

## ADVANCED X-RAY TECHNOLOGY CAN FACILITATE A SAFE AND EFFICIENT FLOW OF CARGO AND PEOPLE THROUGH PORTS AND CONTAINER FACILITIES

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### ABSTRACT

Assuring a safe and efficient flow of cargo and people through the ports and container facilities of the world is critical to assure a vibrant and global economy. The economy and well being of all nations requires a safe and effective transportation system. The global economy necessitates that the ports of a nation be capable of handling import and export trade in such a manner as to assure the nation's citizens as well as the foreign trading and business community that the risk experienced will be at an acceptable and predictable level. Advanced X-ray technology can facilitate a safe and efficient flow of cargo and people through ports and container facilities.

### BACKGROUND

Marine transportation is an integral component of every nation's transportation system. Its efficient operation is critical to the ability to engage in global trade. For example, in the United States, no matter how modern and efficient the highway, rail and air systems are, alone they can not serve the needs of a global economy. This will become even more critical by 2020, when international trade will triple. Based on current United Nations projections, by 2020 world population will increase to nearly 8 billion people. The most dramatic growth will occur in the less developed regions of the world (Africa; Latin America and the Caribbean; China, India, and other parts of Asia and Melanesia, Micronesia and Polynesia). This will drive a commiserate increase in maritime cargo. Again taking the United States as an example, there are 355 ports that handle cargoes at some 4,000 marine terminals. Of these ports, 150 account for 99 percent of the cargo tonnage. The United States is the destination for about 18 percent of all world import tonnage, and about 30 percent of all world merchant vessels call at U.S. ports annually. Ports and marine terminals are the interchange points between the various transportation modes. Any bottlenecks will adversely affect the flow of cargo to its ultimate destination. How well cargo can move through a port will determine the success of a port and ultimately, the success of the trading nation. Applying technology effectively will be critical to achieving this success. Security and cargo "sanctity" has always been a problem. It will become even more so in the coming years. Assuring security will become even more difficult as the quantity of cargo increases. This will be exacerbated by just in time delivery and just in time manufacturing. Cargo, theft, terrorism, alien smuggling, arms smuggling, drug trafficking all will increase, increasing the need for container and passenger examinations. The traditional method will not work without an unacceptable reduction in port through put. Effective application of advanced technology is the only solution. As port authorities apply technology in port facility design, the needs of a security regime must be considered as a matter of priority. It is critical that security consideration be incorporated into the traditional cargo flow considerations given to facility design. Underway as before will not suffice.

### RISK

The global economy necessitates that the ports of a nation be capable of handling import and export trade in such a manner as to assure the nation's citizens as well as the foreign trading and business community that the risk experienced will be at an acceptable and predictable level. The basic tool for monitoring cargo as it makes its way in commerce is the cargo manifest. It is the basis for commercial agreements, for assuring that what is shipped is what ultimately arrives at its destination, the basis for hazardous cargo stowage, the basis for freight rates, and the basis for assessing customs duties. Ports have always proven to be high-risk zones for any government to deter potential security threats. In today's security climate, the threat from arms, drugs, people, hazardous cargo and technology are the biggest threats of penetration. Two additional economic security threats exist that are becoming problems of equal concern in ports are - container manifest fraud and cargo theft. All security threats, ultimately are ones of economic scale since any nation that can not protect its citizens from terrorism, illegal drugs and illegal arms nor assure enforcement of its customs laws and provide an environment conducive to commercial exchange can not long be viable in the world economy.

The manifesting of cargo is critical to shipping evolutions for reasons of import/export control, safe cargo stowage, freight rate assessment and customs revenue generation. As noted above, the manifest is the basic document that establishes communication between the elements in the transportation system. All control must begin with the listing of products being shipped.

Manifest fraud is an inherent problem both from the introduction of "illicit" cargo perspective as well as from the problems associated with manifests that "omit" listings for illicit cargo are self-evident. Manifests that mislabel normal commercial imports deny revenue to governments because of reduced customs revenues and deny revenues to shipping, rail and trucking companies because of misapplied freight rates.

Theft of cargo has a major economic effect on the viability of ports. Review of the claims records of insurance underwriters worldwide demonstrates its impact. While physical security is critical and must be dealt with as a matter of urgency, ultimately all areas need to be handled in such a manner as to achieve assurance of safe and consistent treatment.

## CARGO MANIFESTING

Cargo manifesting in a non-complex environment is adequate to control imports and for assessing freight rates and customs revenues. It was a simple task to make the contractual arrangement for cargo transport based on the manifest and it was easy to verify in the course of loading and off loading. In the early years of shipping, security was primarily a commercial matter based on trust between the shipmaster and the cargo owner. The cargo owner struck a deal for shipping cost based on the listing of the perspective cargo. The shipmaster saw to proper stowage of the cargo received as per the owner's manifest, and the master paid any associated customs duties at the delivery point. Historically, there have been schemes to avoid customs duties and to bring in illicit cargo and persons, but the problem of detection and monitoring for such traffic was not complex nor was it disruptive to those not engaged in such activities.

