MONITORING SHIPPING CONTAINERS USING ARCGIS

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In 2005, the US imported more than 11 million containers into their ports, and by 2007, an estimated 13 million containers will be entering the country annually. [1] In New Jersey's Port Newark alone, 5000-6000 containers arrive daily. [2] With the millions of containers entering the US ports, port security is a high priority. New technologies are needed to maintain security and, at the same time, prevent congestion at the ports.

WHAT IS CURRENTLY DONE IN PORT SECURITY

According to a *USA Today* article, "Most of the Containers Moving Through US ports Unchecked," only 6% of the containers are ever physically inspected. [3] The problem is that if port security officers opened every container, shipments would back up at the ports and would cripple the economy. [3] For example, at Newark Port, out of the 5000 containers that arrive each day, 7% to 8% are put through a gamma ray detector, and from those, only about 20 a day are given a 'full strip.'" [3]

On September 30, 2006, the United States Congress passed a $3.4 billion port security bill to improve security at the US ports. The legislation, H.R. 4954, authorizes $400 million a year through 2011 for direct grants to ports, which can be spent on equipment and training. [4] It aims to tackle port security issue on several aspects including technology, personnel and organization with the Department of Homeland Security. The legislation takes steps to prevent terrorists from hazards in the containers causing harm to the US. According to the article on the *Washington Technology* web site, a major requirement in this bill is that the 22 largest US ports need to upgrade scanning for radiological materials in containers by the end of 2007. [4] In addition, the following equipment is covered: "communications gear that is interoperable with federal, state and local agencies; software to enhance terrorism preparedness; IT programs and software for information-sharing and for handling classified information; and surveillance and security equipment to protect critical infrastructure at the port." [4]

For the personnel working at the ports, "background checks and credentials will be required…at the nation's 361 ports." [5] Many fear that a terrorist organization may have connections with an employee at one of the ports who may, in turn, create hazards to the US, and this aspect of the bill focuses on preventing this possibility.

The legislation also covers the organizational aspect between the US ports and the Department of Homeland Security. It "sets up regional interagency command centers that would coordinate information from the Homeland Security Department and other federal agencies with state and local authorities." [4] In addition, the Department of Homeland Security "would set up protocols for resuming operations after an attack or incident." [5]

Technological advances have been made for port security. New inspection scanners and detectors are being developed. For example, Port Newark in New Jersey will be the first US seaport to test Advanced Spectroscopic Portals (ASP) ASP are detectors "that would identify the cargo as trucks haul the containers out of the out of the seaport without the need for officers to walk around the truck, pressing hand-held units against its side and waiting for sensors to determine what's inside." [2] The ASP detectors cost $1.1 billion to develop, and Port Newark is scheduled to start testing it in October 2006.

Also, tamper prevention devices are being introduced. For example, General Electric developed a sensor called CommerceGuard. The following passage is a description:

> [It] can be mounted inside a cargo container and can tell government officers if a container is opened at any time on its route from factory to store. Randy Koch of GE says the device provides security during the most vulnerable leg of any container's journey: the trip from the factory abroad to a foreign port. That's when terrorists would be most likely to take control of a container and put something inside. The devices will cost about $15 per container. [3]

GIS and the GISSCM

With the help of a global positioning system (GPS) or radio frequency identification (RFID) technology, a GIS may be used to monitor shipping containers, signal alerts when a container strays from its intended path and/or allow additional surveillance of selected "high risk" contents. A well-organized GIS can aid in the security of the containers as they travel at the sea as well as on land. The creation of the Geographic Information System for Simulating Container Movement is the first step.

The Geographic Information System for Simulating Container Movement focuses on the technological aspect of protecting the US and its ports. The simulation program demonstrates that the millions of containers entering the US may be tracked using a user friendly, visual interface that allows the monitoring of containers and the management of the relevant information pertaining to each container. The visualization in the current version is done by ESRI's ArcGIS. Once it enters the ports, the containers continue to be tracked as they travel via truck or rail to the final destination.

COMPONENTS OF THE GISSCM

There are four components of the GISSCM: the GIS Visualization Component, the GIS Container Database, the Simulation Program and the Visualization of the Simulation. The utilization of these components result in a user-friendly, graphical interface that allow the monitoring of containers coming from overseas to the United States in real time. Also, the GISSCM will follow the containers' paths inside of the United States as they make their way to their destinations via ship, truck and/or train.

The GIS Visualization Component consists of world maps of the land and sea surface, including the major foreign container ports. Also, the Visualization Component has the map of the United States with all major container ports of the US. In addition, it maps the

major shipping routes to and from the United States as well as the major interstates connecting the ports and the major cities within the United States.

The GIS Container Database is an attribute database with the following information: 1) Data field for the location of the container with an X, Y coordinate 2) Data fields for the content of the container 3) Data fields for customs information and 4) data fields with information about the shipper. Additional data fields might be developed if found necessary during the development of the GIS.

