Commercial Seaports and Modes of Maritime Transport

Objectives
After studying this chapter, you will be familiar with

1. The functioning and operations of and equipment utilized in container terminals, bulk cargo terminals, cruise terminals, and nontraditional terminals;
2. The roles and activities of key private-sector stakeholders, including terminal owners, terminal operators, stevedore companies, and longshoremen;
3. The impact and role of the development of the container and intermodalism;
4. The origins and development of modern commercial shipping;
5. The types and functioning of modern commercial ships, including bulk carriers, tankers, container ships, freighters, oceangoing tugboats, and cruise ships.

Introduction
The human love affair with the ocean is one that has existed since man first laid eyes on the waters that lay before him. The great seas provided man with mystery and intrigue. The oceans presented a backdrop for stories that served as entertainment and the foundations of religions. The conveyances used to cross first the rivers and then the oceans facilitated international trade and commerce, connected cultures and peoples, and made the world a smaller planet.

The evolution of what we now call the modern shipping industry began small like all things in this world do. The first seagoing traders did no more than cross rivers and float with the flow of the waters. However, with this foundation, man began to thrive. One small village may have possessed an item that another village needed. This prompted traders to bring their goods to different locations along the river in order to trade their items for the items of others. These villages soon became popular trading spots and attracted people from far-away places. The travelers often brought items that had never before been seen in that particular region. These towns became the foundations of our modern ports. Underneath some of the world’s busiest and most modern seaports lie the ruins of these simple yet effective cradles of capitalism.

As oceangoing technology increased, seafarers became more and more bold. They went further and faster in the race to bring trade to the far corners of the world.
Each new vessel arrival brought new languages, merchandise, and products. This often led to conflicts, and man’s ability to use oceangoing vessels as machines of war increased. As the need for protection against military vessels increased, seaports became bases of operations rather than simply trading posts. As technology grew and time marched on, these “bases” became a part of a network of commerce with trade lanes that radiated from ports like the spokes of a wheel. An infrastructure was established and fortunes were made via this ever-expanding spider web of trade.

This chapter focuses on the development, operations, and functioning of the primary variations of the modern commercial seaports and the key types of vessels that call on these ports and ply the oceans of the world.

Commercial Seaports

If you compared modern commerce to the human body, the shipping lanes would be arteries and veins; ships and intermodal vehicles, the blood; their cargo, the nutrients; and the seaports, the all-important organs. The shipping industry operates in many of the same ways as the human body. There are some periods of rest, but very rarely does the flow of cargo stop. Vessels arrive into ports at all hours of the night, which requires many people to be awake and ready to service the vessel. The seaport’s support to the vessels and preparations for cargo operations in the port begin many hours prior to the vessel’s arrival dockside.

Approximately 6 hours from arriving at the sea buoy (also known as the pilot station), a vessel’s captain will begin to initiate contact via VHF radio (contact is made on channel 16, and the pilot dispatcher will switch to the local working frequency). Notice of arrival is given, and the dispatcher provides the vessel with boarding information, including appropriate speed and the side of the ship that the ladder is to be located. The position of the pilot ladder is determined by the wind, tide, and direction of the swell. Pilots are taken onboard via special-platform boats simply referred to as pilot boats. A harbor pilot is a specially trained navigator. He is tested on the local characteristics of the many different factors and variables required to properly navigate from the sea buoy to a safe berth. Once the pilot is onboard, he assumes “the con,” or control of the vessel. The captain of the vessel gives up control but does not relinquish overall responsibility of the vessel during this time. As the pilot carefully guides the vessel to the berth, he is in constant communication with tugboats, which provide the vessel with additional steering capability by connecting to the vessel with large ropes or lines called hawsers. Once the vessel nears the berth, the crew connects the ship’s mooring lines to smaller lines which are thrown down to line handlers. The line handlers physically maneuver the lines to bollards attached to the dock which are used to secure and hold the vessel in place. Typical mooring patterns include a total of eight lines, but the patterns will vary according to currents and tidal fluctuations. Once the ship’s crew lowers the gangway, vessel agents employed by the vessel charterer or owner will come aboard with customs and immigration officials in order to clear the vessel to go to work. Vessel security personnel hustle into place to prepare for the identification and search procedures of individuals boarding the vessel. While this process takes place, stevedores, longshoremen, and company representatives stand by for clearance to begin the arduous process of discharging the vessel.

This whole sequence takes place in a very limited amount of time, and the plasma TV sitting in a container at the bottom of a stack of containers on board the vessel has
not even been moved toward its final destination: your living room. Countless hours of preparation and planning have gone into this process. Millions of dollars’ worth of equipment and man-hours are expended with each and every arrival of every product from orange juice to jet fuel. All of this began with just a simple phone call, purchase order, or Internet search. It is hard for many to comprehend the vast number of resources that are poured into this venture in order to keep the supply chain flowing and further expand the network of commerce. The key component in this process is the commercial seaport, which serves as a launching point for the advancement of supply and demand.

Container Terminals
The development of the modern container—the most efficient, safe, and flexible method to transport cargo across the ocean and land—was a watershed event in maritime transportation and served as a catalyst for the evolution of seaports from only handling break-bulk and bulk cargoes and vessels to also—or exclusively—receiving and loading cargo containers. Today, the majority of cargo transported around the world is via containers, and major ports have dedicated berths and terminals for container handling and staging.

Key benefits for the shipper utilizing a container include the ability to compartmentalize and segregate different kinds of cargoes and, importantly, the container offers protection from adverse weather and water and handling damages. For example, toys for children can be housed in boxes at the front of the container and radios in the back of the container. Also, multiple shippers with small loads can consolidate the cargo into a single container.

