# SHIP SHAPE

## STORIES OF THE CARGO SHIP

On January 18, 2007, the gale force winds in the English Channel were strong enough to take out the power and flood the engine room of the MSC *Napoli*, a 62,000-ton container ship. Though the mammoth vessel went down more than 40 miles from shore, more than 100 of its 2,400 containers—holding a hodgepodge of consumer goods not limited to expensive hand creams, wine barrels, Nike sneakers and even BMW motorcycles—washed up on the beaches of the Cornish coast of England. For weeks following the event, hundreds of locals fought the cold to pillage the loot, until the area was sealed off. According to the United Kingdom's Maritime and Coast Guard Agency, it will be a year before the *Napoli's* valuable floating cargo can be fully recovered by salvage vessels.

Today, more than 90 percent of the world's traded goods—liquid, solid and gas—move by cargo ship. A 1500-foot oil tanker can carry more than a half-million tons of crude oil at one time; much smaller, compartmentalized chemical tankers can safely tow a variety of dangerous, volatile or fragile substances, from hydrochloric acid to coconut oil to beer. And thanks to container ships, which hold as many as 5,000 40-foot steel boxes, Barbie dolls can be made by workers in China, with nylon hair from Japan, plastic bodies from Taiwan and paint pigments from America.

Without question, cargo shipping in the last 50 years has revolutionized the global economy. But with all of the economic growth it's spurred, shipping has its dark side: In the wake of the 9/11 terrorist attacks, Western governments are much more concerned with security threats posed by the millions of containers exchanged between nations each year (see sidebar, page 14). Moreover, massive oil and chemical spills from tankers damaged at sea, as well as the toxic substances given off during the scrapping of old ships (see sidebar, page 12), demonstrate that these incredible vessels can leave a damaging environmental footprint.

These disasters are virtually the only reason cargo shipping makes it into the popular press. But shipping is an enormous industry with a relatively good safety record. More than 2 billion tons of oil is carried by ships each year and virtually 100 percent is delivered without spillage. About 50,000 merchant ships are now in operation, run by more than a million seafarers from 150 countries.

Surprisingly, you don't need many hands to run a ship—crews are 20 or 30 at most. Today's technology allows a helmsman to steer not with a spoked wooden wheel, but with a single joystick and mouse ball.

Technology isn't cheap, of course, and the most expensive

BY VIRGINIA HUGHES

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ships cost upward of $150 million. Still, the investment's well worth it: the operation of all merchant ships generates an estimated annual income of over $380 billion in freight rates, or about 5 percent of the total global economy, according to the Round Table of International Shipping Association.

And experts say the industry will only grow. As John Tuttle of the U.S. Merchant Marine Academy puts it, "We build ships because we enjoy it, but that's not why people buy them. People buy them because there's international trade. And as long as there's a need to move things from one place to another, there's going to be the need to design and build ships."

### BUILDING A CARGO SHIP

Goods have been traded by ship since the dawn of modern civilization. More than 4,000 years ago, the people living in what is now Pakistan used the Arabian Sea to send beads and gems to West Asia and Africa. During the Middle Ages, more than 3,000 wooden sailing vessels in the Venetian merchant fleet served the likes of Marco Polo.

The early 19th century brought about steam-powered ships that revolutionized the industry. By 1820, steamships from America were making trips across the Atlantic twice as fast as the old sailing ships.

And the industry was revolutionized, yet again, when the first steel ships came along at the turn of the 20th century. Builders started by placing a large steel beam from bow to stern, called a keel, around which the hull of a ship was built. In those early days, the steel sheets were riveted together.

In the next half-century, shipbuilding design evolved in parallel with the design of automobiles and airplanes. "A 1935-built ship had a framing and they put the skin on top of the framing. Your old 1950 basic automobile had a chassis, and a skin on top of the chassis. A 1940-built airplane had a frame, then skin on top," explains Vincent Treglia of the Texas Maritime Academy, a maritime engineer for 40 years. Now, he continues, for cars, planes and ships, "the skin—the steel—is an integral part of the structure."

The advent of welded steel came around the time of World War II, and today's modern ships are basically huge boxes made of welded steel. In an empty container ship that weighs about 18,000 tons, for instance, about 14,000 tons of that weight comes from the steel. Shipbuilders usually buy

## TANKER SHIPS: MOVING LIQUID CARGO

**Vincent Treglia of the Texas Maritime Academy has been engineering cargo ships for 40 years. Here we asked him just how a tanker ship loads and unloads its precious liquid cargo.**

**What does a tanker ship look like?**
A modern tanker is a large box. They can be up to 1,000 feet long. Modern oil tankers now are double-skinned, and double-hulled. Then there's a central cargo block, with between 15 and 40 tanks on it.