The Simulation Program has the purpose to simulate and test the GIS for container movement. The program generates a database where the movement of the containers is simulated. The Simulation Program is a software algorithm to create X,Y coordinates for simulation of container movement along international waterways from international seaports to the United States. The software algorithm also creates X,Y coordinates for simulation of container movement along major US interstates from US seaports to major US cities. In addition, the software algorithm is developed to simulate the content of the container database (e.g., container content, customs information, shipping information, etc.). If the GIS system will be implemented to monitor containers, the Simulation Program will be replaced by an interface that will submit the location (X,Y coordinates) via a real-time data link to the GIS.

The Visualization of the Simulation deals with the visual aspect of the GIS. The GIS visualizes the simulation of container movement and the contents of the container. In addition, the spatial database with the real-time movement simulation of the containers can be documented in tables and statistically in the future. Currently, new locations for each container in the database are simulated every hour. The position changes will be visualized along shipping routes, ports, interstates and train routes. [6]

DETAILS OF GISSCM COMPONENTS

Map visualization is one of the integral components of any Geographic Information System. The GISSCM visualization component is represented by a standard ESRI ArcMap interface that allows the display of various data types and information. The visualization interface allows the user to view the absolute spatial reference of features in latitude/longitude, decimal degrees, UTM coordinates, etc. and the relative location of the features referenced to others. The technology and capabilities provided by the GIS are suitable for map display, data analysis and decision support systems. The inherent functionality in this system allows for different types of data to be displayed at various mapping scales based on the scope of the data. The software offers a host of analysis and display capabilities that include viewing data, querying the container database and performing spatial analysis between data layers.

The GISSCM visualization component supports the overall container simulation process by providing an environment that displays the absolute and relative location of containers. The container location, simulated by an external program, can be constantly

updated, and the changing locations are easily presented in the map window. The X and Y location of the container on the map is automatically generated by corresponding "X_Coord" and "Y_Coord" fields in the container database. The container database and all other data layers of the GISSCM are in Geographical Coordinates, and the reference ellipsoid is in WGS 1984.

The representation of container symbols on the map depends on the mode of transportation. The three main methods of transportation addressed in this component are the following: ships, trains and trucks. The display functionality allows the user to discern the varying modes of container transport and their corresponding routes (Figure 1). The display capabilities of the GIS also allow the symbols of the containers to range in size based on the number of containers transported by each method (Figure 2). Figure 3 shows an example of a large scale map of the system.

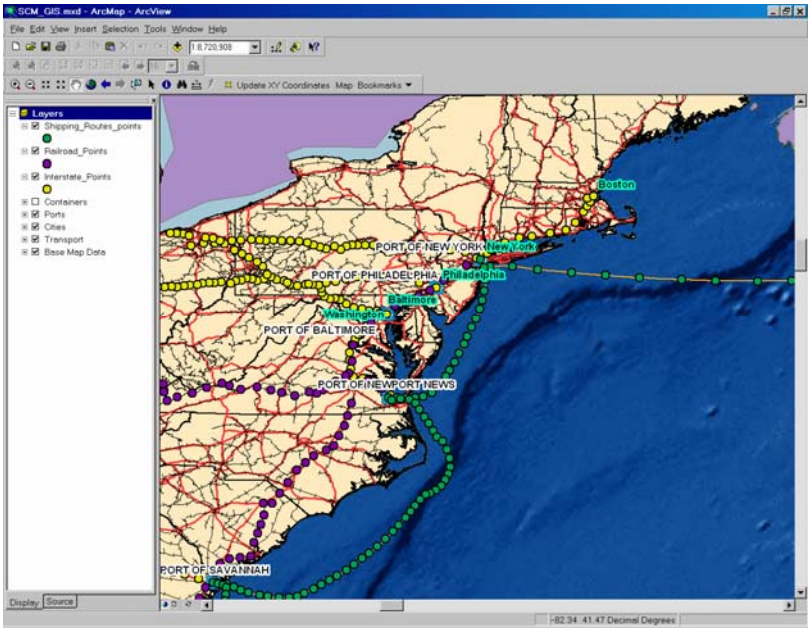

Figure 1: Sample of shipping, train and truck routes.

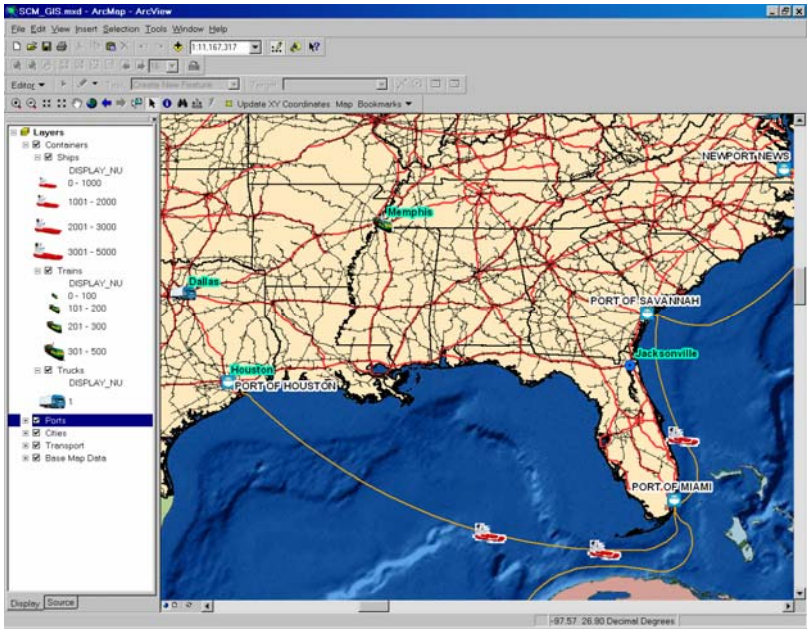

Figure 2: Containers are transported by ships, trains, and truck on corresponding routes. Symbol sizes vary depending on the number of containers at each location.