FIGURE 1-1 The port of Manzanillo International Terminal—Panama.
While there are several versions of the shipping container, most commonly they either are 20 or 40 feet long, 8 feet wide, and 8 feet 6 inches in height. Containers are loaded on and off the vessel via a crane, either a shore-based or ship crane (also known as a Morgan crane), which is mounted on the vessel deck and moves atop rails running the length of the ship. Trailers are containers that have a chassis affixed and are unloaded/loaded onboard a roll-on/roll-off (RO/RO) ship via a terminal tractor. The port may have a special berth to accommodate these vessels and their operations. Some ships carry both containers and trailers, and container terminals generally also service RO/RO ships.

Prior to the advent of containers, cargo such as fruit, textiles, coffee, etc., was boxed or stacked loose or on pallets in hatches below decks and loaded and unloaded via conveyor belts, physical manpower, ship cranes, or nets. This work was especially dangerous, cargo was frequently damaged, and operations were very slow. The discharging and loading of a break-bulk cargo vessel may have taken from 3 to 5 days, but today the same quantity of cargo in containers can be handled in about 12 hours. The efficiencies and reductions in manpower and damages represent a significant savings for both the port and the shipping line.

Container vessels require the port to offer ample space for staging, specialized types of equipment, skilled manpower, and efficient organizational and logistical management. As you can see in Figure 1-1, a significant amount of space is needed to stage containers in the port. Large container ports, such as Rotterdam, Netherlands; Hong Kong; Freeport, Bahamas; and Manzanillo International Terminal, Panama, generally manage a ratio of about 75% transshipment containers and 25% local containers. This means that only 25% or less of the containers originate in or are destined for the country where the port is located. These ports, located along major trade lanes, function as transfer points—much like a rail hub or bus depot—for containers that will then be distributed throughout the region or hemisphere. Large containerships, such as the M/V EMMA MAERSK, carrying up to 11,000 20-foot equivalent unit (TEU) containers will arrive at the port, discharge a portion of their containers, and reload as planned. The transshipment containers are then loaded onto generally smaller ships—called feeder vessels—which then transport the containers to smaller ports throughout the region.

In general, the larger vessels (functioning as “mother ships”) operate in an east-west, pendulum movement through the oceans of the world, from Asia to the United States and back and from Europe to the United States and back. The trade lanes of feeder vessels tend to run north-south. For example, a primary feeder trade lane on the west coast of the Americas runs from Panama (the transshipment hub) south to Chile and north to Los Angeles/Long Beach and Seattle. A typical major container transshipment port or terminal will have at least a million TEU container movements (unloading/loading) per year and receive about 300–500 ships per month. The Port of Rotterdam, Europe’s busiest port, posted a record 2.54 million TEU containers moved during just the first quarter of 2007, up 13% over the same period in 2006. For operations of this magnitude, the port must have adequate container stacking space and function with a high level of speed and efficiency (see Figures 1-2 and 1-3).

At a major container port, from 2–10 gantry cranes may be assigned to unload and load a single container ship, depending on the length of the ship, number and location of the cargo hatches to be worked, and the number of container movements. Gantry cranes

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are computer-automated and highly precise; a single crane has the capability to unload or load upwards of 75 containers per hour, if the terminal operations personnel can keep up with the pace! In smaller or multipurpose terminals, mobile and portal cranes—sometimes referred to as stick cranes—are utilized. In some cases, the ship may have efficient shipboard cranes or the port doesn’t have land-based cranes available, so the ship will discharge and reload using its own cranes.
The lading of the container via a crane is the end of what is commonly called the string-piece. The string-piece is the actual strip of concrete/asphalt/block that runs along the water and extends to the backreach of the crane; however, the term also applies to the final process dockside of container loading. In the string-piece, vehicles, chassis, and bomb carts are staged in line and lurch forward in succession until under the crane, to receive or unload a container. It is important to the speed of the process that there are no obstructions to slow down this movement. Prior to the string-piece, there is a well-choreographed and coordinated movement of the container from where it is “stacked” or staged in the yard or located atop a rail car, to its loading onto a bomb cart or chassis, and then transported through the terminal to the waiting line dockside (beginning of the string-piece). The distance from the rail or stack to the string-piece may vary from 100 feet to a mile and depends on how far away the container stacks/staging areas are from the dock and the layout of the terminal.

For the most part, container vessels are discharged and loaded simultaneously and utilize the same terminal equipment (terminal tractors, top-picks, rubber tire gantry cranes, straddle carriers, gantry cranes, etc.). To add a further level of complexity for the yard planners and vessel planners (the persons in the port who track each container in the port, plan its movement, and coordinate its load position in the ship), each specific container is loaded to a specific position in the ship, so a high level of coordination is required between yard management, equipment operators (who actually sort and move the containers), and the vessel operations (terminal/ship officers).

