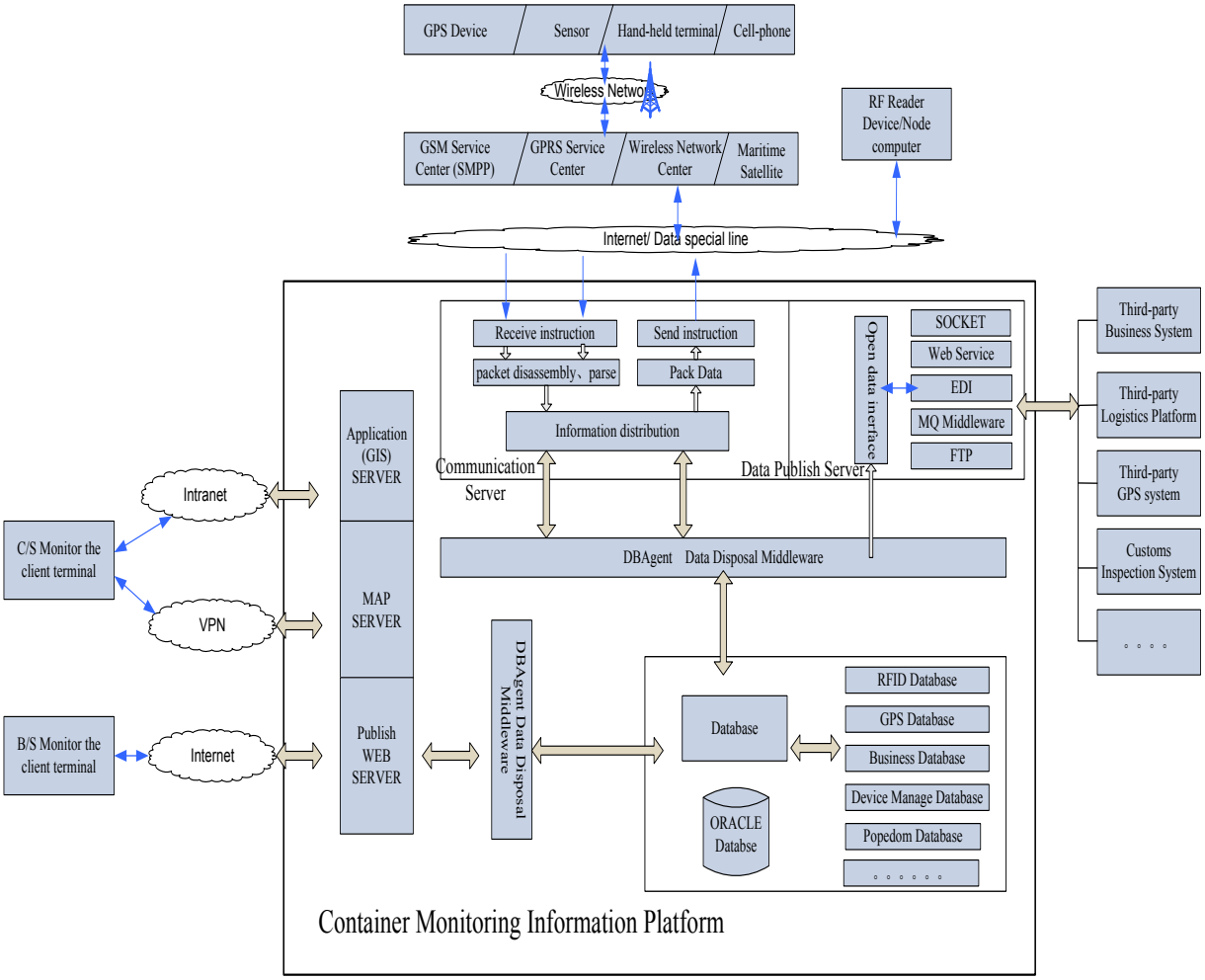


When SSC is transported by truck, train or ship, if we adopt secure and smart device, the GPS and GPRS/GSM module are suggested to be placed at the cab considering power consumption, because there is enough electricity supply at the cab. The secure and smart device can communicate with GPRS/GSM module by short wireless communication technology, such as RFID and Zigbee. In addition to GPRS/GSM module, the satellite also can realize long distance data transmission, however its cost is higher than GPRS/GSM, satellite communication often is chosen where GPRS/GSM is not usable.

3.2.5 Network Information technology

Information network platform is the carrier of logistics information service, As figure6 shows that system structure frame of information network platform contains data collection and communication sub-system, data storage and backup sub-system, electronic map sub-system, data publishment and application sub-system, data safety and device certification sub-system, network monitoring sub-system, and so on.

Figure 6 system framework of information platform



XML(extensible Markup Language), web service technology, multithreading technology, database technology, cryptography technology, GIS (Geographic Information System) technology, EDI （Electronic Data Interchange）technology, and other technology will be used for building the information network platform.

XML is extensible makeup language established by W3C, which is subset of Standard for General Markup Language, XML is a standard of describing network data content and structure, which can be used on different operation system platform. XML occupies more space than binary system data, but its technology is determined by contents, which is most powerful tools for dealing with the structure document and information exchange.

Web service technology can provide an interface for communicating and sparing information among every isolated net nodes, Web service adopts the universal and open standard, such as HTTP(Hypertext Transfer Protocol), XML, SOAP(Simple Object Access Protocol), WSDL(Web Services Description Language), so Web service can be used on Linux and Windows operation system platform, web service is a set of standard, which defines application program how to realize the mutual operation with web, we can use any program language to write web service program on any operation system according to web service standard. The web service platform must provide a set of standards, through which user can communicate with web service, Remote Procedure Call Protocol can help user realize remote data communication, XML/XSD, SOAP, WSDL are the primary technologies.

Multithreading technology is used for completing multitask synchronously, not for improving running efficiency but for improving resource using efficiency.

Database is data storage set according to certain data model, the basic structure of database consists of three layers: physics data layer, concept data layer, logic data layer. The main character of database is as follow:

- Realize data sharing
- Reduce data redundance
- Realize data concentrate control
- Malfunction recover
- Data consistency and availability

Presently, there are many popular databases such as DB2, Oracle, Informix, Sybase, SQL Server, PostgreSQL, mySQL, Access, these databases can be used according to different purpose.

Cryptograph technology is the guarantee of information safety and plays very important role in whole information system, asymmetric cryptographic technique and symmetric cryptographic technique are used widely for information safety, DES (triple-DES) and AES are American block cipher standard, RC4 is very famous stream cipher, RSA and DSA is most popular digital signature mechanism, and cryptograph technology is quite complex, it is hard to make it clear using short words, however cryptograph is essential part of information network platform.

GIS (Geographic Information System) technology is comprehensive technology related to geography, topography, computer, etc. which can combine GPS data of database with electronic map, user can track and trace the container location of map through B/S or C/S mode.

ISO describes EDI（Electronic Data Interchange）technology is ‘ commerce transaction processing is formed to structural format of message data according to accepted standard is transferred from a computer to another computer through the internet ’, Information network platform needs to develop the interface of EDI for transferring the container and cargo information to users.

3.3 Questionnaires analysis

The general functions needed for SSC have already been discussed in the previous chapter with the support of the survey results of certain questions in our questionnaire. It suggests that the SSC should have the functions of container automatic identification, container track & trace and container intermodal transport information service, and the ability to ensure container security, as well as the compatibility/extensibility functions. Here, more detailed issues regarding to these functions and their technical solutions are discussed.

3.3.1 Function modules for SSC

To realize the functions, a SSC should have relative modules: With regard to container automatic identification function, it is thought to be the most important and basic function for SSC that 96% of the participants agree that a SSC should have a container automatic identification module, since it’s the basic requirement for other functions. 88% think that it should have a GPS or similar positioning module; 86% think it should have an invasion detection module; 81% think it should have communication module; 67% think it should also have an alarm module. Apart from these, 60% think it should have the module for inside environment detection.

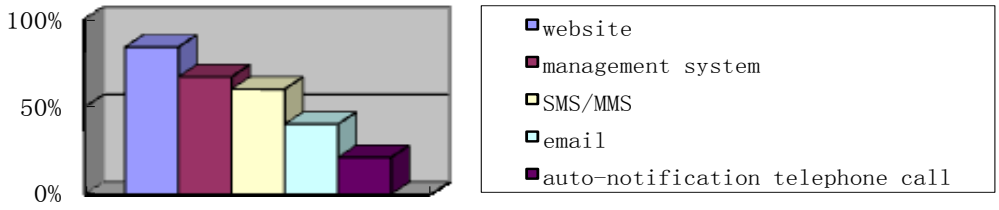
3.3.2 Information needed for the system

For container intermodal transport information service functions, a variety of options for different information needed have been provided. Consequently, over 90% of the participants have chosen “container number”, “origination-destination” and “container location (which is related to trace & track function)”, showing that the three items are the most essential information needed by the SSC. These are followed by “cargo type”, “container spec” and “time in each links/nods”, also very important information for container intermodal transport and are chosen by over 80% of the participants. About 3/4 of them have chosen “time and place of alarm”, “shipper and consignee” and “carrier, number of B/L”, so these information should also be included in the information service functions. Apart from these, about 70% have chosen “cargo weight” and “container owner”.

For container track & trace function and the functions needed to ensure container security, they are actually integrated into the information service functions. Nevertheless, technical solutions are needed for all these functions discussed above. In terms of technical solutions, we see the following results:

3.3.3 Technical solutions

For the ways of SSC information communication, 84% of the participants prefer to access the information via website, followed by 67% choosing management systems, 60% of the participants also chose SMS or MMS, due to its convenience. Only 40% have chosen “email” and 21% chose “auto-notification telephone call”. In summary, information updates by website access and via management systems should be the best way for communication. Short Message Service should be taken as optional, depending on different business modes and customer requirements.



For short distance wireless communication of the SSC system, RFID among other communication technologies is currently the most popular choice with 82% voted for it. None of the other technologies (Infrared communication, Bluetooth, Wi-Fi, Zigbee and others) have won more than one third of the support. Nevertheless, we may still see possible changes as some technologies have great potentials and are developing very fast.

For long distance wireless communication of the SSC system, 70% have chosen GPRS and 42% have chosen CDMA, suggesting public mobile phone communication networks are good choice for the users for the popularity and wide spread of the networks. 61% think satellite communication is also suitable for long distance communication; this is especially viable for long-haul transport such as shipping, by chasing the vessel sailing information, users can get the info on board the ship in real time.

For information services, a platform is needed. With regard to this, over 2/3 of our participants support that it should be run by an independent third party, rather than anyone from the shippers or the carriers, or the government agencies.

The extensibility functions are also thought to be necessary according to the survey results, details as follows:

A. Sensor devices extensibility (chosen by 84% of the participants);
B. Intelligent operation management extensibility (chosen by 81%);
C. Logistics organizing extensibility (chosen by 77%);
D. Container maintenance management extensibility (chosen by 67%);
E. Overload alarm extensibility (chosen by 47%);
F. Other (chosen by 2%)

4. Standard framework

How to realize the consistency of device application and safety operation of SSC system; embody the key value of SSC? The standard is very important. According to the survey, 88% of the participants think that the SSC should have a uniform standard. Therefore, on the base of application and research of SSC, it is necessary to carry on the research of standard system, and under the current standard system frame, work out advanced related standard of SSC to improve the application of SSC efficiently.

The project puts forth the basic frame of SSC standard system based on the ISO standard, related standard and current international research output. Figure 7 depicts SSC standard system frame:

The standard system framework is divided into top two layers: basic universal standard, technology and management standards. The top layer (universal standard) contains two parts: terms and definition, code and identification mark. The bottom layer (technology and management standard) contains three parts: container standard, smart and secure device standard, SSC operation standard.

Container technology standard contains two parts: ISO universal container standard, modified container standard.