A chemical carrier can have up to 100 tanks on it. Or it can be 15, depending upon what they're actually carrying. Some chemical carriers, we'll call them "drugstore ships," carry 30 or 40 grades of cargo.

**(Opposite page) Oil tankers, carrying precious liquid cargo, can be up to 1,000 feet long; (left) A propeller for a cargo ship can weigh as much as 94 tons.**

the steel in rectangular, 10-by-40-foot plates, most of which get cut into much smaller pieces. "You're taking thousands and thousands of small steel pieces and basically welding them into one piece," says Tuttle.

The process is complicated because welding distorts the steel. "Think about taking a yardstick, putting your hand on the center and putting weights on the ends—it's going to bulge," Tuttle explains. In the same way, a ship's steel framing will want to bulge from ocean pressures, "so you have to put the ship together so it can survive this," he says.

Shipbuilding today uses "block construction"—prefabricated, multi-deck sections of the hull or superstructure are built and tested on land, moved to the dock and welded together until the complete ship is formed. Most shipyards install piping and electrical cables while the various blocks are on land because it's usually much easier than assembling them in a cramped and dark interior space of the ship.

Moving the mammoth vessel from land to sea is usually done in one of two ways. The first is called an end- or side-launch berth, where during the building process the ship is attached to a hill with a series of latches. Then when all of the blocks are in place, the latches are removed and gravity pulls the ship down the hill and into the water. Tuttle says this method is "the more traditional way, but in the last 20 years people have done it less because you have to build the ship on an incline, which makes it more time-consuming."

Much more common today is to use a graving dock—a narrow, concrete basin that is bound by gates called a caisson. "It's basically a hole dug in the ground, right by the water, with a door between the water and the hole," Tuttle says. The ship will be put together in blocks on an empty graving dock; then, when it's ready to float, the doors are opened and the water rushes in.

Though small details vary, the underlying construction is the same for oil tankers, chemical tankers and container ships alike. "Going from ship to ship you get the same basic systems to make the ship run, like electric and plumbing," Tuttle says. A tanker, for instance, needs a complicated piping system to get its cargo in and out of the tanks without spillage. But a similar piping design also is needed for the ballast system on a container ship.

What has changed in recent decades, though, is computer technology. A computer calculates the minimum amount of steel that should be ordered, and how to cut the large plates

**How much can an oil tanker hold?**
For a large ship, we're talking 350,000 tons of oil.

**Why put the same liquid into so many different tanks?**
The biggest reason is to prevent something called "free surface effect." Without being divided, if the ship started to roll then all the oil would go to one side and the ship would rock. So you have to make sure the tanks are about 98 percent full, or else even inside the tanks the liquid will slosh from side to side. Fact is that a few ferryboats have sunk over the years because the decks get flooded and they just turn turtle.

**What are the tanks made of?**
They're usually free-standing stainless steel tanks. And the more tanks, the more cost there is to build a ship.

**How does the liquid get on and off the ship?**
Ships are typically loaded on one side of the dock. You connect the ship to the dock either with flexible hoses or with a fixed piping arrangement called a chicksan. It's like a mechanical arm. When the vessel's loading or unloading cargo, its height changes in the water, so this flexibility allows for that. Pipes don't bend, and hoses are, by definition, flexible, so what you choose to use depends on your purpose.

Then they use pumps ... to get the oil, or whatever liquid, from the dock to the ship. There are tanks at both ends [on and off shore]. On the loading end, you've got pumps pumping from the tank on the shore into the ship. And the tanker has pumps to discharge the cargo.

## THE DEATH OF A SHIP

On March 24, 1989, the *Exxon Valdez* tanker hit Bligh Reef on Prince William Sound and spilled more than 11 million gallons of Alaskan crude oil into the water. In response to this environmental disaster, the U.S. Congress passed the Oil Pollution Act of 1990 and other regulations that required oil companies to phase out use of their single-hull ships and replace them with double-hull ships. The idea is that if you have a double hull and hit something—like a reef—the ship's outer hull will break but not its inner hull, keeping the ship afloat and the oil inside. A complicated technical debate exists among marine engineers as to whether double-hull tankers are actually safer; so far, there's no evidence that the switch has caused fewer accidents or oil spills. Nevertheless, the rest of the international political community soon followed the U.S. example and set similar regulations.