The equipment most commonly used in container terminals include

- **Gantry Crane (Figure 1-4):** This large crane has a boom that is capable of extending over the beam of the vessel in order to load/unload containers from the cargo hatch or deck. It is most commonly on rail tracks in order to move.
- **Mobile Crane (Figure 1-5):** Also known as a type of stick crane, this crane has tracks or wheels and can be moved from location to location for the loading or discharge of containers and other cargoes.
- **Rubber Tire Gantry Crane (Figure 1-6):** Also called by its initials—RTG—this crane is used to lift containers on or off a chassis or bomb cart and place them in stack. It is also used for shifting containers within the stack.
- **Straddle Crane (Figure 1-7):** A small but more mobile version of the RTG, this crane is capable of working in stacks of up to three containers high.
- **Shuttle Carrier (Figure 1-8):** Designed to interface between the RTG and the ship crane, this carrier moves containers directly from the stack to shipside, and replaces the use of the terminal tractor.
- **Top-Pick:** This large lifting device is used in container yards to lift a loaded container off the chassis and place it either onto the ground, onto another chassis, or to stack it onto another container.
- **Reachstacker (Figure 1-9):** This device is similar to a top-pick in function but has the ability to extend out (reach out) on a diagonal angle.
- **Side-Pick (Figure 1-10):** This equipment is used to rapidly move and shift empty containers.
Terminal Tractor: Also called a yard hustler, Ottawa (made in Ottawa, Kansas), or mula, this tractor is used to hook up to a chassis or bomb cart to transport containers in the yard.

Container Flat-Bed Chassis (Figure 1-11): This device has a chassis with a wood or metal bed and locking pins for transport of containers in the terminal.

Bomb cart: This piece of equipment resembles a container chassis but sits lower to the ground and has angled corner and side guides (in lieu of locking pins) to facilitate more rapid lift-off/drop-in of containers.

In a select few ports in the world, automation technology has sought to further reduce manpower and increase efficiency. The automated ground vehicle (AGV), developed by Gottwald Port Technology, is an unmanned vehicle powered by diesel or diesel-electric engines and carries up to two 20-foot containers (see Figures 1-12 and 1-13). At the Europe Container Terminal (ECT) in the Port of Rotterdam (the largest port in the world), 280 AGVs have been in operation for the past 15 years. Another Gottwald AGV system is installed at the Container Terminal Altenwerder (CTA) in the Port of Hamburg, Germany. The AGV is controlled by a vehicle navigation system which constantly “reads” passive transponders embedded in the terminal and adjusts its speed and direction. An integrated communication system that can process up to 250 messages simultaneously also provides nonstop communication between the AGV and the fleet management system.
The automated stacking crane (ASC), also developed by Gottwald Port Technology and deployed at the P&O Terminal at the Port of Antwerp, Belgium, is an unmanned portal crane which runs atop rails and can straddle nine containers wide and five containers high. It is generally used to preshift containers for near-term vessel operations and to reorganize the stacks in the yard, both tasks designed to increase productivity when interfacing with the yard management system. According to ECT management, as of May 2007 the efficiencies and cost savings have surpassed initial projections, and in 2008 the Euromax Terminal at ECT also will be fully automated. Additionally, by the end of 2009 a fully automated barge feeder terminal will be operational in Rotterdam.

Most container ports have some type of computerized yard management system, and there are several very good products in the marketplace. One such system, Mainsail Terminal Management System, was developed by Tideworks Technology, a sister company to Stevedore Services of America (the largest U.S.-owned seaport operator). Mainsail is a browser-based interface for gate, yard, and vessel inventory management. Mainsail records all shipping, gate interchange, and dispatch information real-time at the entrance and exit gates (integrating optical character recognition, security cameras, truck scales, voice collection, and information kiosks) and initiates a tracking record of each movement of the container. If the container is shifted from the third to the fifth level in the stack, this information is fully recorded (who, what, when, where, and why). This system also functions with rail operations and relay containers (discharged from one ship and immediately reloaded to a waiting ship).
FIGURE 1-6 Rubber tire gantry (RTG) crane.

FIGURE 1-7 Straddle crane.
FIGURE 1-8 Shuttle carrier.

FIGURE 1-9 Reachstacker.
FIGURE 1-10 Side-Pick is used to rapidly shift empty containers.
Tideworks’ Spinnaker Planning Management System is a supplemental system which interfaces with Mainsail and enables the yard and vessel planners to quickly direct real-time container information into orders for gate, rail, yard, and vessel moves (see Figure 1-14). The system assists in maximizing efficiency in selection of containers for movement, assigns the moves, communicates with yard equipment operators (cranes, RTGs, top-picks, etc.), and defines the plan for loading of the vessel. The Traffic Control module of Spinnaker replaces radio communications and paper instructions with real-time, electronic dispatching of work instructions to equipment operators, speeding up the process and reducing errors (see Figure 1-15). The Spinnaker system also integrates real-time data and information from differential GPS, handheld devices, and mounted mobile display units. Computer-based systems such as Tideworks’ Mainsail and
Spinnaker greatly enhance the efficiency of gate, rail, yard, and vessel operations and reduce the time and expenses of servicing the large container vessels.

When a loaded export container arrives at the port for processing for loading onto a vessel, several sequential steps occur, which refer to what is commonly known as the gate operation (see Figure 1-16). The term gate does not necessarily refer to a physical structure. It can simply refer to the paperwork process through which the container and/or cargo must flow to be cleared for entrance or exit (in the case of import cargo). The gate operation occurs for both import and export cargo and is somewhat different from country to country—because of local customs requirements and commerce practices—but the general process steps are similar from port to port. In the case of an export container, first the container is staged outside the gate (and outside the port), while the driver takes the customs clearance documentation, the bill
of lading, the equipment interchange report, and relevant agriculture/health department certificates to a pre-gate office for processing and information recording in the computerized yard management system. Next, the driver enters the main vehicle gate and proceeds forward to the gate inspection and interchange point and stops atop a scale. Here, the container is weighed; all driver, container, and seal information is verified/recorded on an interchange; and possibly security checks are conducted (explosives, narcotics, WMDs, etc.) by K-9 teams and/or non-intrusive inspection equipment. A checker makes a physical inspection of the condition of the container (holes, damages, reefer functioning and temperature check) and records his observations on the interchange. At this same time, the designated equipment (RTG, top-pick, etc.) operator is informed electronically or via radio of the job assignment. Next, the driver proceeds to the preassigned location in the yard for the container to be lifted off and placed in the stack. The RTG records the exact location of the container, time, date, etc., and this information is transmitted real-time to the yard management system. When the yard and vessel planners program the container for preparation for loading on a vessel, the equipment (RTG, top-pick, etc.) operator is informed electronically or via radio of the job assignment, and he lifts the container from the stack and places it on a chassis or bomb cart. The terminal tractor driver transports the container to the string-piece and awaits his turn to move under the crane, for lifting of the container onto the vessel.