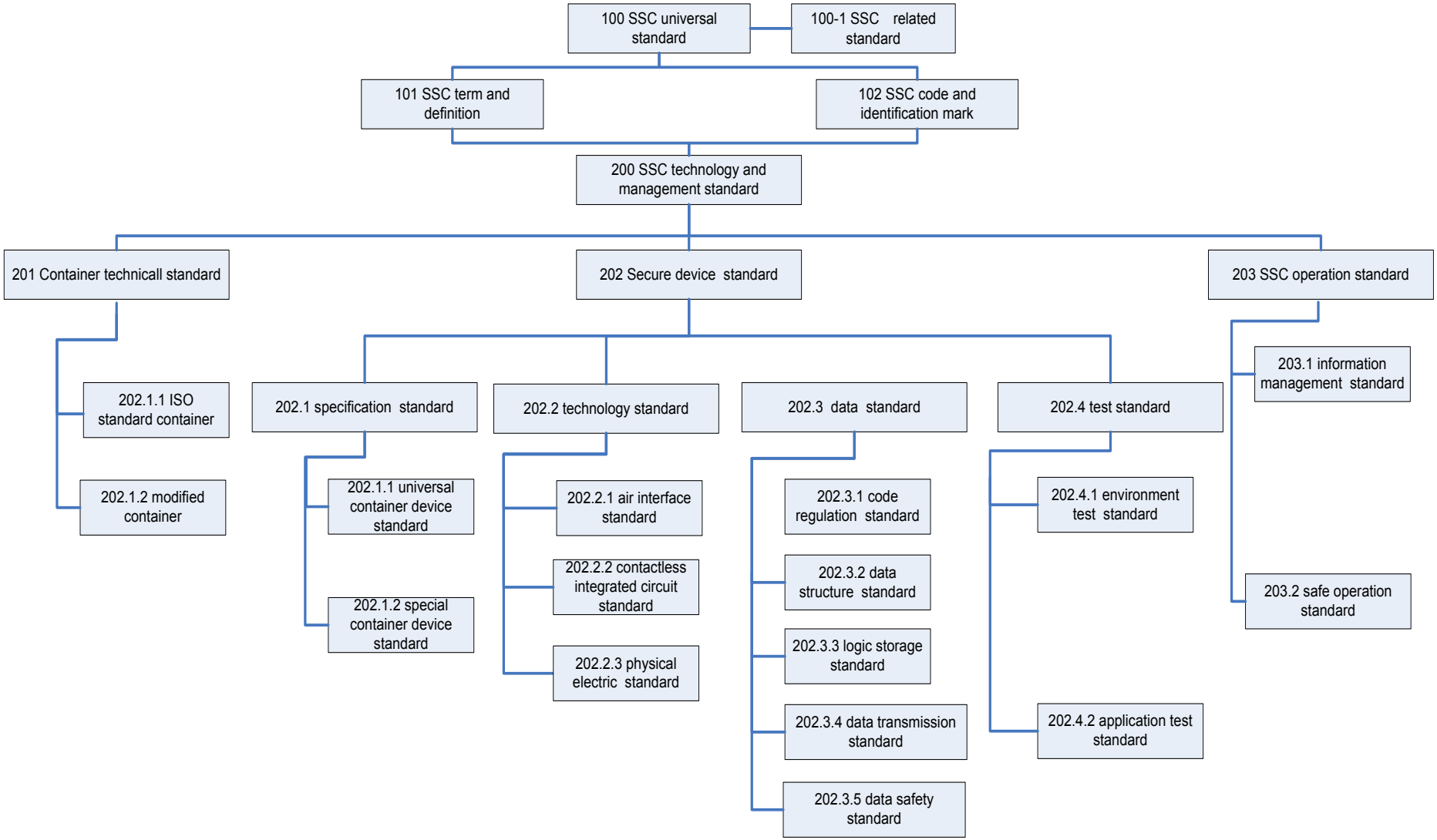
Smart device standard contains four parts: specification standard, technical standard, data standard, test standard. Thereinto, specification standard contains smart device specification of general container and special container, because different containers have different shape, size and function, the specification of smart device should be worked out according to different containers, no matter what specification, exterior size should accord with requirement of ISO668 and ISO 1496, which can not exceed exterior size of container after the smart device is installed
Data standard contains code regulation standard, data structure standard, logic storage standard, data transmission standard and data safety standard etc. data information exchange needs code according code regulation, there is potential risk in process of data transmission when smart device communicates with reader and database platform, secrecy and integrality standard should be contained, there are some related international standards such as ISO18185、ISO17363、ISOTS10891、ISO10374 etc.

Technology standard contains air interface standard, contactless integrated standard and physical electric standard, etc. These standards mainly deal with the technical problems of smart device. Air interface indicates the interface of smart device and wireless access network, short distance transmission technology such as WIFI, Bluetooth, Zigbee, RFID have corresponding air interface, long distance transmission technology such as GPRS, GSM, CDMA have corresponding air interface as well, the air interface of smart device refer RFID air interface standard (ISO/IEC 18000 series standards) and GPRS air interface standard. Physical electric standard should be compatible with ISO/IEC related standard. Contactless integrated standard can refer ISO/IEC 10536 (Contactless integrated circuit card), ISO/IEC 14443(Contactless integrated circuit card-proximity coupling card),ISO/IEC 15693（Contactless integrated circuit card-vicinity card）.

Test standard contains environment test standard and application test standard, Container transport environment by Rail transport, road transport and shipping transport is very harsh, so it is necessary to make out the relate test standard to ensure normal and reliable work of smart device in the process of transit, the SSC always is exposed under long time sunshine and frozen weather, which should endure with high and low temperature from 85 centigrade to minus 40 centigrate, SSC always collides in the process of container transport and load/unload, which should have very high shock resistance, in order to prevent thieves stealing or destroying the smart device by the way of electromagnetic interference, SSC also should have high anti-electromagnetic interference capacity, when SSC can pass the test of related static environment and real application, which can be used for transportation.

SSC operation standard contains two parts: information management standard and secure operation standard etc. information management standard indicates message standard of container transportation etc. safe operation standard indicates SSC safe operation flow, related flow and regulation of safe management.

Figure 7 Standard framework of SSC



5. Conclusions

This report investigated concept, function and standard framework of SSC respectively. Requirement of the industry for high security and smartness of container is the main driving force to create the concept of Secure and Smart Container. We get a comprehensive concept of SSC through questionnaires analysis and research, which Is helpful to achieve a unified understanding of SSC concept.

Based on the concept of SSC, the function of SSC is divided into six key parts to be described as: container automatic identification, ensure security, record environmental information, track & trace, and logistics information service and container operation intelligent management. The survey shows that container automatic identification is the most basic function; track & trace function is in the second place; ensure security is in the third place.

According to the above function, some technical solution is put forward, such as Radio Frequency Identification (RFID), Sensor monitoring technology, Positioning technology, transmission technology and network information technology. Presently, the survey suggests that RFID technology, WI-FI, GPS, GPRS/GSM is the main technologies in the technical solution for SSC. Nevertheless, we may still see possible changes as some technologies have great potentials and are developing very fast.

The standard framework of SSC is also included for improving the development of SSC, this standard framework is pre-output of research, it needs supplement and perfection with development of SSC.

SSC (secure and smart container) is in the phase of exploration and development, so far there is not any container can realize secure and smart function without external secure and smart device, this incorporate container may emerge after meeting the following premise conditions:

- Using external secure and smart devices proves available to improve transport secure and efficiency. Many pilot projects are being carried on, see Annex 2, you will obtain related information about these projects and products.
- There is complete business mode which is supported and accepted widely.
- Governmental preferential policy should be made to promote the development of SSC.
- Related infrastructure and resource should be complete.
- SSC Standard should be uniform and accepted widely.

In this research phase, we have research concept, function and standard framework of SSC. In the next research phase, application mode of SSC will be continued to study.

Annex 1

Questionnaire

Secure and Smart Container Development for Intermodal Transport

Introduction

With the huge container transport volume nowadays, two major issues related to the sustainable development of container transportation are recognized:

a. Container handling/customs inspection efficiency;

b. Container transport safety and security.

To address these issues, the concept of “secure and smart container” has been put forth, yet it needs to be carefully studied. We are doing an APEC funded study project on this issue, for which the first step is to collect professional opinions from different parties within the industry.

You are kindly invited to answer this questionnaire. Your opinion is very important to the research and is highly appreciated. The final report with the survey result will be available on the APEC website later.

APEC Project Team of Secure and Smart Development
Waterborne Transportation Institute, MOT, PRC
2009-06

1. Gender

○ Male ○ Female

---

2. Your name/title/organization （optional）

---

3. Your email addres□(opti□nal)

---

4. You are from:

○ Ministry of Transport/ MSA
○ Cargo owner/shipper who use containers
○ Ship Owner/operator
○ Container port
○ Others
○ The Customs
○ Road/rail transporter
○ Logistics company
○ Technical company

---

5. Which link(s)/node(s) within the multi-modal container transportation network may have the highest possibility of security problems(the vulnerable points)?

☐ Container freight station
☐ Railway transport
☐ Loading/unloading operation
☐ Transport environment
☐ Road transport
☐ Operation in container yard
☐ Waterway transport
☐ Others

---

6. Which link(s)/node(s) within the multi-modal container transportation has the most inefficiency?

- [ ] Container freight station
- [ ] Road transport
- [ ] Railway transport
- [ ] Operation in container yard
- [ ] Loading/unloading operation
- [ ] Waterway transport
- [ ] Transport environment
- [ ] Others

---

7. Have you heard of the “secure and smart container”?

- ○ Yes
- ○ No

---

8. What makes a secure and smart container, in your opinion?

- [ ] Installing removable secure and smart container devices, such as RFID(Radio Frequency IDentification) tag, sensors and GPS module etc, to the ordinary container.
- [ ] Manufacturing new containers with the above modules fixed to it.
- [ ] Either of above with the support of appropriate management information systems.
- [ ] Container made by special material with the sensor function

---

9. Considering the container transport development, what function(s) do you think a secure and smart container should have?

- [ ] Container automatic identification: Reducing the error caused by manual input information to improve the efficiency.
- [ ] Information service: Recording key information such as container number, location and customs declaration information etc. Information inquiry/management is available by authorization.
- [ ] Ensure security：Once the container is invaded from any side without authorization, it will record and alert automatically. Authorized opening and closing, such as loading/unloading, customs random checking, will also be recorded.
- [ ] Trace and track: Record and track the location of container via technical methods, alarm will be sent if its route is different from the preset transport route.
- [ ] Compatibility/Extensibilities
- [ ] Others

---

10. what Compatibility/Extensibilities function(s) do you think a secure and smart container should have?

- [ ] Logistics organizing: Harmonizing operation flows of container transport, ensuring the visibility and safety of all operation flows.
- [ ] Intelligent management: For example, when gantry crane catches the container in container yard, the container number will be automatically identified, and then the management system will tell the driver where the container should be placed according to the operation plan.
- [ ] Using special sensor devices to detect and record the environmental information in the container, such as temperature, humidity etc.
- [ ] Container maintenance and management: Secure and smart container will record the manufacturer, produce date, spec, maintenance record, owner information, and the schedule of maintenance can be automatically scheduled.
- [ ] Overload alarm
- [ ] Others

---

11. For the Information service function, what information should be included?

- ☐ Container owner
- ☐ Container number
- ☐ Container spec
- ☐ Departure and destination
- ☐ Carrier
- ☐ Seal number
- ☐ Time in each link/node
- ☐ Time and place of alarm
- ☐ Container location
- ☐ Cargo type
- ☐ Cargo weight
- ☐ IMDG Class , Important Precautions
- ☐ Shipper ,receiver /cargo owner
- ☐ Container inside environment: temperature and humidity etc
- ☐ Others

---

12. By which mean(s) do you hope to gain the information of secure and smart container?

- ☐ Website
- ☐ SMS or MMS
- ☐ E-mail
- ☐ Management system
- ☐ Auto-notification telephone
- ☐ Others

---

13. What kind of cargo should use secure and smart container?

- ☐ General containerized cargo
- ☐ High value cargo
- ☐ Time sensitive cargo
- ☐ Dangerous cargo
- ☐ Tanker container
- ☐ food, such as fruit, vegetables, meat
- ☐ Others

---

14. Which modules are necessary for secure and smart container?

- ☐ Automatic identification module
- ☐ Communication module
- ☐ Alarm module
- ☐ Invasion detecting module
- ☐ GPS module
- ☐ Inside environment sensor
- ☐ Software module of information management
- ☐ Others

---

15. Which communication method is the most appropriate for short distance information exchange of secure and smart container?

- ☐ Infrared communication
- ☐ Bluetooth
- ☐ RFID
- ☐ Wi-Fi
- ☐ Zigbee
- ☐ Others

---

16. Which communication method is the most appropriate for long distance information exchange of secure and smart container?

- ☐ Fiber communication
- ☐ GPRS

- [ ] CDMA
- [ ] Satellite communication
- [ ] Private network communication
- [ ] Others

---

17. Which organization do you think is appropriate to operate as the database centre/the information management platform for secure and smart containers?

- [ ] Ministry of transport /maritime administration
- [ ] The customs
- [ ] Transport corporation
- [ ] An independent third party
- [ ] Distributed in all above
- [ ] Others

---

18. What is the driving force for developing the secure and smart container?

- [ ] Requirement of import countries
- [ ] Upgrade requirement in the logistics industry
- [ ] Requirement from transport law and regulations
- [ ] Expected profit and cost saving

---

19. What is your attitude towards the development perspective of secure and smart container discussed here?

- ○ Optimistic
- ○ Pessimistic
- ○ Not sure

---

20. Why do you hold such attitude?

- [ ] Secure and smart container is unnecessary, because secure and smart transport can be realized by establishing a series of secure and management systems and standards.
- [ ] Uniform management/security standards are hard to achieve, so it is necessary to develop the secure and smart container, to ensure transport security and efficiency through technical solutions.
- [ ] Application of secure and smart container is determined by its cost/benefit.
- [ ] Others

---

21. Compared to ordinary container, how much extra cost do you think is acceptable for a liner company to buy a secure and smart container?

○ $5 ○ $20 ○ $50 ○ $100 ○ $500 ○ $1000 ○ Others _____

---

22. What are the ways in which the secure and smart container would be beneficial?

- [ ] Improve transport efficiency
- [ ] Improve transport safety and security
- [ ] Real-time information updates of container transport
- [ ] Improve the management of container logistics
- [ ] Improve seamless connection of intermodal transportation

- [ ] Optimize transport route
- [ ] Others

---

23. Do you think secure and smart container should have a uniform standard?

- ( ) Yes
- ( ) No
- ( ) Not sure

---

24. Do you think the following business mode would be viable for SSC? The business mode is that Secure and Smart Container Operation Company constructs the SSC infrastructure, including the reader devices and logistics information platform, and take charge of all the operations of SSC; shippers or carriers purchase or rent the secure and smart container (or devices to be installed to their containers), with the authorization from Operation Company, users could obtain the information service

- [ ] Yes
- [ ] No
- [ ] Please explain your choice:

---

25. Do you think which party(s) should be the operation company of secure and smart container?why?

- [ ] Government
- [ ] Container manufacturer
- [ ] Shipper /cargo owner
- [ ] Container port
- [ ] Railway company
- [ ] Container line
- [ ] Other
- [ ] Please explain your choice

---

26. What are the current issues related to information exchange in Multimodal transportation chain?

---

27. What are the related infrastructure necessary for the operation of smart container? (transreceivers on land transport, railway, port, on ship, etc..)