Besides the visualization of containers, the visualization component of the GIS includes the following layers: national and international roads, railroads, ports and cities, the world countries, all states in the United States, world satellite imagery and world elevations data. Some data sets have been compiled by heads up digitizing and others are from the following data providers: ESRI, WorldSat International and the Bureau of Transportation.

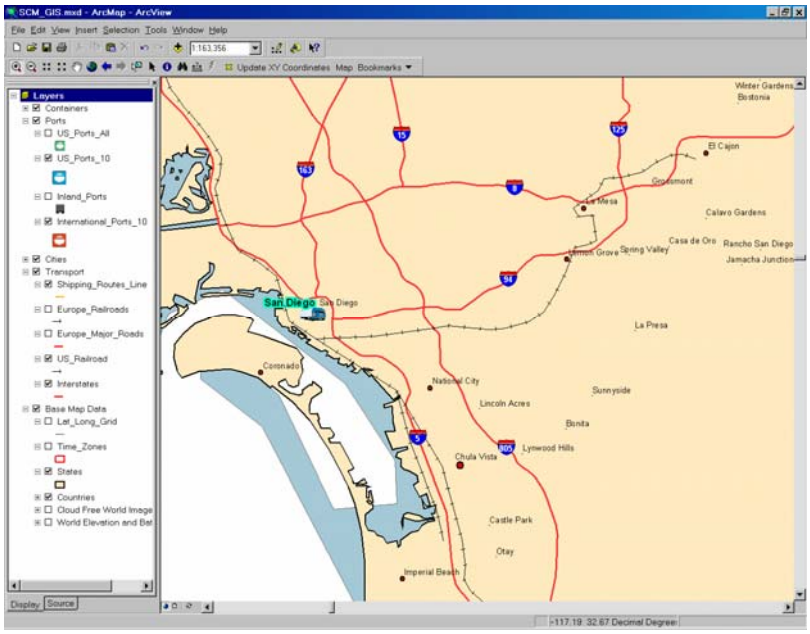

Figure 3: Container location in San Diego relative to local cities, interstates and railroads.

The current visualization configuration is the first step toward fully developing a comprehensive worldwide GIS that contains standardized and complete data layers. By further integrating world data coverage, the analysis and systems developed for this project can be applied to any other location in the world. The map visualization is the backbone for performing analysis and making spatial sense of the locations for simulated or real cargo containers.

For phase 1 of the project, a Visual Basic.NET program was developed to populate a Microsoft Access database with approximately 100,000 records. Each database record represents one container and consists of the following fields: Object ID, X and Y Coordinates, starting point, destination, container content, mode of transportation and the display number (see Table 1). The database was used as an input for the GIS visualization component to display an example of containers along shipping routes, truck routes and railroads.

OBJECTID	X_COORD	Y_COORD	START	DESTINATION	CONTENTS	MODE_OF_TRANSPORT	DISPLAY_NUM
1439725	-82.9988021851	39.9611740112	Newport News	Columbus	Unknown	Train	57
1401653	128.215766459	30.3235607189	Kaohsiung	Long Beach	Unknown	Ship	4971
1388710	-4.21372277446	49.5739971822	Antwerp	New York	Unknown	Ship	4837
1417742	136.505084225	27.4880860741	Busan	Long Beach	Unknown	Ship	4566
1380142	110.302855855	7.3406763661	Kalang	Long Beach	Unknown	Ship	4301
1384443	92.5395549291	9.84959456289	Kalang	New York	Unknown	Ship	4267

Table 1: Example of container database records.

In phase 2 of the project, a program will be developed to simulate the worldwide movement of containers. The simulation program will update the X,Y coordinates of each container in the way that the movement of the container can be visualized in the GIS along international waterways from international seaports to the United States of America. [6]

CONCLUSION

Although the GISSCM was created for the purpose of port and homeland security, it may also be used for businesses that may use it to prevent theft and locate merchandise. Whether it is used for security, business or both, the GISSCM demonstrates that monitoring the containers at the sea and on land prevents the opportunity for terrorism, theft and other unauthorized tampering to occur.

Port security is a nationwide issue with an estimated 11 million containers entering the United States this year, and 13 million containers forecasted to enter the US in 2007. [1] The GISSCM demonstrates that it is possible to monitor the millions of containers that enter the US using ArcGIS software. Once the container enters the port, it may be tracked as it travels on the US railways and highways until it reaches its destination. The database would list each container with its XY coordinates, origin, destination, contents, mode of transport (ship, truck or train) and whatever else that may be needed.

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