The processing of pickup and delivery of import cargo/containers to the consignee is somewhat the reverse of the process for the export container. Essentially, when import cargo

FIGURE 1-14 Tideworks Technology’s Spinnaker Planning Management System uses modules to provide and automate real-time yard mapping and container movement and vessel loading information.
FIGURE 1-15 Spinnaker's Traffic Control module replaces radio communication and paper instructions with accurate, real-time, electronic dispatching of work instructions to equipment operators in the port terminal.

FIGURE 1-16 The process and movement of a container entering the port gate, staging in the terminal, and then loading on a ship.
is scheduled for pickup at a port terminal, a contracted truck driver arrives at what is typically called the port gate dispatch office (pre-gate) and presents one or more reference documents (dock receipt and/or equipment interchange receipt, bill of lading, pickup order) to the terminal operator—demonstrating that he has been contracted by the importer or shipping line to dray the container or cargo to the consignee. Once the documentation is processed, the driver will be given a load order or load document, instructed to enter the port gate (if the office is located outside the port), and go to the yard location where the cargo/container is to be picked up. The driver will then proceed into the cargo/container/trailer staging area, as per the instructions, and provide the load document to the clerk or foreman working with the loading gang. The truck will be loaded according to the driver’s instructions. Once the cargo or container is loaded and inspected/recorded by the checker, the driver will return to the dispatch or clerk’s office and retrieve the bill of lading and new equipment interchange receipt. The driver signs the bill of lading and interchange, which is proof that he is authorized to transport the container to the consignee. Once this step is completed, the driver is usually free to begin his journey to the consignee. On some occasions this process actually takes place at the exit point or the gate, but it is not necessary as long as the appropriate steps are taken. This brief process is a small part of a much larger system called the supply chain.

Most container terminals also are capable of receiving break-bulk vessels and their cargoes. An example of this type of vessel and cargo would be a reefer ship and its cargo of fresh fruit (bananas, pineapple, mangos, melons, etc.). The cargo bays in these ships are refrigerated to keep the boxed fruit cold. The boxes either are loaded loose (individually) or are palletized. Loose boxes are loaded on/off the ship via a conveyor belt, whereas palletized fruit boxes are hoisted on/off the vessel via stick cranes or ships’

FIGURE 1-17 Palletized boxes of fruit are loaded via ship’s gear into the temperature-controlled cargo bay of a reefer ship.
cranes. In the latter case, the pallets are moved into a metal frame, as in Figure 1-17, via a forklift or hand-truck. The cargo is shuttled from the vessel to cold storage warehouses via forklifts or trucks. Both of these cargo operations are laborious, time-consuming, and frequently impacted by inclement weather. The unloading of a reefer vessel, such as the ones seen in the figures, may take from 24 to 48 hours. Ports providing services to reefer ships usually have large cold-storage facilities and warehouses located inside the terminal.

Bulk Cargo Terminals

Bulk cargo can be classified in two ways: liquid bulk cargo and dry bulk cargo. The terminals that receive, house, and ship bulk cargo are fairly simple in nature but are diverse in structure. This diversity is strictly dependent on the type of cargo being handled at the facility. For the purposes of this discussion, we focus on petroleum/LNG terminals, grain/mineral/cement terminals, and dry bulk facilities.

Petroleum or oil port terminals can vary in size and design, depending on the location of the facility, its services, and the needs of the company which owns it. Typically, there is a refinery or storage facility in close proximity to the dock area (see Figures 1-18 and 1-19). LNG terminals are designed only for the transfer of LNG product, and the terminals are self-contained and self-sustaining. In the case of a petroleum products facility, it is connected to the dock area by a series of long pipes that lead to multiple holding tanks. These pipes can reach miles inland, their length depending on the final destination of the product being delivered. Oil tankers will carry either refined or unrefined product in multiple cargo holds. The dock area contains a large manifold with load/discharge hoses attached that feed the pipelines leading back to the refinery or storage tanks. The vessel will also have a manifold onboard, and each manifold has valves that can be opened and closed to control the flow of the liquid. There are also a series

![FIGURE 1-18 Very large crude carrier (VLCC) unloading crude oil at a port.](image)
of pumps both onboard and at the terminal which move the liquid cargo through the system. If the vessel is discharging the product from its tanks to the facility, then the chief mate (cargo officer) will arrange the manifold in the proper setup and will control the starting and stopping of the necessary pumps to move the cargo through the onboard pipelines to the manifold and then to the hoses which link the vessel’s manifold to the shore-side manifold. Onboard personnel and shore-side personnel stay in constant communication to make sure that the flow rates and tank volumes maintain the proper safe levels. If the vessel has arrived empty and is scheduled to load product, the process is reversed, utilizing the pumps located within the terminal. The unloading of LNG is similar, with the pipes carrying the super-cold liquefied product to a large storage tank set within a spill containment area (see Figures 1-20 and 1-21).