Suddenly, the oil companies had a big problem: How to get rid of these huge single-hull ships? Some ship owners chose to convert their single-hulls to double-hulls at a cost of many millions of dollars rather than scrap a relatively young, and still commercially viable, asset. But most have gone for the cheaper option of shipbreaking (or in more positive terms, "ship recycling"). In theory, ship recycling makes sense: these huge ships are full of valuable steel and other materials and parts that can be scrapped, melted, resold and reused. (A very large tanker, for example, can provide 30,000 tons of steel, worth about $1 million on the scrap market.) But in practice, ship recycling—done almost exclusively in poor countries where labor is cheap and the local demand for scrap steel is high—is notorious for its medical and environmental hazards.

Scrapping a ship by hand can be done in as little as six months. First, anchor chains and braided steel cables pull the vessel up the beach and secure it to the ground. Next, the ship's fuel tanks are emptied. Usable oil gets resold, while sludge is burned on the beach. Next, the crews attack the inside quarters of the ship, ripping out wood paneling, the electrical system and asbestos-filled insulation to get at the valuable piping. Finally, the ship's engine is removed and the remaining steel monster is cut apart in large pieces, using torches, and hauled up the shore.

With a vast, starving population, South Asia has a pool of laborers willing to subject themselves to harsh conditions for meager wages. Now, more than 90 percent of the world's junked ships go to India, Bangladesh and Pakistan to be dismantled.

into smaller pieces with the minimum amount of waste. And computer programs can give ship engineers precise geometric and technical descriptions of the ship. The computer also tells the engineers who parts are being bought from, what they cost, and what their physical properties and dimensions should be. Every player on the design team can see design changes immediately after they're made, averting problems before they happen. Thanks to computers, an entire ship can be built easily in less than a year.

This isn't to say that the process is completely automated. "You certainly need people to design the thing, to run the computers, to make sure that the machines do everything correctly," Tuttle says. He adds that the preliminary design—done by a half-dozen human engineers—is the most important part of the shipbuilding process, and is what has led countries like Japan and Korea to pull way ahead of the rest of the world.

"It's all in the planning and the engineering. The Koreans and the Japanese spend an awful lot of time in thinking about how they're going to put the things together before they start," Tuttle says.

Other economic and political factors also have contributed to America's lag in the shipbuilding industry. In 1920, the Jones Act dictated that all ships carrying the U.S. flag must be built in the United States and owned by U.S. citizens. And because the cost of parts and labor is much more expensive in the U.S., ship operators are more inclined to fix up old American ships rather than build new ones.

Fifty years ago, the U.S. merchant fleet had 3,083 deep-water vessels of 1,000 tons or more and was ranked largest in the world. But by 2005, this number had dropped to 412, which ranks 15th in the world.

Because shipbuilding uses a wide range of technologies, employs many workers and generates foreign currency income, it's an attractive industry for developing nations. Today, South Korea is the world leader. But in the next few years, because of massive government investment and low labor costs, the top spot will probably go to China.

## THE CONTAINER REVOLUTION

On May 1, 1956, a crowd of hundreds gathered at Wharf II in the Port of Houston to watch as the world's first container ship sailed into port. As one witness later described, "We had seen thousands of tankers in Houston, but never one like this. So everybody looked at this monstrosity and they couldn't believe their eyes."

Indeed, the *Ideal X* was a wonder. Just five days before its arrival in Houston, a 72-foot land-based crane in Newark, N.J., had loaded it with 58 aluminum trailer trucks full of cargo. The crane dropped one box onboard every seven minutes; the entire vessel was ready to go in less than eight hours.

Watching the loading while eating his lunch was 43-year-old Malcom McLean, the restless and calculating entrepre-

neurial genius whose thriving trucking company, McLean Industries, was funding the shipment. The idea came to him three years before, in 1953, when he learned that the U.S. government was selling leftover World War II tankers to shipping companies for practically nothing. Worried that this would take business away from his trucking company, McLean thought he might literally piggyback onto the competition—and avoid the increasing congestion on U.S. highways—by rolling his trucks onto ships. Because truck wheels would use up valuable cargo space, this roll-on idea was soon scrapped in favor of standardized, stackable containers. In 1955, McLean's company acquired the Pan-Atlantic Steamship Corp., bought two of the old T-2 tankers, hired top-notch container engineers and began the container revolution.

Before this, transportation was very much mode specific. "People were either railroad guys, or maritime guys, and thought that their particular vessel was very important," explains Marc Levinson, economist and author of *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*. But McLean realized that manufacturers cared not about how the goods were shipped, but how efficiently. "The idea of putting goods into a container didn't originate with Malcom McLean; this was not his brainstorm," Levinson explains. "His accomplishment was finding a way to do it that was actually profitable."