## CARGO MANIFESTING AND INSPECTION

As a complex society evolved, physical inspection of cargo became necessary to verify that the manifest was reflective of what was actually being shipped. This was necessary for a number of

reasons. Shipping evolved to using larger, swifter and more complex ships. The relationship between shipping companies and cargo owners changed and close association is impossible. Masters can not know what really is in the vast array of containers. The number of non-compatible products increased immensely, making safe stowage of greater concern for cargo owners and to nations from a fire safety/port security perspective. As the importance of nation states increased and with the associated need for customs generated revenues the need for cargo scrutiny increased. Cargo manifest verification by cargo inspection became the common solution. This has taken many forms and with time has become very people intensive and intrusive to shipping and cargo handling operations. Port Authorities in each port review the manifests to determine what is carried, assess its stowage for fire safety and port security and cargo holds and containers are opened and physically inspected to assure that what is carried is what is noted on the manifest. Where there is suspicion of illegal cargo or blatant mischaracterization of the cargo value, very strict protocols are followed to determine what is the true nature of the cargo is very people intensive and disruptive to the flow of commerce. The significant point is that it is disruptive and causes delays to the predominance of the shippers who are engaged in an open legitimate trading operation. As governments face more austere budgets funding for the number of inspectors, administrators and training cadre' will not be available to meet the need for deterrence through physical container inspection.

#### CARGO MANIFESTING, INSPECTION AND ADVANCED TECHNOLOGY

Using advanced technology, coupled with cargo manifesting and very selective physical inspection will answer the needs for the coming years and be compatible with the evolving tools used by shipping companies to track and monitor their cargo operations. Proper technological solutions to meet governmental security needs and can be made to assist shipping companies in assuring they are getting the proper rates for their services and will enhance their cargo operations. The number of containers and the need for moving them quickly through the ports on to their ultimate destination is paramount. While containers make theft less probable, opening them puts their contents at risk. As shipping has evolved, so has the organization and skills of the criminal community and full containers can be rerouted to other than they're the intended destination. Technology properly applied will minimize these problems. It is no longer productive to physically inspect every container, break-bulk package or suitcase to inhibit the flow of contraband or to assure proper customs duties are rendered. This approach is people intensive, subject to "variation" and disruptive to the flow of containers and cargo. Opening of containers also offers greater opportunity to insert and extract unknown "cargoes".

Technology is currently available to permit examining the inside of containers without opening them and do it will less disruption to the flow of container traffic while maintaining the same level of security now afforded by physical inspection. It also permits authorities to intelligently locate and monitor the logistical flow of the said contraband. When discovered it need not be dealt with immediately as is now required by the physical inspection techniques now employed. The "offending container can be allowed to move along its natural course to its destination and authorities can build enforcement cases against the originators and the organizers of the criminal activities.

This ability can be significantly enhanced by the coupling of electronic surveillance technology with computer technology to build better enforcement profiles thus permitting targeting of probable offending containers. This permits refining the screening of containers flowing through

a container facility lessening the disruption to normal commerce while rising the level of security and customs enforcement. The building of data database will ultimately aid in locating the "kingpins" who present potential unrest and also systematically sponsor rogue operations.

## TECHNOLOGY

### High Energy and Low Energy Systems

While only a small fraction of cargo currently shipped throughout the world is being screened, most industry observers agree that the future will bring ever increasing concerns about smuggling of contraband, terrorist [activity, and the need for manifest verification, which will increase the demand for effective screening equipment. Several different detection techniques have been developed by the security screening equipment industry that are suited for non-intrusively screening cargo. Since the early 1980s, there has been considerable interest in using large, very high-energy x-ray systems to screen cargo. Over the years a few of these devices have been deployed at seaports, airports and border crossings. All of these systems can be viewed as "brute force" devices, in most cases employing very high x-ray energies, 5 to 10 MeV (Millions of Volts). As a result, they require large building structures to contain the complex x-ray accelerators and to support the substantial amounts of shielding required to contain the large amounts of radiation these systems generate. The proponents of these very high-energy systems make the case that they can blast through dense cargo. The most immediate problem is that the image produced is not of a quality sufficient to detect anomalies on a continuing basis. Others contend that there is little additional useful information available at these higher energy levels except when attempting to analyze the most dense cargoes.

### High Energy Systems

High-energy systems offer high penetration. To contain the high energy x-rays generated by these systems, buildings with thick concrete walls and shielded doors to protect the health and safety of the operators and general public alike.

The large buildings require extensive infrastructure with the associated problems of land availability in congested port areas and protracted construction programs. High-energy systems are complex and require large numbers of highly trained support personnel including at least one radiation health physicist at each site. Most high-energy systems only a single transmission x-ray image, which makes it difficult for the operator to interpret the cluttered images common in complex cargo containers. High-energy systems are incapable of providing multiple x-ray technologies such as backscatter x-ray which limits their ability to accurately discriminate organic material.