---

28. What is the best model for applying the secure and smart container for intermodal transport?

---

29. What are the major obstacles for developing secure and smart container for intermodal transportation?

---

30. How to improve and promote the development of secure and smart container?

Annex 2

Introduction of pilot project about container using secure and smart devices

Waterborne Transportation Institute, MOT (WTI) has united the China International Marine Containers (Group) Ltd. (CIMC) and China port enterprises to use RFID technology on the container, and carried out pilot application on inland shipping on the Yangtze River successfully. This project respectively researches E-tag and E-seal system, E-tag central working frequency is 915 MHz according with ISO18000-6B, E-seal adopts double frequency work mode, low frequency(125kHz) is used for awaking work, ultrahigh frequency (2.45GHz) is used for transmitting data, working frequency of corresponding reader is 2.45GHz and 125kHz as well. Figure 1 and 2 are E-tag and E-seal which are used in this project.

Figure 1 E-Tag

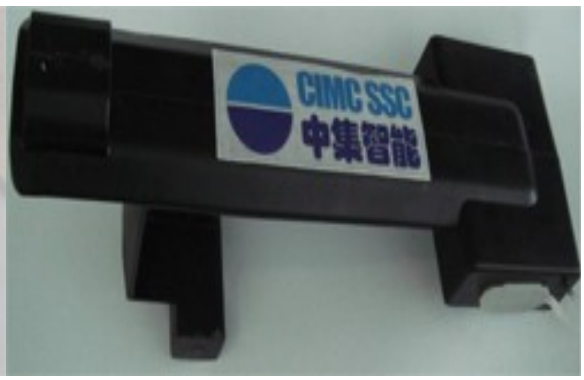


Figure 2 E-Seal

Antenna of E-Tag and E-Seal and reader can be found in the figure 3 and figure 4, when containers with E-Tag and E-Seal passing the checking bridge of port, container information will be read by the reader, then reader transmits container information to the management information system and information central platform on internet, this system can improve passing efficiency, reduce waiting time.

Figure 3 Antenna of E-Tag and E-Seal and reader

Figure 4 checking bridge of port

Antenna of E-Tag and E-Seal and reader also are installed on gantry crane (figure 5) and others working machines (figure 6), for moving working machines, the reader transmits the container information to management information system and central information platform on internet by wireless network.

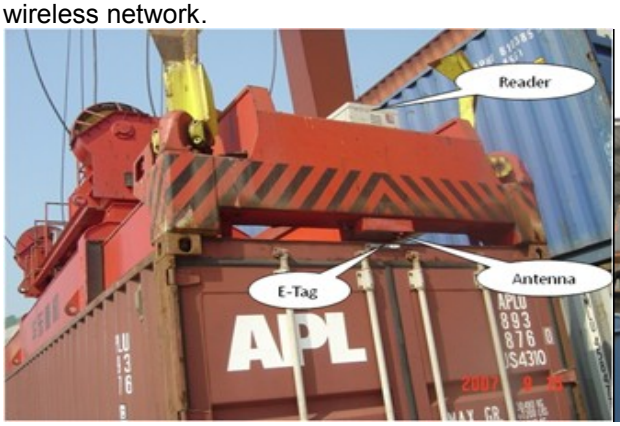


Figure 5 Reader and antenna fixed on gantry crane

Figure 6 Reader fixed on moving machines

Hand-held readers also are used for reading information from e-tag and e-seal or writing information to e-tag and e-seal, figure 7 shows researcher is reading information of e-tag and e-seal. And then hand-held readers transmit the container information to management information system and information central platform on internet. Users can inquire container information such as status, location, etc from website, its website interface is as figure 8, users can inquire container information and its status.

Figure 7

Figure 8 website interface

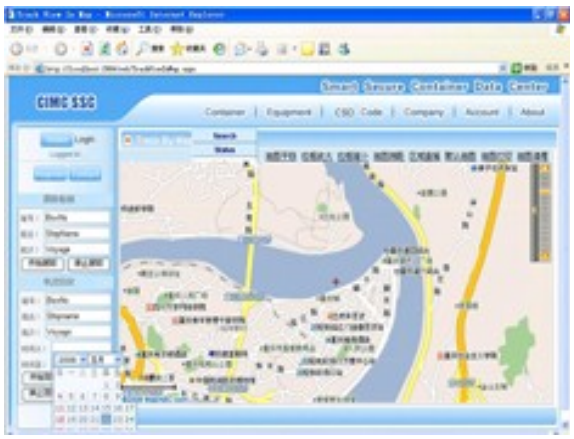


Figure 9 container location

Figure 9 is E-map that can display current location of container on the map.

Lock ‘Strongest in World’, Claims Sweloxx

A container lock has been launched that is said to be one of the strongest in the world due to the fact that it locks both from the inside and out.

Gerard van Loenhout, Europe distributor, Sweloxx International (company behind the lock), told CI:” The Seloxx lock is much stronger than other locks because one part of it is placed inside the container, meaning the container is locked from both the inside and outside.
“This makes it impossible to remove the lock by force from the outside.” Other benefits of the heavy duty steel container lock are that securing a sea container with it takes 25 seconds and it can be re-used as there is no need for welding.

Van Loenhout added that the lock should be able to electronically traced from anywhere in the world within a few years.The padlock and lock together sell for EUR317.50(USD501).

Abstract from Containerization International, 2008No.5, P21

Schenker pilots box monitoring system

Schenker has completed the first test phase for a new container security monitoring system. The logistics provider has initiated a technique that continuously monitors its Smartbox containers wherever they are around the world.

The system includes special GPS sensors and RFID technology. The GPS security devices communicate the current coordinates, temperature levels and security parameters, such as door activities.

RFID status notifications communicate the most important points where liability changes hands – when the containers are loaded and unloaded at the packing stations – as well as the time of arrival at the terminal, to provide a clear view of when and where the load is being transshipped.

The transport units have been fitted to 10 containers in the first test phase, and are now in regular use between Hamburg and Hong Kong.

Dr Wolfgang Drager, Schenker’s senior VP for ocean freight, said: ‘This technology will be ripe for serial production in the near future. At least the RFID technology promises to be suitable for use on a wide scale.’

The new GPS sensors provide information at regular intervals about conditions in the container, including sudden changes in temperature, whether the container is shaken up during the course of the journey, and whether it deviates from the planned route. Data is compiled in a report, which Schenker can then consult.

The system can determine when and where the door of the container has been opened. If this happens unexpectedly or the door is forced, and alarm is triggered and appropriate security measures initiated.

Abstract from Cargo Systems, 2007No.11, P27

Sealing Progress

Container security remains high priority, as ISO-17712- defining mechanical security seals-is finally due for ratification and ISO-18185 has recently approved two radio frequencies for electronic versions．Andrew Foxcroft reports．

The humble security seal is still viewed to be the first line of defence in the fight against container theft and terrorism．This has been borne out by the lengthy and highly involved debate that finally resulted in the ratification of a new standard covering the manufacture and use of ‘mechanical’ seals．

These comprise a11 types of bolt, cable or higher-strength bracket designs．ISO-17712-the new standard’s official acronym-has grown out of a specification introduced almost five years ago in the aftermath of 9/11 and formation of C-TPAT and other US-1ed transport security initiatives．It is due to officially enter the ISO statute book by 2008．

ISO-17712 has been created to settle, once and for all，the criteria differentiating mechanical container seals from their purely indicative counterparts. The latter usually comprise a simple plastic or metallic strip，used by many shippers as a sole means of protecting their consignments. Their ease of checking also made them popular with customs and port officials，while the cheap cost endeared them to ocean carriers (normally responsible for the actual provision of container security)．

However，more recently，there has been an ever-louder call for mandatory use of stronger security seals offering some kind of physical barrier as well-although this has been difficult to implement in the absence of an exact definition of the necessary characteristics．

ISO-17712 effectively sets this out-and in some detail. By addressing four main strength parameters (tensile, shear, bending and impact), it provides a set of minimum requirements and lays down the exact ‘neutral’ test methods to be used．

Testing of all mechanical seals can only be approved under ISO-17712 if carried out by a test site accredited to ISO-17025. Much of the recent delay in ratifying the standard can be attributed to fine discussion about the test procedures．

In addition，ISO-17712 addresses the whole area of security seal use, including the need for manufacturers/suppliers to keep precise records of sales and numbering sequences，and end-users to adopt comprehensive auditing processes of their own．

Providing a much-needed definition for bolt, cable and stronger devices should prevent the production of low-quality seals and help stamp out fraud and counterfeiting. However, there has already been criticism from reputable seal manufacturers reportedly having difficulty in achieving the necessary approval. To date, only a very small number of test laboratories have been nominated, and all are based in the US.

The first, Bodycote ACT Laboratories, was appointed in May 2007 by the International Seal Manufacturer’s Association (ISMA), which although representing over 80% of global seal production has less than a dozen actual members. They include EJ Brooks, Tyden-Brammall, OneSeal, Universeal, ITW-Envopak, Acme Seal, Unisto, American Casings and Seal lock Security Systems.

However, there are many dozen companies currently making or trading seals worldwide, the majority of which have a good name.

Such drawbacks aside, the creation of ISO-17712 has clearly brought benefits, with the vast majority of interested participants (seal suppliers, shipping lines and exporters/receivers) already accepting its principles.

The draft standard was endorsed by the World Customs Organisation and World Shipping Council back in 2005, while the US Department of Homeland Security-acting through the C-TPAT rules, all such boxes would have to carry an approved mechanical seal, or be subject to stoppage and delay. Any use of a stronger seal design could, meanwhile, earn a higher tier status.

There has already been a substantial rise in demand for bolt (and cable) seals, with these fast becoming the norm for the majority of container shipments. Many are also now being fitted routinely to empty containers as well.

The indicative seal is still popular, but no longer as a sole means of protection. Instead, it is now often used in conjunction with a mechanical seal to provide an extra layer of visible protection for easy customs' checking.

The increased use of stronger mechanical seals has already resulted in robust 10%-plus growth in their annual global sale for several years, spelling good news for manufacturers, and output now runs into tens of millions a year.

Nevertheless, the mainstream development of a 'smart' electronic seal continues to be viewed as the logical progression. An important step was made earlier this year towards achieving some global standardization in this area as well, when ISO-18185 was drawn up and approved two frequencies for use in RFID (radio frequency identification) interrogation of electronic container seals and sensing devices (see 'Increased frequency',pp77-79)
One is 434MHz, and largely encompassed by technology currently on offer from Savi Technology. The other is 2.4GHz, presently favoured by GE Security, working in conjunction with Siemens and Mitsubishi Corp.

The latter collaboration has resulted in the 'CommerceGuard' container security system, the latest version of which (3.0) was introcduced this year. This is a full-blown remote securing device, installed permanently on the container, whereas Savi's offering is more of a tagging system and perhaps better suited for incorporation within an existing one-trip mechanical security seal.

However, the complexity and relatively high price of these (and other) 'e-seal' alternatives are continuing to act as deterrents to their more widespread uptake, especially when compared with the cheaper USD1 or less paid today for a passive (non-electronic)bolt or cable seal.

Moreover, independent tests carried out recently by certain interested parties (including APL) have shown that most existing e-seal designs can still be breached relatively easily and so are vulnerable to attack.

In consequence, there are as yet no plans for their serial manufacture, even though many well-known producers of mechanical versions have long been involved with e-seal development, and further progress is imminently expected in setting standards for communications and other protocol.

Abstract Containerization International，2007, No.10, P75-76

RFID: Improving the Supply Chain for Shippers

An e-seal fixed to a container

The main benefits to shippers of RFID-based system, which incorporate e-seal (or tags) on containers, read by devices located at various points in the supply chain (encapsulated in ISO 18185), are as follows:

▲ E-seals provide as added level of deterrence unavailable with mechanical seals. The latter require a physical inspection to identify security breaches. E-seals simplify this process by providing a wire-less and automated alarm and tracking feature. However, e-seals do not prevent theft via a hole being cut in the container's side or its doors being removed.

▲ ISO 18185 incorporates two radio frequencies to make the RFID system compatible with different industries and cover the requirements of all segments of the supply chain. These are active UHF (433MHz) and microwave (2.45GHz). This so-called 'active-based' RFID system features a longer range than 'passive' systems, which are restricted to deployment in small sections of the supply chain. For example, passive systems meet Wal-Mart's requirements for all its shipments from US-based suppliers to its US distribution centres to be RFID-enabled. Active systems have the added advantage of allowing omni-directional communication for increased flexibility.

▲Cargo is still predominantly tracked today using antiquated electronic data interchange (EDI) or fax-based methods, which are error-prone and unreliable. When attached to a container, an RFID e-seal provides a wire-less, automated alert to port officials, customs inspectors, ocean carriers and shippers that the seal has been tampered with , negating the requirement for a manual inspection.

According to consultant ABI Research, the cost of RFID devices is expected to decrease rapidly in the next few years. This is largely due to the increase in RFID system suppliers with the advent of ISO -18185.

Many active RFID solutions include tags costing USD50-100. But single-use e-seals, designed to be the cheapest active RFID devices available, today cost about USD20. According to vendors and users, the target suggested retail price is approximately USD10 in volume.

In addition, shippers have to pay the system suppliers –the largest being Savi Technology and General Electric (which markets its non-ISO based Commerce Guard system) – a service fee, usually on a per transaction basis.