Grain, mineral, and cement terminals are specialized facilities for a particular type of cargo. These facilities can be identified by the large conveyor belts, load chutes, and storage silos that are integral to the loading or discharge process. Grains and minerals can come in a variety of sizes and shapes, but most of these cargoes are the size of pebbles or pellets. Vessels that carry this type of cargo typically utilize large cargo holds that hold multiple tons of cargo. These vessels may or may not have cranes on board in order to load directly to trucks or rail cars if a conveyor-type dock facility is not available. When a conveyor-type facility is used, the discharging gear will extend from the shore to the cargo hold of the vessel. The cargo is either vacuumed or scooped up and placed onto a conveyor belt that will transport the cargo from the hold of the vessel across the dock and into a storage silo. The conveyor belt is elevated off the dock so that the cargo is gravity fed into the silo or even directly to trucks or rail cars. These facilities do not require a great deal of land or dock space at their respective ports. Belts and hoses can be extended along the length of the dock in order to allow multiple
**FIGURE 1-20** Liquefied natural gas (LNG) facility.

**FIGURE 1-21** Vessel docking and product transfer equipment at LNG port terminal.
vessels to work at the same time. Cargo operations within these terminals must be watched very closely due to the rapid movement of large amounts of cargo. Vessel trim and stability measurements must be closely monitored to ensure that the vessel does not have too much stress placed on its structure or that too much weight is loaded to one area of the vessel. Improper loading or discharge of these vessels can result in vessels flipping or even breaking up. Another danger at these terminals is the dust that is generated during cargo operations. Grain dust and mineral dust can not only be bad to breathe in, but can also be highly explosive in nature. Grain dust in particular is extremely explosive and must be very closely monitored during discharge or loading. Any ignition source must be removed from the area in which cargo operations are taking place.

Dry bulk facilities are the most simple of the bulk terminals. Dry bulk cargoes are also the most diverse in type. Dry bulk can be palletized or simply loaded into the holds. Examples of dry bulk cargoes are steel, cotton, paper, wood, lumber, and palletized food products. The terminal itself could be as simple as a paved lot that connects to the dock. In some cases, the cargo does not require a warehouse, such as with steel. Wood and lumber products are housed in a standard warehouse or shed. These terminals are typically accessible by rail and truck, depending on the type of cargo being discharged or loaded (see Figure 1-22).

Equipment commonly used in bulk cargo terminals includes but is not limited to the following:
Mobile Portal Crane (Figure 1-23): Also known as a type of stick crane, this crane has tracks or wheels and can be moved from location to location for the loading or discharge of bulk cargoes.

Pontoon Crane: This type of crane is used when the vessel cannot dock against the quay.

Flat-Bed Chassis: This equipment is used to transport the dry bulk products. Typically, heavy tie-downs and chocks are used to secure the cargo.

Dump Truck: This truck has a hydraulic lift and swinging gate and is typically used to haul dirt, grains or other loose-type cargo.

Forklift: This wheeled machine has two large metal “forks” used for lifting palletized cargo and other items that can’t be lifted by hand. Forklifts can be propelled by diesel, propane, and even electricity. Forklifts also come in various sizes, and the size of a forklift is related to its lifting capacity.

Cruise Ship Terminals

Cruise vacations are rapidly becoming one of the most popular ways to relax and see different countries. As the market increases, cruise ship companies have to find ways to
compete in a rapidly expanding market. This competition will often affect the terminals that receive the passengers boarding the vessel. This type of terminal is the most aesthetically pleasing of all the terminals since people are the cargo; therefore, the boarding areas must be presentable (see Figure 1-24). Some cruise ship terminals mimic airport terminals and provide coffee shops, restaurants, and souvenir shops.

Cruise ship terminals are not isolated in industrial areas but are often in the heart of town in order to be easily accessible, such as the Port of Miami—the largest cruise port in the world. Cruise ship terminals must have vehicle access so that passengers can drive up and drop off luggage before moving on to the parking areas. While the external areas of the terminal are designed to please and attract passengers, the internal areas must be able to handle other operations that are hidden from the public. Baggage screening areas are set up in order to make sure that illegal or improper items are not being loaded in passenger baggage. Since a cruise ship is essentially a floating hotel, many supplies and food items must be delivered to the vessel. Therefore, the terminal must be accessible by truck or delivery van. There must also be sufficient space to house the equipment that is going to take the supplies off the trucks. Forklifts, pallet jacks, and dollies are used for this purpose. Ideally, all of this activity is done out of the sight of the passengers in order to maintain the clean look and feel in the terminal. These terminals are expensive to build and operate but contribute greatly to local economies by creating a location that people travel to in order to board a vessel prepared for fun and relaxation.