Profitable it was. In 1956, the cost of loading a ship was $5.83 per ton. On the *Ideal X*, the cost per ton was just 16 cents. In the 1950s, the cost of ocean shipping accounted for a whopping 12 percent of the total value of U.S. exports, and 10 percent of imports. But now, thanks to containers, say economists Edward Glaeser and Janet Kohlhase, "moving goods is an essentially costless" part of the production process.

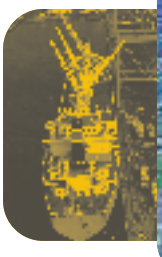
These immense savings came about because container shipping minimized the time that a ship was idle—the most expensive part of the process. "A ship's not generating revenue when it's sitting in port," Levinson says. "So to really cut costs, you've got to expedite the loading, and unloading, get the ship under way."

Before container shipping, a typical port was made up of wooden piers that stuck straight out from the shore into the water. The ship would pull in alongside the pier, and be tied up for a week or two while teams of longshoremen would unload its contents into nearby warehouses.

Today's port scene is drastically different. When a ship comes into port, it docks not beside jutting piers, but parallel to the concrete waterway. As soon as the ship is tied up, land-based cranes—usually three or four—immediately go to work. The cranes lift containers off the ship and then place them on vehicles to be moved to a storage area. After a certain number of containers have been removed, the cranes start moving in both directions—unloading and loading simultaneously.

"A port is a lot like a factory these days," Levinson says. Computers give crane operators the precise order in which to unload and load the containers, and drivers are told which containers go to which storage yard, and when. "The company will know how many containers per hour a single crane operator has moved," he adds. "They're measured, above all, by efficiency."

Within a decade of *Ideal X's* historic trip, container shipping had facilitated a sweeping change in the way goods are sold and moved around the world. Before the revolution, goods were generally manufactured from start to finish at the same place, which was usually near a port to cut down on transportation costs. After containers, transportation became cheap and the supply chain could be made longer.



As Levinson puts it, "The container made a fundamental change in the cost of transporting goods. Shipping goods internationally used to be extremely expensive. Now it's very cheap. And the decline in the cost made it feasible to trade many things that couldn't be traded before."

After the world's largest shipping companies jumped on the container bandwagon, ports had no choice but to adapt. The biggest ports like New York, Los Angeles, Rotterdam and Sydney had to overhaul their layouts to accommodate large, land-based cranes. And since factories no longer needed to be near a port, container shipping gave smaller port cities a huge opportunity. In 1950, Seattle's six piers in use for general cargo were in danger of being closed. Instead, the Port Commission wisely spent $32 million building two new container terminals, and today Seattle is a major player in the distribution network. Perhaps most noticeably, the container revolution made Far Eastern countries—eager to build their economies with foreign investment, especially in manufacturing—major players in the shipping industry. Of the 300 million containers that moved across the oceans in 2006, 26 percent originated in China.

Since the early '80s, as container shipping drastically lowered the cost of international freight, the volume of freight has quadrupled. Brian Cudahy, director of the Steamship Historical Association and author of *Box Boats: How Container Ships Changed the World*, calculated that in 1975, Sea-Land company's containers placed end to end would stretch from Manhattan to Cleveland. Today, if you placed end to end all of the containers needed to exhaust the world's fleet, it would more than encircle the Earth.

In modern society, we use and depend on goods every day that were produced someplace else without much thinking about the boats that brought them to us. But from distributing Barbie dolls to fueling the ever-changing world economy, those big boats are truly indispensable for living in the modern world.

## CONTAINER SECURITY AFTER 9/11

Nearly 10 million containers came into U.S. ports in 2004. In a post-9/11 world, U.S. security officials see each container as an opportunity for terrorists to carry out another catastrophic attack.

The very reason container shipping is so profitable for exporters and importers—a sealed container can go efficiently from origin to destination with no intermediate handling of its cargo—makes it a nightmare for customs officials. The fact is, if each and every container ship was searched thoroughly, it would slow down the transportation process so much that the ships' amazing cost savings would evaporate.

Moreover, imagine the manpower that would be needed to check each box on a container. For just two of America's largest ports alone—Los Angeles and Long Beach—searching every container that comes in every day would take 35,000 customs inspectors.

Each container comes into port with a list of what's inside, but there's no way for a security official to check that the list is accurate. If you open one container's side doors, you'll see only a wall of cartons stacked floor to ceiling, blocking the rows and rows of others stacked within. It's easy to see how the container full of illegal drugs or immigrants could sneak through without a problem.