Abstract Containerization International，2007,No.10, P79

[1] Henry H. Willis, David S. Ortiz, Evaluating the Security of the Global Containerized Supply Chain. RAND. 2004

[2] Assaf, Michael et al. Global Sourcing and Purchasing--Post 9/11. J. Ross Publishing, Incorporated. 2005

[3] UNCTAD secretariat (2008). Review of Maritime Transport 2008. UNCTAD, Geneva

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Secure and Smart Container Development for Intermodal Transport

----Study on the Application Mode for Secure and Smart Container
SSC: application mode, promoting strategy and suggestions (project phase II)

(FINAL REPORT)

APEC Transportation Working Group

June 2011

CONTENTS

1. Introduction

1.1 Review on related studies

In the last report “Study on the Concept for Secure and Smart Container --SSC: functions, technical solutions and standards (project phase I)”, the concept, function, technical solution and standard of SSC are investigated. And it is concluded that the SSC is a system concept, integrated with all kinds of multimodal container transport facilities and resources, business operation systems and container security devices and their supporting IT systems by applying different technologies. Without the support of related systems, the container itself will not be able to ensure its secure and smart functions. Available technical solution is put forth, and the functions of SSC mainly contain the following aspects:

Container automatic identification,
Ensuring container security,
Recording environmental information,
Trace and track,
Logistics information service, and
Container yard intelligent management,

All of which can be realized by current technologies. Preliminary standard framework of SSC has also been formed and needs more supplement and perfection along with the development of technologies and the international standards. Apart from the technical solutions, an effective application mode will determine the perspective of SSC development, which is vital for the success of SSC. In this report, SSC’s application mode will be discussed and investigated based on the output of last report.

SSC development for intermodal transportation is the means to link the transport chain efficiently. Market forces increasingly highlight the advantages of SSC for intermodal transportation, SSC development is based on how to best use new and emerging technologies, including both the hardware and software. The way these technologies meet customer needs in the marketplace, determines how changing government policies and regulations can enhance or hinder intermodal movements.

Research of this project also considered other related APEC projects, and some further studies based on the informed research and the new developments within the industry are made.

1.2 Methodology

As the first step to gain the extensive professional opinions from different parties in the container transport related industries, a questionnaire has been designed according to our project planning, and was then uploaded onto a special questionnaire survey website in China. The questionnaire can be found and answered in the following address:

http://www.sojump.com/jq/107863.aspx?source=qq

These links to our questionnaire, as well as the same questionnaire in other forms (such as electronic version sent via emails, or hard copies) are distributed to different professional receivers in China and other countries from June 2009 onward. Until the completion of this report, 57 effective copies feedback have been received by the project team, which were used as the basic data for survey analysis in this project.

2. Study on the demand of SSC mode

2.1 Innovation requirement from the modern logistics theory and practice

Nowadays, the rapid development of society and economy more and more depends on the effective and consistently improved transport and distribution system. According to international

accepted standard of evaluation, every unit of economy development needs to be supported by two units of logistics industry development. Theoretically, Logistics contains four different types of flow: cargo flow, capital flow, resource flow and information flow. Modern logistics system relies on the interaction of resource flow and information flow. In order to improve the efficiency of transport system and the utilization ratio of resources, different resources such as vehicle, container transportation units and infrastructure should be integrated and optimally utilized. Some scholars think the logistics concept will transform to 'function flow', which means logistics system not only contains flow of cargo, but also all resource planning to ensure the whole life cycle function flows.

In order to improve logistics system, the manufacturer, logistics personnel and customers need to provide more and more timely and high quality information. Requirement of logistics information has spread to customers and customers' customers from manufacturers and logistics companies. Such information is called vertical information. For coordinating and integrating different parts of logistics system, more and more information such as logistics resources (vehicles and personnel), relevant status and position information are needed, and such information is called transverse information, which is the main precondition of improving the efficiency of system. In this regard, logistics resources and their information need to be combined closely together so that locating of people and objects could be possible. SSC (secure and smart container) widely involves related information of container transportation and resources management, which is significant for improving utilization radio of transportation resources and efficiency of transportation.

2.2 Security and safety requirement from special cargo

Regarding special cargoes, the following types of cargoes are of significant importance in terms of container transport.

Food products include the raw materials like the grains and the processed products are especially sensitive and thus need better transport quality assurance compared to ordinary cargoes. Once there's a weakest point in the supply chain, it may result in serious social incident relating to citizen's health problems and medical treatments and severely ruin the company business image at the same time. So from a social perspective as well as from the shipper's perspective, there's clear demand for safer and more reliable multimodal container transport services.

Similarly, medicine and medical product is another type of sensitive good requires highly reliable container transport services.

Dangerous good is another major concern of the container shipping realm. Due to the fact that the goods inside the containers are invisible, it brings some challenges for dangerous cargo container transportation safety.

Reefer containers are increasingly important for container shipping industry. Traditionally, refer cargoes such as seafood and fruit juice are carried by refer ships in bulk quantities. After the introduction of reefer containers, the transport mode changes dramatically with more and more cargo being transported in reefer container in relatively small quantities and higher frequency, in order to gain more flexibilities and JIT logistics services. As a growing sub-divided market, there's also great potential for SSC applications in the reefer container market.

Apart from transport safety and security issues, another angle to illustrate the requirement from the aforementioned special cargoes is the positioning requirement of such containers. An example to explain this would be the well know case of the "Prestige" accident which happened in 2002, when the vessel carrying some 2000 containers sunk at sea, leaving the containers floating everywhere. Noting that there were about 170 containers carrying dangerous goods, it would have been much better if those containers were SSC and can be positioned within a short time period to avoid pollutions and cargo damages.

2.3 Technical update requirement from container multimodal transport

With the rapid increasing of volume of container transportation and port throughput, traditional system of container transportation faces two main issues:

1） How to improve the efficiency of container intermodal transport further, realize every chain of container intermodal transport seamless connection and meet the requirement of logistics service under the limited condition of infrastructure expansion?

2） How to ensure the safety of container transportation in the whole transit process given that the customs have not enough capacity to check every container?

In order to improve the efficiency and reliability of container transportation, all the related transport sectors are taking a series of measures from its own perspective. For example, as the main body of international container transportation, most liner companies have introduced container tracing services based on their management information systems. Shippers and their customers can inquire the transportation status of cargo on the website of liner companies using the bill of lading or container number; most of the big ports also take measure to improve the working efficiency, and extend part of their business to inland area and establish “dry ports”; some ports applied the RFID technology on the truck to realize identification of truck. From the government level, after the “911” incident, US Customs and Border Protection proposed Customs-Trade Partnership against Terrorism (C-TPAT), wished to co-operate with related industries to establish supply chain safety management system for ensuring supply chain safety and information unblocked. American customs also proposed Container Security Initiative (CSI), intended to ensure that high-risk cargo is examined or scanned, preferably at the port of departure. Some countries also probes new effective technology such as e-seal etc. to deal with the problem of monitoring containers. In addition, some high-tech companies developed a series of secure product of containers. However, as the current situation, what all related sectors have done is based on their business areas; the overall effect to the multimodal container transport system is limited. To overcome such problem, innovations should come from the container itself, because the container, as an international standard transport unit, is the only object that goes through the entire multimodal transport networks during its transportation, and has essential impacts to all the routes and terminals within the network involving all transport modes.

2.4 Trade facilitation requirement from governments

In the past few decades, globalization has boomed international trade significantly. Countries are giving more priority to trade facilitation in order to develop their economies and improve people’s life. According to UNCTAD, today 80% of developing countries’ exports are manufactured goods, up from only 20% two decades ago. Multinational enterprises (MNE) with their globalized production played an important role in this process. About 1/3 of global trade is intra-company trade, and around 30% of trade is trade in components and unfinished goods, suggesting an increasing logistics market. Recognized the important role of the MNEs, countries are trying their best to attract investments from them, in order to develop the economy. Among various incentives like preferential taxes, an important measure is to consistently improve the trade environment, also known as trade facilitation which include hardware constructions (improve transport services networks etc.) and software upgrade (remove institutional barriers etc.). As a vital component of trade facilitation, multimodal container transport development is an area to take close look. With SSC, on the one hand, trade safety and logistics service quality can be assured; on the other hand, efficiency is expected to be improved as well.

3. Study on the application mode of SSC

3.1 The organizing of container transportation

There are two main forms of container cargo flows: one is full container (cargo) load (FCL); another is less than container (cargo) load (LCL). Full container (cargo) load means that consignors are in charge of packing, counting, stowing and sealing with lead. Usually, there is only one consignee and one consignor. Less than container (cargo) load means that carriers are responsible for packing, counting, filling packing list and sealing containers with lead in container freight stations. Container cargoes will involve more than one consignee and one consignor. For FCL, to container as a unit, carriers take the responsibility of receiving and delivering FCL when containers and seals are complete. But they aren’t in charge of damage, short-loaded and over

loaded of cargoes inside the containers, except that cargo owners can prove that the loss is indeed caused by the carriers. The differences between FCL and LCL can be listed in table 1.

Table 1 Comparison between FCL and LCL

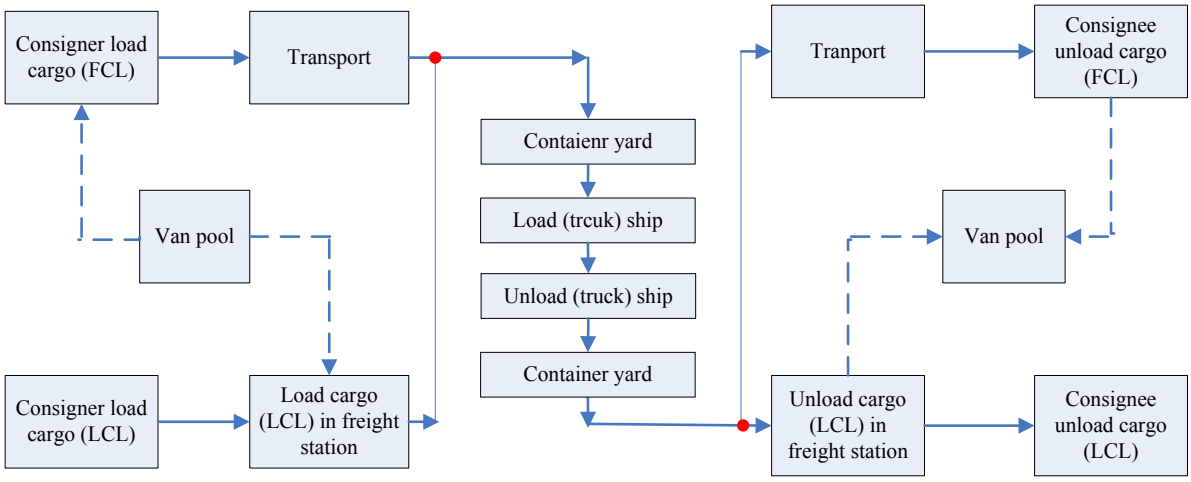
	FCL	LCL
no. of shippers	1	multiple
loaded by	shipper	CFS, LCL operator, carrier
manifest and seal	shipper	same as above
handover at	Gate, CY, under tackle	CFS
Handover checking	Container and seal in apparent good order	cargo inside need to be checked
B/L	unknown clause applicable: SCAC,SLAC, SSBS,STC	SCAC，SLACS，SBS，STC not applicable
procedures	shipper CY at loading port sea transport Cy at unloading port consignee	shipper truck station, CFS CY at loading port sea transport CY at unloading port truck station, CFS consignee

According to the economic and geographical conditions of specific routes, the container cargo flow has four types of organization:

FCL/FCL：Organize FCLs at the delivery location, and give them to the consignee when they are transported to the place of receipt.
FCL/LCL: Organize FCLs at the delivery location, and open the containers and send cargoes to every consignee when they are transported to the warehouses of the place of receipt.
LCL/FCL：Organize LCLs at the warehouses of delivery location, and give them to the consignee when they are transported to the place of receipt.
LCL/LCL: Organize LCLs at the warehouses of delivery location, and open the containers and send cargoes to every consignee when they are transported to the warehouses of the place of receipt.

Figure 1 shows the whole organization flow of container transportation. The first type is the most conducive one to organize door to door transport in the four types of organization, and the transportation of SSC is the safest under the first form.

Figure 1 Organizing of FCL and LCL



3.2 The operational mode of SSC

SSC could realize the safe and efficient container transportation via technical solutions. Since the organization of container cargoes are in different ways as discussed above, the operational mode of SSC also varies. The container intermodal transport mainly involves railway, highway, and waterway (air transportation does not use ISO standard containers). Figure 2 shows the international container intermodal transport process of SSC. In short, what kind of transportation mode is chosen depends on the actual geographic location of consigners and consignees.

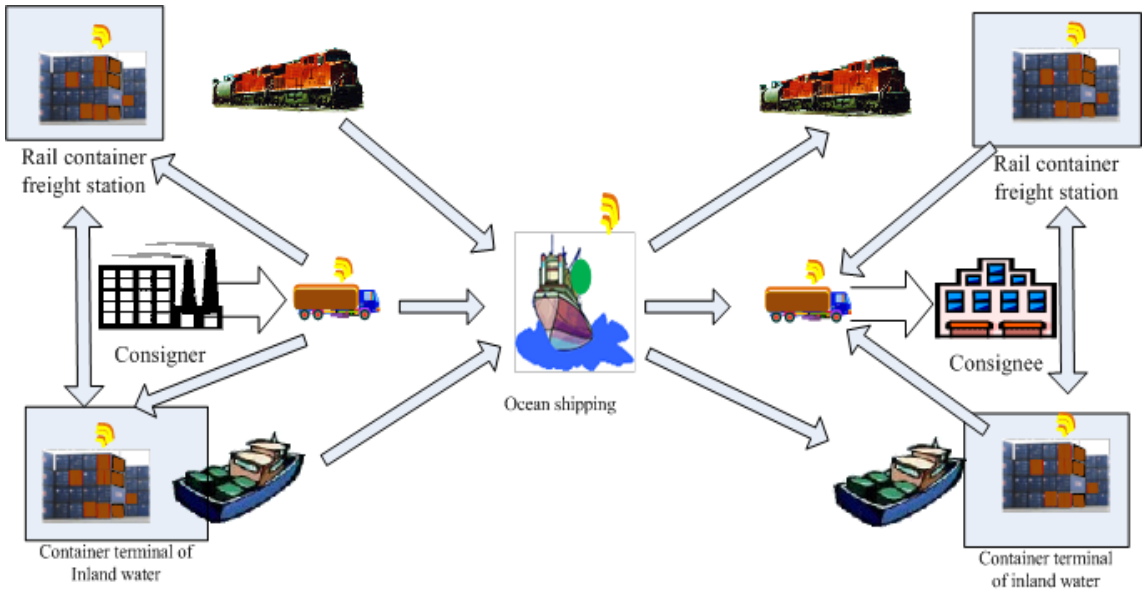
We can deliver the cargoes to buyers by road transport if they are within the economic distance of road transport to the port.