\textbf{Nontraditional Ports}

It is important to appreciate that not all—not even the majority—of the ports worldwide have a movement of 1 million containers per year or discharge/load millions of tons of bulk materials annually. Likewise, while the vast majority of ports of the world have berths and quays, in some locations there is a significant amount of regional and international maritime commerce but no formal port. The reasons for this generally tend to be
environmental issues (silt buildup so that large ships cannot get to the shoreline, insufficient economic incentives, and/or political instability). For example, Turbo, Colombia—where dozens of ships per week load hundreds of thousands of boxes of bananas—does not have a “port.” Turbo is an area where the para-militaries and the narco-guerrillas constantly battle for control of zones. In the small town of Apartado, the main town, dead bodies frequently litter the roadways. Nevertheless, this location is an excellent growing region for bananas and a significant fruit source for Dole Fresh Fruit, Chiquita Brands, Del Monte, Turbana, and other fruit companies. The ships anchor in the Bay of Uraba, located in the Caribbean between Colombia’s northwest coast and Panama. The bananas are cut and boxed at hundreds of farms and transported by trucks to central palleting stations along the rivers flowing into the Gulf. The palleted bananas are loaded into bongo barges, which are hooked together like train cars and pulled by a tug. The tug collects the barges and transports them—with stevedore labor onboard the barges—into the bay and alongside a ship. When the fruit barges arrive alongside, the laborers slide back the roof on the barges, allowing access to the pallets. The stevedores climb the ship’s rope ladders and onto the deck and then scurry down into the cargo bays. The pallets are lifted from the barges using the ship’s cranes and loaded into the cargo bays. Once unloaded, the tug returns the bongo barges to the load points for restocking. Because the cargo operation is very long, 36–48 hours in duration, additional maintenance and stevedore housing barges (where the stevedores sleep and eat) are also brought alongside the ship. As you would imagine, these break-bulk operations require a large number of stevedores, from 25–40 per work shift. (see Figures 1-25 to 1-27).

There are also ports where cargo ships tie up to anchored barges and other ports where coastal freighters simply float up onto small boat launches. In the latter case, the
The port of Chepo, Panama, shown in Figure 1-28, serves as a good example. Chepo is a river port in Panama with direct access to the Pacific Ocean and is close to the border of Colombia. Chepo serves as a maritime commerce point for tens of small towns and villages in the region, as well as a transshipment point for narcotics from Colombia and arms and supplies going to the narco-guerrillas in Colombia. Again, there is no formal
port. Small craft and even coastal freighters load and discharge all types of merchandise—even shipping containers and trailers. In other river and bay-loading locations, containers are transported ship-side in long boats, as shown in Figure 1-29. Similarly, but for other reasons, bulk ships on the Mississippi River anchor and use cranes from barges to transfer cargo, as shown in Figure 1-30.
Stakeholders

Terminal Owners

Terminal owners can be private, or they may be public entities. A public entity such as the group that operates the Port of Houston is controlled by a board of directors whose members are appointed by a city official, most commonly the mayor of that city. The board will hire a port director who manages the overall function of the port and provides the board with updates on the progress of the organization. A privately held port is owned and operated just as any other company. Whether privately or publicly owned, the port always has a staff that includes Operations, Accounting, Sales & Marketing, and Personnel. There may be variations of this business design, but they all follow a similar concept. It is the responsibility of the sales force to attract business to the port in order to ensure revenue and cover the costs of operation. Many times the port will make long-term deals with a company (shipping line or terminal operator) and will lease the space at the port to that company for its exclusive use. In other instances, the port will operate the terminal and charge fees to the shipping companies that bring in cargo. Fees that are charged are typically assessed by length of the vessel, duration of stay, tonnage of the vessel, and weight of the cargo that is discharged. Ports will also charge for the use of other services, such as providing potable water, truck weigh scales, or even security services. With all companies battling to reduce cost and increase profit, terminal owners must often think outside the industry common practices in order to draw in as much revenue as possible. Increased revenue means that there will be money available to maintain and update the port infrastructure (cranes, RTGs, roadways, etc.), which in turn means a greater ability to lure customers to the port.
Terminal Operators

As previously mentioned, sometimes the terminal is operated by the terminal owners themselves. However, in most cases, a company will lease space from the port in order to conduct business. The companies that lease the facilities are considered to be the terminal operators, and may be shipping lines or companies which specialize in the functioning of a port for multiple users. The terminal operators will staff their facility with a variety of personnel and deploy a number of assets and equipment to handle the day-to-day business. The principal role the operator plays is to provide a plan for and coordinate the discharging/loading of cargo to the terminal or vessel and the movement of the discharged cargo into a warehouse or to its consignee. The operator will also act as a liaison between the crew of the vessel, the vessel managers (who direct the activities and schedule the fleet for the shipping line or ship owner), the terminal owners, and the workers who handle the cargo. The duties of the terminal operator also may include clearing of the cargo with local customs agents, overseeing the work of vessel agents, supervising cargo operations, preparing all necessary load and discharge documents, and developing and implementing safety practices and procedures.

Stevedore Company

A stevedoring company is a company that is hired by the terminal operator to provide the machinery, hire the laborers to work the vessel, move the cargo within the terminal, and handle the execution of the loading of cargo that is to leave the terminal. There is typically a superintendent of stevedores who is the company representative for the stevedoring company. The superintendent will supervise all aspects of the operations within the port and will act according to the plan that has been provided by the terminal operators. The superintendent will ensure that all equipment that is in use is in good working order and is safe to operate. There will be a maintenance staff that executes a preventative maintenance plan and handles any emergency repairs. The stevedoring company will handle all aspects of the payroll for the cargo workers. The stevedore will then bill the terminal operator for services. Perhaps the most valuable role that the stevedore plays is as a buffer between the laborers and the management of the terminal operator. The labor may or may not be members of a labor union. It is often beneficial to have that layer of insulation that the stevedore company provides in order to make the operation move more smoothly.

The stevedore company will also lend valuable expertise to the terminal owner/operator in the area of cargo operations. The superintendent is experienced in the loading and discharge of vessels and has valuable knowledge about manpower requirements that will maximize the efficiency of operations and decrease the cost associated with the operations. The stevedore company not only provides a layer of insulation from the labor, but also alleviates the liabilities that are associated with working in this hazardous work environment. Since the employees are actually employed by the stevedore company (full-time or day labor), the stevedore company is responsible for paying workman’s compensation and also indemnifying the terminal operator/owner in the event of a lawsuit from a longshoreman.