So what's the solution? Within months of 9/11, the U.S. Customs and Border Protection agency (part of the Department of Homeland Security) began a program called the Container Security Initiative, intended to prevent terrorists from delivering a weapon via container. The CSI starts by identifying the small number of high-risk containers (using "advance information and strategic intelligence"). Then, for countries that have agreed to participate, these high-risk containers will be screened at their point of origin, using large X-ray and gamma-ray machines and radiation detectors. Some shipping companies also are starting to use "smart" containers, which will tell U.S. security officials if they've been tampered with during transit.

So far, more than 50 ports across the world—in South America, the Caribbean, Europe, Africa, the Middle East and throughout Asia—have signed up with the CSI, which according to U.S. Customs, accounts for more than 90 percent of all trans-Atlantic and trans-Pacific cargo imported to the United States.

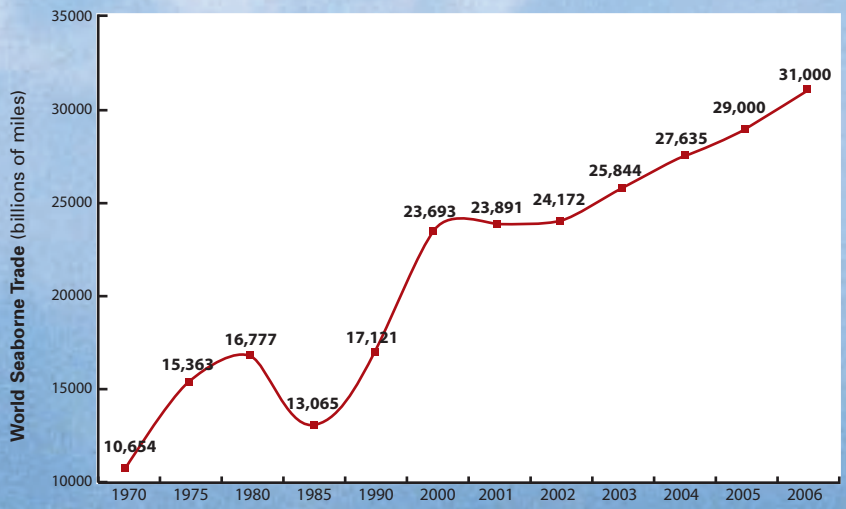
Still, economist and author Levinson is dubious about the effectiveness of these or any other container-searching initiatives. "At this point, frankly, the biggest concern is politics," he says. "There's a lot of people talking a lot of nonsense here, because it's really important for them to be seen as being tough on terrorism, seen as doing something. Despite what the people concerned may tell you, this thing basically runs on the honor system. If they know you, and if you're a regular shipper on a particular route, your container isn't very likely to get searched."

# Cargo Shipping By the Numbers:

Shipping trade estimates are usually calculated in ton-miles—a measurement of tons carried, multiplied by the distance traveled. In 2004, for example, the industry shipped 6.76 billion tons over 4 million miles, resulting in a staggering 27,635 billion ton-miles of trade.

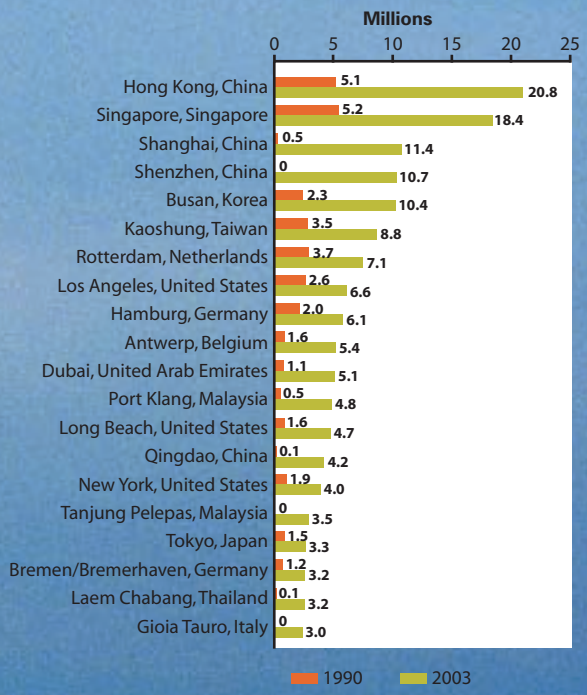
The graph (right) shows the **Growth of the Cargo Shipping Industry** since 1970. The figures for 2005 and 2006 are estimated.

Source: International Maritime Organization report on International Shipping and World Trade, September 2006.




## The World's Largest Container Ports

*ranked by number of containers handled annually*




**Containers are counted in 20-foot equivalents; if a port handles 40-foot containers, each one is counted as two for purposes of this chart.**

source: The Box, by Marc Levinson