We also can deliver the cargoes by road transport - rail transport - ocean shipping - rail transport - road transport if the buyers and sellers are located in the remote inland areas with railway connections.

And we also can deliver the cargoes by road transport – inland waterway transport - ocean shipping - inland waterway transport - road transport if the buyers and sellers are in developed inland waterway regions.

Therefore, taking the cost, time and other factors into account, containers transport by road, rail and waterway can form a variety of joint combinations. At the same time, it can result in information transfer delays on various aspects, and largely limits the sustainable development of container intermodal transport. The development and application of SSC will greatly overcome such problem, and help to promote the rapid development of container logistics industry.

Figure 2 International container intermodal transport processes



3.2.1 SSC operational mode at the introductory stage

Currently, the development and especially the application of smart and security container are still in early stage. Installing smart security electronic devices in containers can reflect the security and intelligence characteristics of containers. These devices are mainly RFID tags, electronic seal and GPS device. They serve different functions. RFID tags mainly work for automatic identification of containers, speed up clearance and improve the efficiency of transport nodes intelligence operations. Cargo tags simply record related information of container cargoes. And the electronic seal can record and monitor container transport security. GPS device can track locations.

At the primary stage of its development, a mature market for SSC's application has not fully formed, in other words, it is still at the market cultivation stage. So the logistics information of container transport

process may not necessarily go through the public information platform to integrate container logistics information, and all the information regarding container logistics chain may not necessarily be shared. These have determined the experimental characteristics of the operation mode at this stage, which doesn't imply for substantial business profits in the short/medium term.

According to the different organizational forms of container cargoes, the operating mode of SSC could be slightly different. For FCL / FCL model, there is only one cargo owner (forwarder).

(1) The preparation work

Before cargoes are loaded in the container, the cargo owner (forwarder) should select the containers with E-tag, E-seal and cargo tags. After cargoes are completely loaded and get checked by customs officers, the container will be sealed with information written in electronic seal with handset, such as loading time and location, operator etc., such information recorded in e-seal couldn't be changed without authorization. The information recorded in cargoes tags, such as names, types and related information of cargoes couldn't be changed without authorization either. Container number, owner, origin and destination etc. can be written in a passive RFID tag. The tag ID is unique in the world, once it is bound with the container number, the information couldn't be changed, but can be read at any time with authorization.

After finishing loading, it will enter into the stage of laden containers transport. As shown in Figure 2. Take intermodal transport of smart security container in road - railway - inland - water as an example, inland container depots, inland freight stations, railway container handling stations, container terminals and inland container ports as important nodes in the transport networks of SSC have direct impacts on containers transport safety, security and efficiency. The readers of RFID tags are installed at the interfaces between such transport nodes.

(2) Port/terminal operations

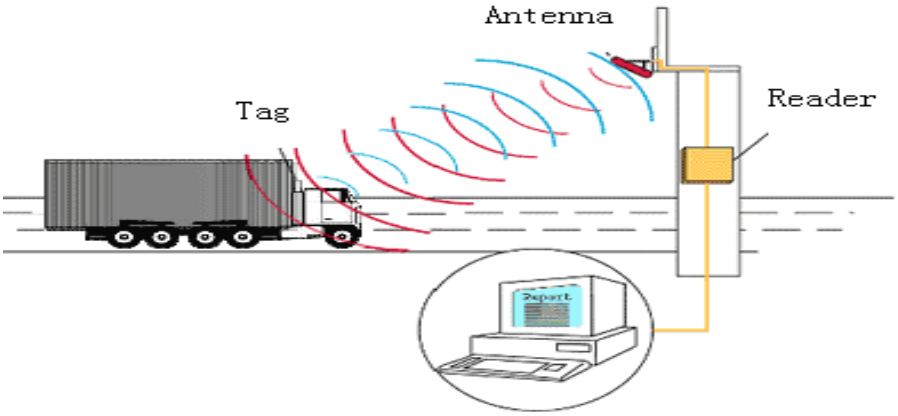
The reader is usually installed in the entrances and exits of the stations and cargo handling machines. Set the container terminal as an example:

1) When a truck carrying containers fitted with RFID tags enters the gate of a container terminal, with pressure getting on the weighing system which will send a trigger signal to activate the reader, its antenna (shown as figure 3) will start to work.

Figure 3 Antenna of RFID reader at the gate of container terminal

2) The RFID container tag will be activated by the reader's antenna, and read container-related information written in the tag, so as to realize automatic identification of container number. This auto-identification principle is shown as figure 4.

Figure 4 Working principle of container auto-identification

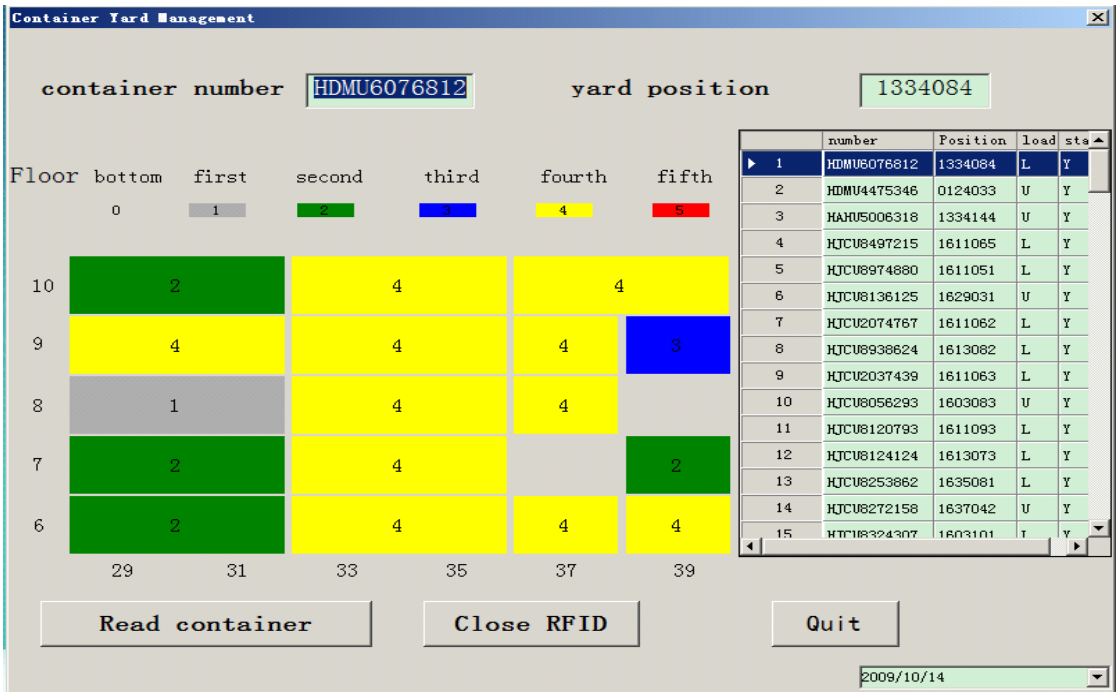


3) Container related information, which is read by the reader will automatically be recorded into the container terminal management system. Weighing data of containers will be input in management system manually or automatically, and all information will be sent to the port information center at the same time.

4) After verified by the port information center, information will be feedback to operator whether the container is allowed to enter or leave the port, and the information centre will upload the time of entering and leaving the gate and related information of containers to internet. This process can be completed by itself without human intervention and authorized users can get access to the information.

5) In order to improve the operational efficiency of mobile equipments in container yard, a set of operating software system can be developed, which combines MIS with RFID technology, help the operators improve the efficiency and realize automation management in the whole container yard. This software can be installed in the driving house of gantry crane. The interface of this software is shown as figure 5.

Figure 5 Interface of Container Yard Management



6) Using this software, which can automatically read the container task lists from operation planning sector of container port by local port wireless network, task lists will tell drivers which containers need to be operated today, and where these containers will be placed. In order to realize auto-identification of container, the reader of RFID tag is necessary, which is installed as figure 6.

When spreader of crane approaches the container, the driver clicks on the "Read container" button as figure 5 shown. The system will automatically read the container number, automatically find out the planned location information of the container in the task list, and figure out working position of the container and the environment status around it with Two-dimensional yard bitmap, so that the driver can clearly see the container's operating location through this interface. The system also will upload information of the container to the port information center while read the number of container successfully. Take figure 5 for instance, while spreader of crane approaches container and read it, the container number "HDMU6076812" will be identified and shown on software interface automatically, the management information system will quickly find out the location of container is 134084 on the list. It means that the container will be placed in field 13, coordinate position is row 34 and column 8, 40-foot container at fourth floor. According to different floors, the displayed container color will be different, the container's indicator icon will flash constantly, and the place status around it can be seen clearly. So the driver can complete the operation more efficiently. The system will automatically delete the container number after completing the task and clicking the button of complete. If the container number is unscheduled, the system will prompt that it is not in the task.

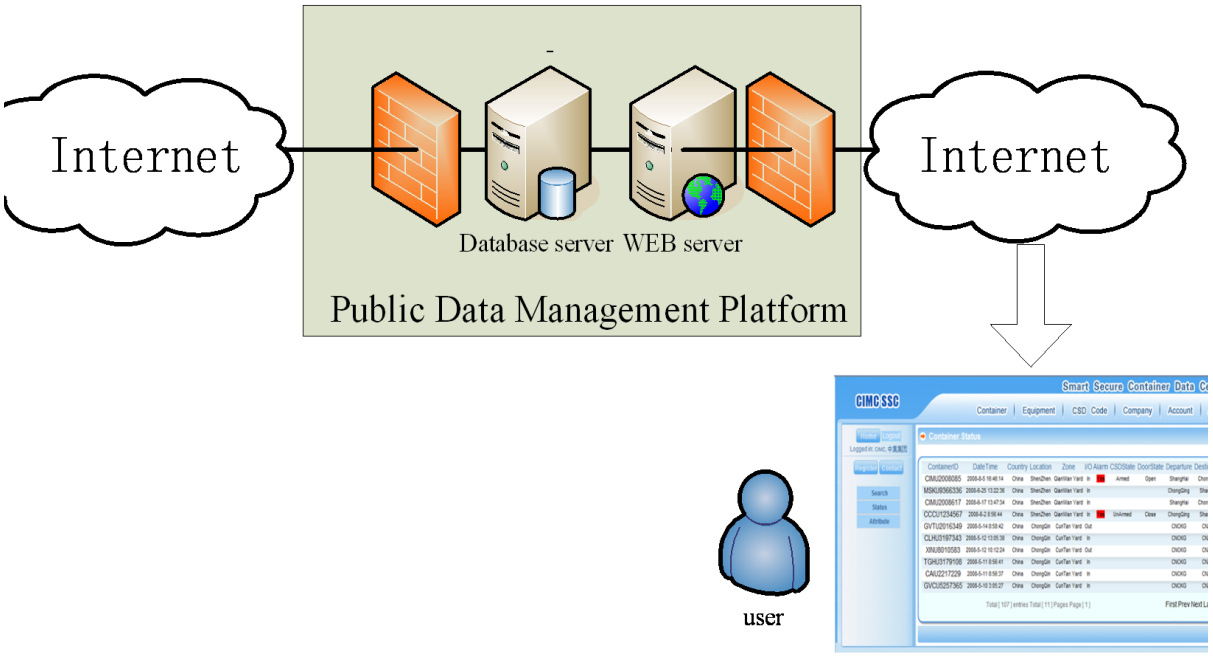
When a shipping order/advance is received and input to the yard management database. A timely "container pick" task instruction is then issued to a proper crane by a wireless communication system. The crane operator will have on broad graphical information "where to find the unit he needs to pick up" and will use the map to direct the crane to the container. The container ID is verified once it is gripped by the crane. An alert is issued if a wrong container is selected. The correct container will then be moved to a discharge-staging area. A message is then sent to central database.

7) Quayside container crane is the frontier of loading and unloading containers from container port to waterway transportation. The Installation location of readers is the same as is shown in figure 6.

Figure 6 Reader installed on the gantry crane and the E-tag on the container

During the loading or unloading process, the reader will read the information of container, and judge whether the container is coming to port or leaving off port according to the background data. Then the information will be sent to the container port information centre through local wireless network.

Figure 7 Remote Track Framework of SSC



As is shown in Figure 7, the port information centre will also upload information to the public data platform by internet. This platform is suggested to be constructed, managed and maintained by the third party jointly appointed by the users and the Ministry of Transport. Every country may establish its own public data platform. The main function of the platform is to store and share container data uploaded from the port information centers or other transport nodes such as inland container depots, freight stations, railway container handling stations. This container transport information will be shared by B/S (Browse/ Server) mode. Users who register user names, passwords can realize remote query and track of container information on website.