Medium energy systems that operate in the range of 450 KeV to 1 MeV offer an alternative to high energy systems. Medium energy systems require minimal land space. A typical system occupies less than 1000 square meters of land.

- the x-ray sources used in the do not require extensive radiation shielding.

- a typical a medium energy system can be operated by three people with a minimal amount of training.

- can incorporate both transmission and backscatter x-ray technology facilitating fast and accurate analysis of complex cargo.

- allow for a combination of fixed-site and mobile systems for maximum

flexibility in port screening applications.

## RADIATION SAFETY

The medium level technology uses a small, tightly-collimated pencil beam of x-rays and is inherently low dose. The worst-case entrance exposure to the scanned container occurs in the slow speed of one meter per minute and is less than 2 mR per scan. Entrance exposures at the faster speeds are proportionately less. Radiation exposures to the interior of the container, including cargo (or occupants, if any) is even smaller. For comparison, a typical chest x-ray requires an exposure of 20 mR. Dose to cargo: less than 0.25 mR per scan, high throughput mode less than 0.5 mR per scan, fast mode less than 1.0 mR per scan, normal mode less than 2.0 mR per scan, high penetration mode.

## EFFECTIVENESS OF COMBINATION SYSTEMS AT SEAPORTS

A multi-system approach, one that combines the best features of both transmission mechanism, multi-view, fixed site scanner with the flexibility and speed of a mobile scanner, complimented by a smaller unit for pallets or air cargo is an effective method to give governments, port authorities and container facilities better manifest verification. This approach provides the user the ability to inspection coverage at a greater number of ports of entry. This offers a higher probability of apprehension and increases the deterrent factor to potential smugglers.

This concept responds to the need for two levels of screening:

Level I. The heart of such a system is a fixed-site system designed to screen large vehicles and sea containers. This fixed-site system is smaller than the very high-energy systems. Properly configured, this smaller system provides excellent screening information. It employs up to four sets of x-ray detectors and two x-ray sources, thereby providing a greater number of imaging perspectives, and more comprehensive imaging information than the large systems. A Level I system would serve as the front-line inspection location and would process high volume traffic across borders and at ports. Level II: The next line of detection would be provided by several mobile systems capable of driving to a desired location in response to increased border traffic or specific needs. The mobile systems can be used to supplement the fixed-site systems when traffic is particularly heavy or it can serve as a pre-screener for a fixed-site system. Mobile systems bring flexibility to respond to changing requirements and provide the tactical benefits of surprise and maneuverability.

Each of these systems employs conventional transmission x-ray as well as X-ray backscatter technology. Together, these two technologies provide the highest level of detection and make image interpretation of complex cargo faster and easier.

## BACKSCATTER AND TRANSMISSION COMBINATION

Most metals, many mineral-based products, and inorganic manufactured goods, have high atomic numbers and are designated "high Z." High Z items, whether legitimate, contraband, or "threats" such as weapons, absorb X-rays well and present strong "signatures" in conventional transmission image scans.

Conversely, materials such as organic manufactured goods, drugs, paper currency, explosives, light metals (e.g., aluminum) and light carbon- or silicon-based minerals (e.g., coal or sand) have low atomic numbers, designated "low Z." Low Z materials, especially if thin, are weak in attenuating X-rays and may have insufficient transmission signatures to be detected in a cluttered background of overlying high Z materials. Backscatter technology helps

to overcome this problem. Low Z items have a strong backscatter signature. An image formed from these back scattered X-rays can clearly reveal low Z objects even when they are superimposed over a high Z background.

The greater image (i.e. cargo) understanding is obtainable from using backscatter technology. This derives from the strong surface and shape cues that highlight weapons and from the nature of electronic assemblies. In backscatter, one also can more clearly see contraband hidden behind false partitions.

In addition to conventional transmission x-ray images, back scatter x-ray produces an image quality that identifies shape and texture of objects interior to a container with much more of a photographic quality than the shadow graph of the classic transmission x-ray image, enabling the inspector to count individual items and undertake manifest verification of the cargo with relative ease. The angled configuration of the provides two (2) ZO Backscatter which, when combined with the two (2) conventional transmission images generated with vertically diverging beams from either side of the cargo, provides a three dimensional visualization of the contents of the object being inspected. The combination systems provide at least v four (4) separate images of the cargo being inspected enabling much better determinations by operators.

Technology is now such that inspection of containers in a port environment is possible in an innovative manner and provides maritime safety administration, customs officials, port authorities and shipping companies with an integrated inspection solution which will reduce the incidence of manifest misrepresentation by means of deterrence as well as direct detection and therefore reduce the resulting loss of revenue. This much-heightened degree of scrutiny can be accomplished without slowing down the flow of containers to a degree greater than now experienced by convention means. Indeed the promise is for increased efficiencies and even greater scrutiny as the technology improves.