Longshoremen

Longshoremen are the actual laborers who handle the equipment and discharge or load the equipment. It is important at this juncture to clarify that longshoremen is a term used in the United States and in some European countries. In all Latin American...
countries and many other parts of the world, longshoremen are called *stevedores*. Most longshoremen are hired on a daily basis, and they are often hired through a local union hall. The longshoremen are divided into *gangs* and assigned to *hatches* (also referred to as *cargo bays*). There is a *gang foreman* for each gang, and it is his job to ensure that the men in his gang are working according to plan and in a safe manner. The gang foreman will also report the hourly count to the *clerk in charge*. This information is used to calculate finishing times, which helps plan for the departure time of the vessel. Crane operators are specialized longshoremen who have experience in the operation of all the different types of cranes, including ship cranes. The remainder of the gang is divided up according to seniority and ability. Gang size is dictated by the type of work and the kind of contract that is used when working the vessel. When labor unions are involved, contracts are negotiated based on what type of cargo is being worked. Labor start times, hours, wages, and other work rules are included in these contracts. These laborers are an integral part of the overall process in port operations.

**Intermodalism**

*Intermodalism*, propelled forward by the advent of and explosion in the use of cargo containers, represents several of the links in the cargo supply chain and has revolutionized the way ports and ships are designed and function. The use of two or more modes of transport in a shipment from origin to destination is referred to as *intermodalism*. The most common modes of transportation are via sea, air, and over land (trucks and rail). In fact, nearly all door-to-door cargo/container shipments—which are by far the most common type of shipment—use the intermodal transport system. In a door-to-door shipment, the cargo is picked up at the *exporter* (factory, manufacturer, plant, etc.) and transported all the way to the consignee (Wal-Mart distribution center, private residence, etc.). Portions of these links in the supply chain may be controlled by the exporter, the importer, an agent or broker, or the shipping company or airline. However, the exporter and/or the importer determine their level of involvement in the transport and can make certain decisions. For example, Victoria’s Secret in the United States places an order for 50,000 bathrobes with its factory coordinator in Colombia. The purchase order is executed, bathrobes made, and either the exporter (factory), the consignee (Victoria’s Secret), or an agent/broker coordinates the shipment. The decision of which mode to be used at each transport link on the supply chain (from the factory in Colombia to Victoria Secret’s distribution warehouse) may be based on cost, time frame, and/or the type and size of the cargo. The first decision is whether to use sea or air for the international leg of the journey. In this scenario, it most likely would be maritime transport—due to volume and cost—from the closest seaport in Colombia. So, a contracted trucker (first mode of transport) will dray the container(s) from the factory to the seaport. The container(s) will be loaded on a ship (second mode of transport) to the destination port. Once in the U.S. port, the container either will be drayed directly to the Victoria Secret’s distribution warehouse or loaded on a cargo train (third mode of transport) and sent via rail to the rail hub closest to the warehouse. If rail is chosen, once at the rail hub, a local trucker will dray the container to the warehouse. As you can see, in this scenario there are at least three links in the transport portion of this supply chain and a minimum of two modes of transport.
Malcom McLean’s invention of the large, modern shipping container\(^2\) and its rapid acceptance as the primary method of shipping nonbulk cargo has driven the intermodal transportation system to be the primary way cargo is moved worldwide. Later in this chapter we review in detail Malcom McLean’s invention of the container. For now, let’s discuss its benefits and impact on intermodalism. What was new about McLean’s innovation was the idea of using large containers that were never opened in transit between shipper and consignee and that were transferable on an intermodal basis between trucks, ships, and railroad cars. The reduction in loading time (about 1/20 of the time used for the same quantity of break-bulk cargo) and the reduction in overall port/shipping costs (about 1/50 of the cost of loading and shipping the same quantity of break-bulk cargo) had a huge financial impact on the cost of the operation. These benefits, combined with McLean’s freely releasing his patent on the container to the International Standards Organization, ushered in the creation of the standardized container and the development of container terminals and container ships to support these shipping operations.

### Modes of Maritime Transport

Suppose you are driving along one of the many U.S. interstate highways with a young and inquisitive companion. As you begin passing multiple semi-tractor trailers, the questioning begins. A Wal-Mart truck passes by, and your guest asks about its contents. You logically assume that it is carrying furniture, toys, or even clothing. Next in line is a silver tank trailer being towed by a Peterbilt with red diamond-shaped placards on the sides and back end. He again asks what is being carried, and although unsure, you surmise that the trailer contains a flammable liquid of some sort, perhaps gasoline. This satisfies your companion until a large brown truck comes into view. After seeing the initials UPS on the side, you safely answer that many packages are on their way to be delivered. As you can see, the cargoes being carried on our highways vary greatly, and similarly, the vehicles carrying such items are just as diverse in their designs.

The same type of truck is not used to carry both household items and flammable liquids. Therefore, different designs are imperative for a particular use or mission. The same can be said for vessels engaged in ocean transport. Upon our oceans, sounds, bays, rivers, and harbors, you may observe a multitude of different types of ships, boats, watercraft, and occasionally aircraft. In this section of the chapter, we discuss the various types of merchant and commercial vessels, occasionally also referencing military or public vessels. However, the discussion of military vessels, which can also be considered emergency vehicles, is for identification and comparison purposes alone, and instead the unique challenges posed by commercial and pleasure vessels, as well as their own security options, are the main focus.