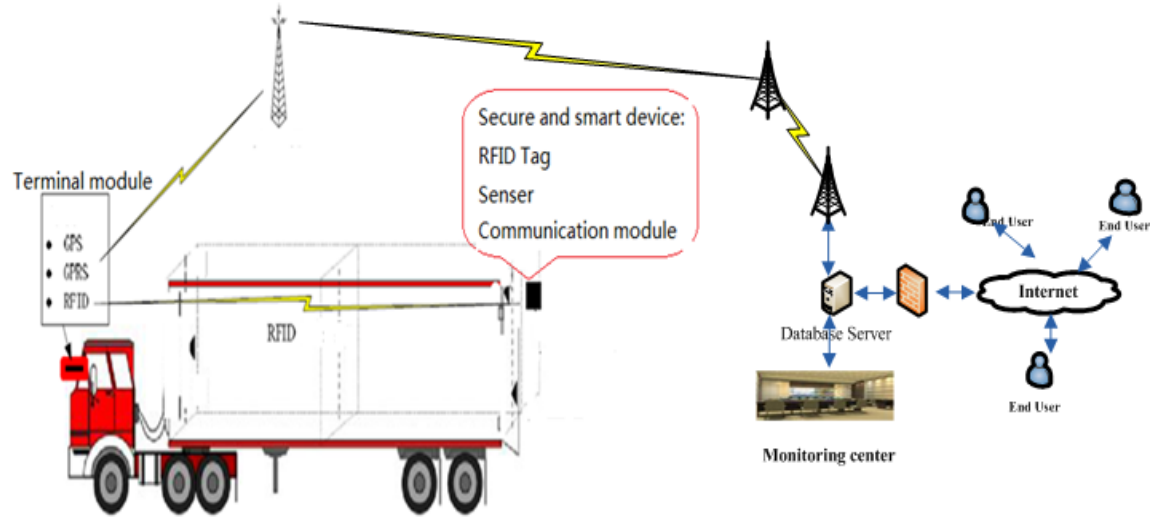
All above is the operational application mode of security and smart container at container terminal. This mode can also be used in other important nodes of container transportation, such as inland container depots, freight stations, railway container handling stations and inland ports (dry ports). It can greatly improve the security and efficiency of container transportation.

(3) Road, rail and shipping operations in the container transit process

Road transport

For the road transport, the Terminal module consists of GPRS, GPS and RFID reader will be placed at the cab, secure and smart device is responsible for collecting container information such as door switch status, inside temperature, humidity and shock, and these information will be stored in the RFID tag, the data communication module transmits these information to the vehicle Terminal module according to certain spacing interval, so the driver can see the container information in real-time, and the Terminal module will transmit the container information and its' position information to remote monitoring server via GPRS or satellite. Considering the power supply for GPS module, the GPS module is not integrated in the SSD, but in the terminal module.

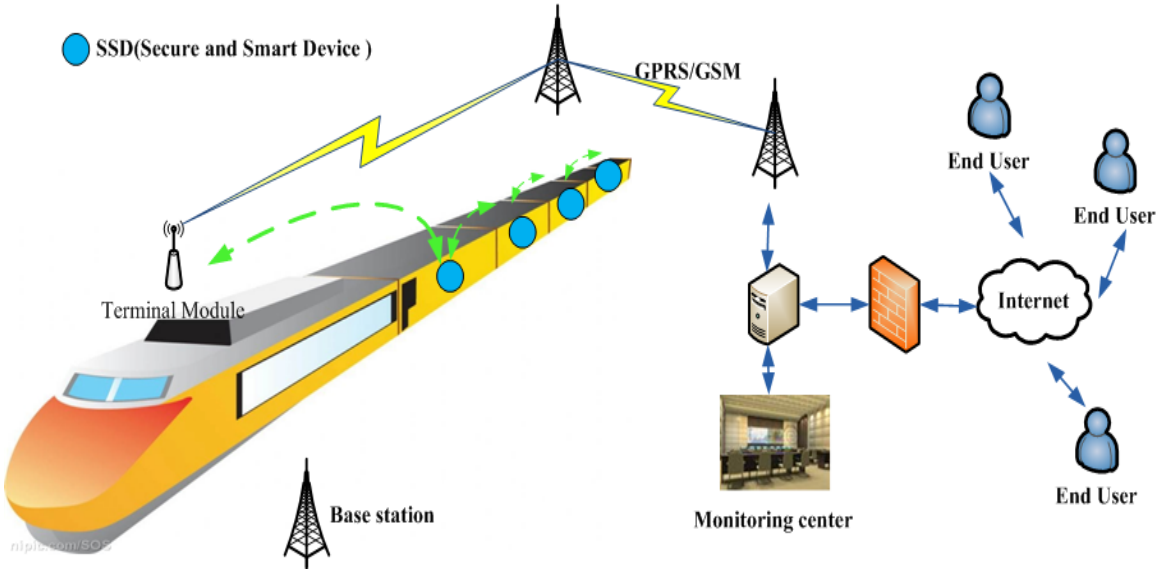
Figure 8 Road transport operation mode



Rail transport

For rail transport, the train is relatively longer, main problem is to address communication between SSD and vehicle terminal module, therefore, choosing the appropriate ad-hoc network communication module is very important, the current The ZIGBEE technology, shown in the figure9, it can achieve information transfer among SSDs, even if the monitoring information of container at the end of train also can be transferred to vehicle terminal at the cab, and then container information and rail position information will be transmitted to remote monitoring server via GPRS.

Figure 9 Rail transport operation mode

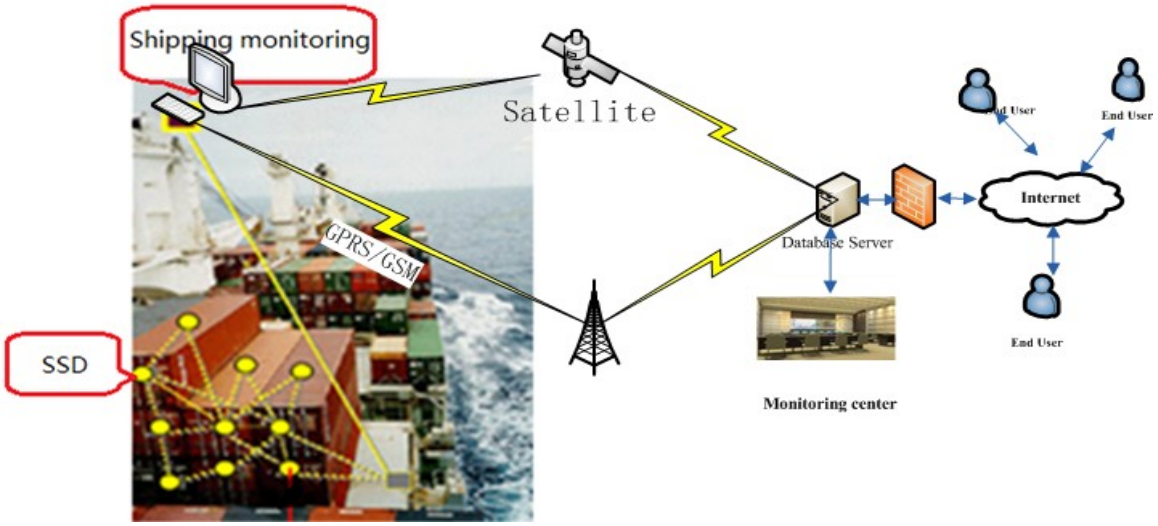


Shipping transport

For shipping transport, since containers are stacked together, if using WI-FI, RFID technology, as containers are surrounded by other containers, the wireless signal will be largely shielded, the information stored in the SSD is hard to be transmitted to the vehicle terminal module. Through research, we found ZIGBEE technology is an available to deal with this problem. Signal transmit path as shown in Figure 10. If the SSC is transport in waterway, the shipping monitoring terminal can transmit container information and position information to remote server via GPRS, if the SSC is

transport in the ocean, the information needs to be transmitted to monitoring center via maritime satellite.

Figure 10 Shipping transport operation mode



(4) Other relevant operations

When containers pass the customs, the customs officers do not need to open the door of the container, they can just take handsets embedded with RFID readers and read the information carried with the container. By reading the E-seals they will know whether the SSC has been opened illegally or not. If the containers have not been opened legally, the SSC can pass the barrier immediately. If the container seal has the records of being opened illegally, records can directly be read that when and where the SSC was opened, then the officers can open and check it further. Before opening the door of container, the Customs officers need to open the container seal with their authorization. This operation will also be recorded in the container seal, and treated as legal operation. It will be recorded in the container seal that the number of handset which is used to open the seal, time and operators information for such information. After checking, if the SSC is still safe, the customs officers will seal the container again.

After the container arriving at the destination, the consignee will read seal with handset before he checks and accepts the cargoes. If there's no illegal opening record, it means cargo transport is safe, the consignee then can sign to accept cargo. If there is the records that the SSC was opened illegally, the consignee also know when and where the SSC was opened, it is easy to make the liabilities and responsibilities clear. For example if the food transported by containers causes people poisoning, it can quickly trace back when and where the food has been possibly polluted in transit, if no abnormal record is found, then it can be concluded that the problem has probably happened before the transportation. Such kind of working mechanism also can prevent theft and improve transport safety more efficiently, and avoid the loss of goods in transit.

As is shown in figure 1, the difference between FCL/LCL mode and FCL/FCL mode is that LCL mode need devanning operation at container freight station, and distribute the goods to their consignees. Freight forwarders or transportation companies will read the container seal on behalf of the consignees to make sure the transportation is safe, and tell the record of SSC to the consignees.

For LCL/FCL mode, freight agents or transportation companies can seal containers to SSC for consigners at container freight station. Other processes are the same as FCL/FCL mode.
For LCL/LCL mode, the container loading and devanning operation are both at container freight station.

So the freight forwarders or transportation companies can complete the operation of sealing and sealing off for the consignees and consignors. Thus it can be seen that SSC is adaptable to a variety of transport modes.

3.2.2 SSC operational mode at the mature stage

We can see from above that in the early stages of the development of SSC, its function is limited, and it does not give full play to its function of logistics organizations due to objective reasons. After the primary stage of the development of SSC, hopefully it can develop towards the mature direction by technological innovation and large-scale capital investment. Its development into the mature stage needs the following conditions:

1) For inland container depots, freight stations, rail container handling stations, inland container terminals and container port and other important transportation nodes, they shall complete infrastructure construction required by SSC, such as the reader installation, management information system and network upgrades etc.
2) Huge market demands for SSC, after primary stages of SSC development, SSC is widely recognized by the market, it benefits shippers, transport companies and ports which in return, demand more SSC services and generate a bigger market to sustain this new product.
3) Different countries achieve agreement to establish uniform standards, national surveillance container data platform, realize data exchange between countries, and propose the related preferential policies to promote development of SSC.

With the market development of SSC up to a large-scale, installation of secure and smart devices will bring tremendous amount of work. Therefore, the E-tag, E-seal and goods-tag are better to be integrated into the container, make secure and smart devices become inseparable parts of the container which in its true sense becomes the Secure and Smart Container. Device recycle, loss, and installation problems are without consideration, integrative SSC simplifies operational procedures and reduces overall workload. With the rapid development of modern sensor technology and “internet of things” technology, the function of SSC will be strengthened, container real-time status information will be collected, status information including temperature, humidity, velocity, acceleration and position information. Secure and smart devices will no longer be made for additional equipment, but a part of SSC, SSC can exchange information with transport vehicle, such as vehicles, ships and operating machines etc., so it makes workers at the production line such as drivers, crew and so on can grasp the state of the container transport.

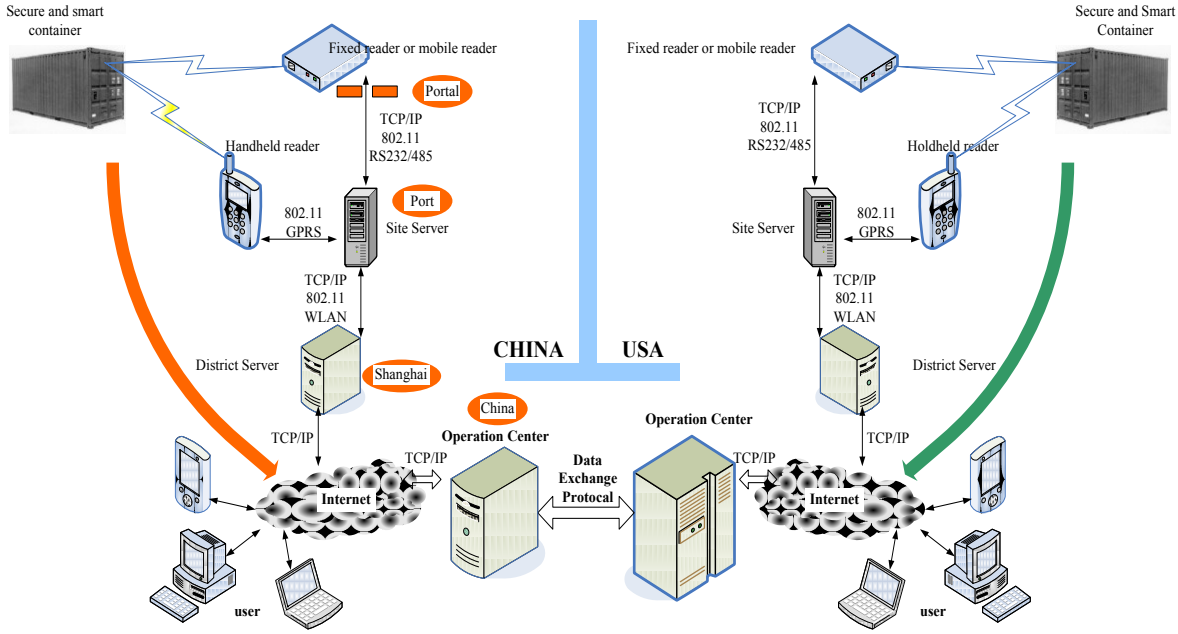
Information network structure and data platform

SSC at this stage is easier than early stage in the operation process. The establishment of container public data platform makes the container realize visualization. In the mature stage of SSC, international monitoring network will be formed, it makes the transport state of containers in the world can be monitored.

As shown in figure 11, take construction of China and the U.S. global SSC surveillance network for example:

Each country has its own independent national container monitoring network, the state is responsible for data monitoring, data security certification, equipment registration, certification and registration of users, data operation; The SSC monitoring network is established based on uniform international standards.

Figure 11 Global Secure and Smart Container Monitoring Network Structure



Data exchange among different countries by data monitoring platforms is mainly based on agreement of standards and secure certification program, China and the United States exchange container data through their national data operation center, reference to the provisions of the U.S. AMS(Automated manifest system), for all goods in U.S. routes, the carrier or NVOCC(Non-vessel Operating Common Carrier) must provide to AMS of the U.S. Customs with four major categories of 14 manifest information by means of EDI, so this 14 manifest information is suggested to be stored in the SSC, the customs read the container directly by handsets can ensure container transport better. The 14 manifest information contents contain:

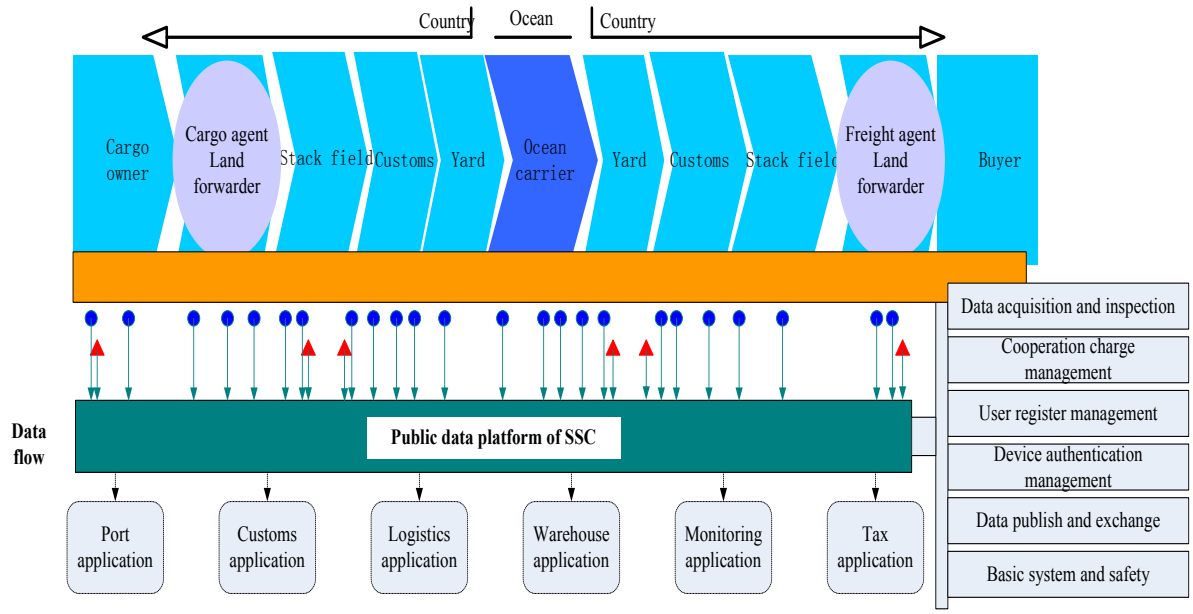
The last foreign port before arriving at U.S. ports;
Carrier SCAC (Standard Carrier Alpha Code) number;
Carrier voyage number;
The date of ships first arriving at U.S. ports;
Carrier number of bill of lading, total number, main bill or sub bill;
The first foreign port to accept shipment of goods destined for the United States by carrier;
Detailed description of the goods including weight;
Name, address and ID number of shipper;
Name, address and ID number of the consignee and the delegate of owner,
Vessel name, flag and IMO (International Maritime Organization) number;
Foreign ports of goods shipment;
International standard code for dangerous goods;
Container number;
Container seal number:
Data storage format of SSC and EDI data format should be consistent.

SSC public data platform can promote seamless connectivity throughout the logistics chain and improve transport efficiency. SSC transport data directly related to national and corporate interests, therefore, third-party designated by national governments such as the Customs or the Ministry of Transport is suggested to take charge of data security certification, data acquisition and inspection, cooperation charge management, user registration management, device authentication management, data publish and exchange, basic systems and safety through the national SSC public data platform. The third party should ensure the data platform's security, fairness and authority. As is shown in figure 12, the SSC logistics chain involved in cargo owners, shippers, freight forwarders, road transport companies, railway companies, container yards, terminals, waterway carriers, customs, consignees, banks and other enterprises and entities. And the public data platform will bring benefits for all

companies and entities in the logistics chain, where the container transportation is made visualization by SSC.

SSC public data platform can create a vertical alliance of container intermodal transport service providers, and form a collaborative service model through the system platform; owner can organize the whole process of container transport through the platform, and achieve substantial improvement of container intermodal transport service level. Similar to airline alliance* platform, passengers can inquire airplane information and arrange their own journey by airline alliance platform in the different airlines and different lines within the alliance. SSC public data platform receives uploaded information from SSC in logistics chain, sorts and stores this information to the database which is constantly being updated, and publishes to public data platform; enterprises also can upload and publish their own information in public data platform in time to ensure the accuracy and timeliness of the information. So cargo owner or freight forwarder can inquire container information and arrange their own container transport by SSC public data platform.

Figure 12 National public data platform structure of SSC



Users' operational modes

Container intermodal transport operators can be classified into transport operators and transport auxiliary operators according to the service object and nature, as shown in figure 13.

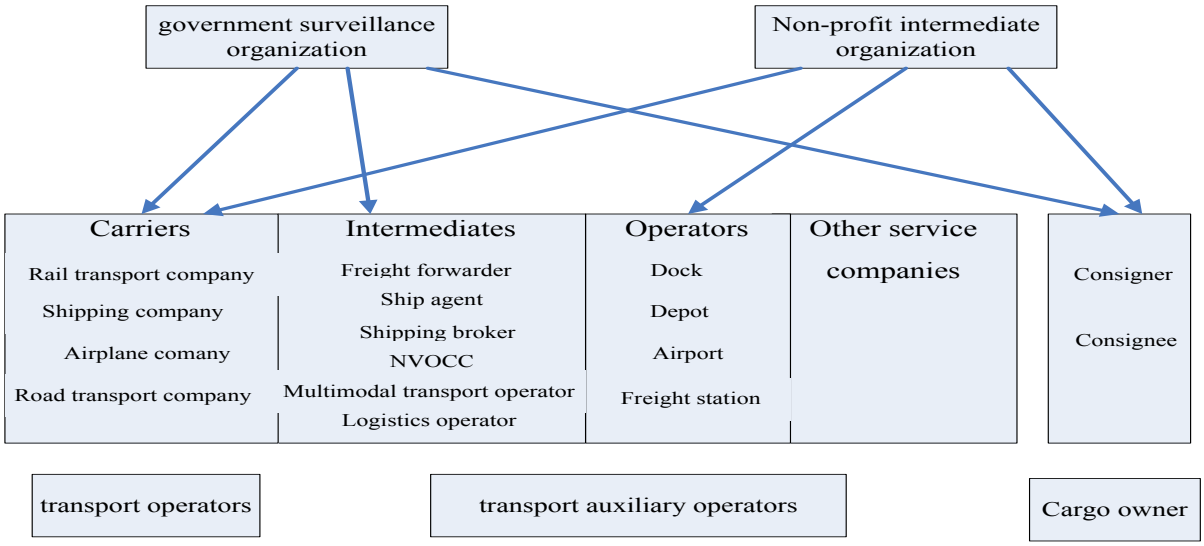
Carriers (railway transport companies, shipping companies, air transport companies, road transport companies) upload their respective transport information such as transport cycle, price, routes, transit time, reserved status information to public data platform, these elements will make transport nodes form huge container logistics information network, owners (freight forwarders) only need to input the delivery location and place of receipt, public data platform will automatically calculate shipping costs and transportation routes to select the best container intermodal transport lines just like E-trade in the retail industry nowadays.

After select container transportation route, reservations can be made on the public data platform, this process is similar to the process of taking the Star Alliance flights that passengers who only need to purchase a ticket in advance and select seat and transport routes, can travel smoothly. Similarly, the owners (freight forwarders) can take a one-time payment by means of online payment, in transit, the carriers obtain their due profits though public data platform automatically, such as SSC with road

* Including passenger alliances such as the Star Alliance, SkyTeam and Oneworld and cargo alliances, such as WOW Alliance, SkyTeam Cargo and ANA/UPS Alliance.

transport - rail transport - sea transport intermodal process, containers are transferred from road transport to rail transport, location and status of SSC will be displayed clearly in the public data platform, if there is a smooth transition, road transport companies will gain their transport income, the income will be deducted automatically for one-time payment; if there is not a smooth transition, goods are stolen or container door is illegal open, road carriers need communicate with shippers timely to make sure whether the freight is safe, explain related issues, they will gain profits until affirm the container freight is safe.

Figure 13 Related Parties of Container Intermodal



Combination of SSC and public data platform will realize container transparent to transport industry, transport auxiliary industry in transit, we can achieve the effects as operating mode above.

For inland container depots, freight stations, rail container handling stations, inland container terminals and container port and other important transportation nodes, their operating models have been described in the primary stage of SSC which can speed up customs clearance and improve operational efficiency. Port and other transportation nodes arrange schedule of production such as loading, unloading, storing, and other operations according to information on public data platform; as the container information can be quickly and accurately displayed on the public data platform, consignees also can grasp accurate arrival time of the container, so as to take the goods at the first time. It saves container stockpiling costs in ports or stations, and reduces inventory costs and storage costs caused by large number of goods stockpiled. If containers stay in the port for longer time, that will waste limited resources. However, it's hard for the port managers to deal with this issue on their own, once they get rid of such kind of containers, sometimes their owners may still take the containers in spite of high storage cost. SSC can deal with this issue, it will send a warning signal to the manager on its own initiative and tell container manager the basic information of its owner including the way of contact, maintaining records and other inherent property, and then the manager can use the information provided by SSC to contact owner of the container.

The customs officers can monitor security situations of containers in transit from public data platform. This new method can reduce the inspection time and improve customs clearance efficiency. Countries which have the requirements for imports and exports of container cargo like the United States needs to clearly grasp the whole process of container transport from origination to destination. And the public data platform is helpful to increase transportation security and prevent terrorists from using containers to jeopardize social security and stability.

For consignees, cargoes transported by containers are directly related to their normal life and production, such as automobile manufacturers. In order to arrange and conduct the next step of the production work, the manager needs to understand the transport situation of each major import components in the assembly of cars, they can accurately judge the arrival time of different parts. For food enterprises which have high requirements for quality and freshness, they can monitor cargo

container temperature, humidity in real-time. If freight containers do not meet prescriptive conditions of temperature and humidity, they can communicate with transportation companies via public data platform to get things corrected in order to avoid loss.

Cargo owners, carriers and transportation brokers can submit the information to customs declaration, inspection and quarantine, taxation and other agencies via public data platform for approvals after the reported information is accepted, and the agencies per se can give approval information back to the cargo owners, carriers and transportation brokers, who can then sign online contract by digital certificate or other encryption methods on public data platform.
SSCs can ensure the information of container transparent and visualize, monitor the transport of goods and transfer process by public data platform. Owner companies and port operators, transport operators can complete financial clearance of banks, financial and insurance institutions, cargo insurance, tax rebates and other services via public data platform, it speeds up the trade turnover, and improves the market efficiency. In mature stage of SSC development, it will optimize the integration of the various transport resources, promote the rapid development of containers intermodal transport, and greatly promote the efficiency of container cargo transport to make the global container transport to a higher development level.

3.3 Business development mode of SSC

It depends largely on the development of suitable business models that whether SSC can be promoted rapidly and extensively, and used in container transportation and plays a secure and smart role. As SSC is involved in a broader sense than just the container itself, it requires pre-construction of associated infrastructures, upgrade of existing systems, and change of logistics management and post-maintenance. Presently, there isn't a mature and feasible business development model. Business model will be slightly different according to the different stages of SSC development.

3.3.1 SSC business mode at the introductory stage

As the SSC is at its stages of development, it requires construction of associated infrastructure, such as the installation of reader and communication equipment in important transport node and system upgrade, etc. In order to make good use of SSC, building infrastructure in one or a small number of transport nodes is not enough to effectively ensure secure and efficient transport, It is necessary to build infrastructure in transport nodes as much as possible, in order to promote the development of SSC better. Under the present circumstances, it would be difficult for shippers, port companies and shipping companies to invest too much to develop the market, therefore, we can learn from the business model of the Mobilephone operators. Network operators invest in the base station, operate and maintain its network, while users can buy mobile phones in the market, and pay for the services to their mobile operators. Only authorized mobilephone products can be used in mobile networks. Similarly, SSC related infrastructure can be built by a state-appointed third-party institution, which can gain fund from government or financings through various channels. For instance, it can ally reader manufacturers, RFID manufacturers, transport enterprises and port enterprises to raise funds. Under the condition that many economies would vigorously promote the development of "Internet of things", the financing should be able to raise enough fund, which is mainly to be used to build infrastructures and trading networks of SSC. When the infrastructure is completed, cargo owners are expected to be its main users for the purpose of improving transport efficiency, security and real-time tracking in transit. Cargo owners will rent smart and secure devices for high-value, high time-sensitive goods.

For ports and other important transport nodes, application of secure and smart device can improve the efficiency of port operations, enhance competition level and attract more container business. In order to encourage cargo owners to use secure and smart device, container operation fee can be set as a preferential price, and other related fee get discounted. Since the application of SSC will become driving force to promote the rapid development of related industries, such as Internet of things, RFID reader, electronic tag, and other service industries, SSC provides a broad platform for related technology suppliers, promotes the new technology transformation from the laboratory and industrial testing phase to the practical application. Apart from that, it may even cultivate a new type of industry such as electronic seal/ electronic lock and other container security device leasing, it will provide the community with more job opportunities and social and economic benefits. To promote the application

of SSC, it is essential that governments take some measures to reduce tax of port and related enterprises to return money to the port as compensation of discount to the users.

For transportation companies, secure and smart device can monitor whether the cargoes are stolen in transit, track container transport status in real-time, monitor the operation and management of transport enterprises, it can also reduce compensation caused by losing cargoes or unreliable container inside environment, such as temperature, humidity etc. However, if the secure and smart device appears damaged during transportation, transport companies should bear the corresponding liability. Transport has obligation to protect smart and secure device from being damaged.

For the aforementioned third party who invests most in early stage, its post-operation income mainly comes from:

1) Access fee of secure and smart devices. These devices can only be used after get authentication by third-party network operating agencies.

2) User registration fees. User is required to pay a registration fee after 2~3 years, and registration fee is free at this early stage, service fee is only charged by information quantity or service times when user tracks and inquires container status.

3) Financing from capital market, ally with other companies to collect fund.

4) Government fund. Money is not enough to operate the SSC system only by business operation at this stage; government should provide a special fund to operate SSC system.

3.3.2 SSC business mode at the mature stage

When SSC develops to a certain extent, with the increase of SSC volume and market demand, application scale also will become large. However, along with a larger volume, the installation, recovery and management application of smart and secure devices will face outstanding problems, such as smart and secure device missing and higher recovery and management cost. As a transitional product of integrated SSC development, installation of secure and smart device will gradually be replaced by integrated SSC. Container manufacturers will embed secure and smart devices (such as E-tag, E-seal and other sensors) into the container. Cost of SSC will increase. Questionnaire shows that it is acceptable to add $50-$100 to present container price. Because SSC can provide users with more information such as location, arrival time, container status, and more other benefits such as quick passing and security, adding price will not affect the sale of SSC, inversely it will improve the competitive advantage of container manufacturers.

Every country will establish their own public SSC data platform, users could register and login access to the own country's public data center to realize information inquiry and logistics organization functions. SSC data platform is not only a container monitoring, location query, and security monitoring platform, but an integrated international container logistics platform.

For the carriers (railway transport companies, shipping companies, air transport companies, road transport companies), they are able to release business messages on SSC data public platform to get more attention, service fees are charged through advance reservation position services on the platform, conveyance can communicate with SSC in real-time. It can help improve the security of conveyance, reduce the risk of accidents. For example, the drivers of trucks with dangerous goods can monitor real-time status of dangerous goods, once there is anomaly, they can take measures to avoid serious accidents in the first time.

As SSC is widely used, it would be seen that container depots, rail container handling stations, terminals and other key transport nodes have their efficiency being improved, their productivity increased, their internal operation mode optimized, and cost effectively saved.

Customs, inspection and quarantine, taxation and other government departments can clearly monitor the state of container during transport through SSC and public data platform, so as to realize a visual

surveillance logistics, a clear division of responsibilities, making accident investigation easier, and customs checking and customs clearance would also become more efficient.

Bank, insurance companies and financial institutions can realize financial balance sheet reporting, cargo insurance, tax rebates and other services on SSC data platform, which helps speed up capital turnover rate, and simplifies the financial settlement, tax rebate and other programs. Owner (agent) can book positions through SSC data platform, realize optimization of transportation routes and costs, reduce transport costs, and check the security status of cargo and its transport situation. SSC's economic benefits are expected to be significant.

For the aforementioned third party who invests most in early stage, his post-operation income mainly comes from:

1. Access fee of SSC. SSC can only be used after get authentication by third-party network operating agency.

2. User registration fees. Container data platform run by third-party operator keeps historical and real-time information of every container. If user wants to track and trace container, they have to register on the public container data platform first and become member. Registration fee is free in the early stage of SSC development. It is only required to pay an annual registration fee after 2-3 years. Presently, the user number of E-Port System is 190,000, so the respective annual registration fee is 190,000*$1000 =$190 million.

3. Data operating fees, which is charged by information quantity when user tracks container. Presently, the number of electronic documents handled by E-Port is 500,000 everyday. If every electronic document needs one $0.1, the total fee is considerable. Actually $50,000 is enough for supporting normal operation of the third-party.

4. Other charges, such as interface transfer fee, etc.

4. Promoting strategy for SSC

To achieve the effective operation of the SSC, the following preconditions need to be met: First, the countries and various types of users involved in container intermodal transport come to a consensus on the concept and operation mode of SSCS; Second, The countries need to work together to develop or adjust the appropriate customs and transportation management system in order to facilitate the formation of SSC application environment.

4.1 The expected timetable for SSC application

In general, we can refer to following four phrases:

(1) Preparation (before 2011)

At present, development of SSC is at this stage. After digesting and arguing concepts and techniques in the early introduction, enterprises and research institutes have carried out the research, experiment and demo-project of container security and safety devices applications, and have gained valuable experience. For example, in China, Ministry of Science and Technology and other departments also actively encourage research in this area, and fund a series of research projects. All these efforts have accumulated a great deal of experience and knowledge for further application of this technology in the next stage, and lay a foundation for the development of standards. In the phase, existing technical bottleneck of container smart and secure devices is expected to be resolved.

(2) The promotion in main regions and enterprises (2011-2015)

Based on the experiences gained in the last phase, the application of smart and secure devices on container transport can be started in domestic ports and interior of big enterprises, then gradually expand to international container intermodal transport. Infrastructure construction for SSC is

expected to be carried out in as many as possible ports and other transport nodes, such as depots, railway container station, etc. Eventually, these transport nodes could establish green channel for containers adopting smart and secure devices, encourage transport sector to use smart and secure devices.

Government should play a leading role to establish appropriate data management platform, complete preliminary infrastructure and put forth preferential management policy. At this stage, we could start application in regions and enterprises which undertook application and demonstration projects before, and also in large enterprises, making SSC application running and continue to absorb small and medium enterprises into the SSC network. Meanwhile, we need to study the emerging problem, and improve technology application model further. Try our best to reduce the cost of smart and secure devices by further research, lay a foundation for further large-scale application.

(3) Transition period from introductory stage to mature stage (2016~2020)

With more and more ports and others transport nodes installed the reader devices, infrastructure environment for SSC gets better obviously, the advantages of SSC will be emerged, more and more users begin to use the smart and secure devices to track and monitor their cargoes. Meanwhile, smart and secure devices have very high reliability and its monitoring result is acknowledged by customs and others inspection organization of the majority trading economies, the checking time of opening containers is expected to be reduced greatly. The whole standards of smart and secure devices are formed gradually, so smart and secure devices made by different companies would also have very good compatibility and interoperability. Every trading partner which join in the SSC network has a public data platform to serve native users, and the data platform can realize communication and information sharing with other data platforms, the functions of the platform become very strong, which can realize the real-time visualization of the supply chain completely based on containers and other value-add services. At this stage, government is expected to put forth laws and regulations to force containers loaded with hazardous cargoes and food to use smart and secure devices for transport safety. Some big scale container manufacturers begin to integrate the smart and secure devices to container, as an incorporated SSC, smart and secure devices and container will not be detached.

(4) Mature applications (After 2020)

More and more incorporated SSCs will occupy the large proportion of container transport market, with the development of internet of things, SSC could also become part of “internet of things”, what is needed to be done is to research how to connect with internet of things, making SSC compatible with other things, appearance of new materials may take place of present heavy containers, all our mentioned functions of SSC will be realized, users could choose SSC with different functions according to their real requirement on different levels.

4.2 Currently existing issue

1）Law and regulations

Due to the fact that SSC is still in its early development stage, the existing laws and regulations for container management can not completely accommodate the development of SSC system, Moreover, international law and regulation for container transport management also varies between places, for instance, different counties have different regulations about the frequency of auto-identification technology, so the cooperation mechanism between trading partner countries and customs has not been established. As a result, security and intelligence functions of SSC have not been fully realized and acknowledged generally.

2）Insufficient infrastructure construction for SSC

As discussed above, whether SSC can realize its functions mainly depends on sufficient infrastructure construction, which is far from enough at present. Due to huge investment and uncertain prospective profit, infrastructure development for SSC is only implemented in some pilot container terminals and depots.

3）Technical standard and certification system of related products

Technical standard of container mainly adapts ISO standard system, ISO standard of E-Tag and E-Seal applying on container as part of SSC is under research, the detail technical standard of SSC has not been studied, and the report has put forth the conceptual SSC standard frame, and does primary research on it. In addition, for container E-Tag and E-Seal testing, there is not a universal authoritative testing organization and system in line with international standard.

4）Effective resource integration of existing management information system is needed

In the condition of intermodal seamless connection to be realized, shipping, railway and road transport companies have themselves management and business system, it is hard to form a systemic and universe container intermodal service platform, this problem is very prominent.

5) Compatibility and interoperability of secure and smart device

Because secure and smart devices are made by different manufactory, compatibility and interoperability becomes another existing problem. For instance, the readers produced by a Company A can not identify E-Tags made by Company B, which restricts development of secure and smart device to a large extent.

4.3 Countermeasures and suggestions for SSC development

Application of SSC should follow market principles. Under the guidance of government and international cooperation mechanism, Ministry of Transportation, the customs and other government agencies are suggested to jointly organize the formulation of relevant laws, regulations, and technical standards, and offer appropriate incentives to encourage enterprises to apply SSC.

1) Establish SSC Standard

The establishment of technical standard for SSC is essential to deal with the compatibility issue for SSC and its components which may be made by different manufactories, and regulate and induce sustainable development of SSC. Industry alliance is believed to be the best way to improve standard establishment, application and update. However, the standard of SSC is very complex, which involves many fields, such as auto-identification field, sensor monitoring field, positioning technology field, data communication field, network information technology field and structure design field etc. So any country or organization is hard to establish SSC standard alone, in contrary, a joint SSC research group is recommended to work on it. This group should be organized by experts from different countries, different fields and international standardization organizations. At present, it is urgent to unify the frequency of auto-identification applying on SSC.

2) Promote development of container intermodal transport

Since it's invented, container transport has gained a great market share over other traditional transport modes, and its market share is still growing. In the long term, the larger market for container transport, the larger market for SSC. Promote development of container intermodal transport, aiming for smooth seamless connections among railway transport, road transport, shipping etc., optimize and upgrade related intermodal transport resources, these resources include their management information systems, information service and decision-making platform, SSC can provide the detail container information when container transport by railway, road, and shipping, we can take advantage of SSC to organize container transport and optimize transport efficiency, seamless container intermodal transport also can embody value of SSC, accelerate its development.

3) Improve container intermodal transport infrastructure

According to the modern logistics concept and requirement of seamless connection of intermodal transport, complete infrastructure, which mainly contains reader devices installation, wire and wireless network environment construction, etc, is the base and premise of applying SSC. Every

node on the logistics chain can realize visualization depends on whether there is complete infrastructure. Because infrastructure needs huge investment, but profit return is slow, it is suggested the government put forth favorable policies and funding to support SSC infrastructure constructions and market cultivation. Nevertheless, only government funding is not enough, suggesting more investments from the private sector need to be encouraged.

Apart from the hardware constructions, software upgrade is also necessary, for instance, the construction of SSC data platforms. Public data platform is an essential part of SSC system, which provides container logistics information for users, in order to actively promote the construction of public platform, public platform and SSC should have accordant data interface, data exchange protocol, at the same time, public platform of every country should connect and communicate with each other.

4) Update law and regulations for SSC transportation administration

Expedite adjustment of domestic and international laws and regulations involved in SSC, SSC as a new transport tool which will lead the transport management system change, new related management system regulation needs to be change to meet the development requirements of SSC transport. Because container has the character of global transport, the internal and international laws and regulations should be coordinated, it is necessary to communicate in the form of forum or seminar among the countries before establishing laws and regulations, unify SSC transport procedure and inspection procedure.

5) Make policies for special cargoes (food and dangerous goods) transportation.

In order to ensure the safety and security of special cargoes, government should reinforce classification inspection of dangerous cargoes, food, medicine, in the mean time, cultivate potential market demand from special cargoes transport to use SSC., For other high-value cargo transportation, users can use SSC voluntarily in order to improve their management level and market image. Taking the initiative to use SSC in these types of special cargo transport will help promote SSC in a wider range of applications.

6) Enhance international cooperation

Due to the international and complex nature of container transport, wider and substantive cooperation is needed among corresponding transport administrative departments of government, the World Customs Organization, International Standardization Organizations, International Maritime Organization, APEC and other regional or international organizations, to deal with related technology, standards and management policy of SSC together. To set up an available cooperation and communication channel is necessary. For instance, a contact person from different organizations or governments should be designated; this contact person will be in charge of cooperation details.

7) Support the construction of SSC laboratory and testing center

SSC involves different technologies and research fields, in order to deeply study on SSC, and to deal with existing technical bottleneck problem, it is necessary to set up special SSC laboratory, provide technology support for SSC, SSC laboratory is different with companies, companies hope to master key technology by themselves that restrict development of SSC, however, laboratory will share its research output that is helpful for SSC development, which is a very good communication platform for SSC research. Making technology standards of SSC should rely on research achievement of laboratory.

Every country should have testing center to regulate normal development, while SSC is not in line with standards of SSC, it will be not allowed to use.