The merchant or commercial vessels tend to complete their passage as efficiently as possible when proceeding from point A to point B. The military mission is often varied and does not follow the most expedient route when sailing due to specified requirements. Research vessels may head into the ocean only to conduct experiments and then must return to the original port of call. Pleasure craft are not required to follow such plans and may return to a port only after exhausting their fuel or if passenger needs require a stop.

There are many ways to categorize merchant or commercial vessels. Size and type are the most common categories. To fully understand this, you need to be familiar with the units of measurement used in the maritime world. With truck trailers, carrying capacity and length are two common measures. When we refer to ships, the units of measurement differ and consist of gross tons, net tons, deadweight tons, displacement tons, long tons, metric tons, and short tons. Each of these units of measurement has a unique meaning. Gross ton is a volume measurement of 100 cubic feet equaling one gross ton. Net tonnage is also a volume measure indicating the area available to earn revenue. A long ton equals 2240 pounds. A metric ton equals 2204.6 pounds. A short ton equals 2000 pounds. The long and metric tons are commonly used when describing cargo ships. A short ton is used only when referring to the cargo weight. It has been replaced by the long or metric ton in most cases. Gross tonnage is used when bragging about how large a cruise or passenger ship has been built. A ship displaces water in direct relation to its total weight. A large oceangoing ship may easily displace 80,000 long tons or, stated on the metric scale, 81,280 metric tons. The cargo-carrying capacity is known as the deadweight tonnage. It also can be stated in both long tons and metric tons. The deadweight capacity is most easily remembered as the “earning capacity of a ship.” After you subtract out the actual weight of the empty ship and the fuel, lubricants, water, and the crew and provisions needed to operate the ship, the remaining lifting capacity is the deadweight. Deadweight listing is often used when comparing tankers and bulk-carrying ships. Deadweight is abbreviated dwt. Since most of the world has switched to the metric system, you can assume each dwt is 1000 kilograms or 2204.6 lbs.  

By international treaty, ships can be loaded only to a predetermined limit noted on the side of the hull by an international load line or Plimsoll Mark. A certain amount of the hull must remain out of the water. If this Plimsoll Mark (a horizontal line inside a circle on the side of the ship) is submerged, local authorities can easily recognize the ship is overloaded. If the voyage is relatively short, the master or owner may decide to carry less fuel and more cargo. But if the fuel price is very low at the departure port and the freight rates are not all that high on this voyage, it may be decided to fill all the fuel tanks and “cut” or reduce the cargo loaded. As you can see, deadweight is very important when deciding to charter a vessel.

Samuel Plimsoll of Bristol, England, as a Member of Parliament in the middle 1800s, campaigned for legislation to protect merchant seamen. Being aware ship owners often overloaded ships, he proposed the marking of the ship’s hull with a line, which would disappear below the waterline if the ship were overloaded (see Figure 1-31). To this day, most seamen know the international load line as the Plimsoll Mark.

A cruise ship’s enormous appearance is a result of large volumes of air and lightweight fixtures. Cruise ships are seldom loaded down to their Plimsoll Mark. To compare the size of these popular vessels, gross tonnage is used. The word gross is nearly always dropped. The net tonnage would actually provide a truer measure. When you subtract from the gross tonnage, the area consumed by the engine room spaces, crew’s quarters,
control rooms, fan rooms, and navigation spaces, the result is the net tonnage or “revenue-generating space.”

These maritime measurements can then be used to understand the next classification of commercial vessels. These two categories include those vessels on a scheduled, published service and those vessels in a tramp service. You could think of scheduled service similar to FedEx, which lists on its website all the cities it serves regularly. All you have to do is call and request a pickup location. The tramp service closely resembles a moving company similar to North American Van Lines. The tramp service does not necessarily have the destination port determined at the beginning of the voyage. For example, when a family quickly sells their home, they must move out, but without their next location in mind, they may be forced to store their belongings until they can relocate. With shipping, you may ask how this routine could be possible or practical. The answer is simpler than you would think. Tramp service allows for a charterer to stow its commodities onboard until it can find a buyer. A time charterer may load a ship with 50,000 tons of coal and instruct the master to sail to the Panama Canal. The charterer knows this particular ship will take 10 days to reach the Canal. So, during the next 10 days, the charterer will advertise and arrange for a buyer for the 50,000 tons of coal. The master will be advised either before or after he transits the Canal as to his next port of call. If the charterer cannot find a buyer at his desired price, he may order the ship to stop and drift or proceed to anchor and wait. This is somewhat like the family putting their furniture in storage at North American Van Lines. The vessel owner is being paid for every day the time charterer has his vessel hired, so he doesn’t mind if the ship must remain at anchor for weeks at a time. The tramp vessel may never have called at the ports it is currently sailing and after this voyage may not ever return again. Those vessels on scheduled runs tend to call at the same ports over and over again until market conditions dictate a change. The security assessments will be quite different for a scheduled liner service vessel and a tramp vessel. A terrorist likely would not or could not as easily plan an attack using a tramp vessel, since he has no certainty it will even reach the desired target country or the desired port.

The type of cargo being hauled further categorizes these oceangoing commercial vessels. Ships that carry large quantities of liquid cargo are called tankers. Those that haul their cargo in standard-sized shipping containers are termed container ships, or as a class load on/load off (LO/LO). Ships that have their cargo broken into smaller
quantities and are usually more specialized are termed *freighters*. Bulk carriers or *bulkers* carry large, homogeneous cargoes. Ships that are designed for the cargo to be driven onboard are called *roll on/roll off* (RO/RO) vessels. Other specialized vessels being discussed include oceangoing tugboats, cruise ships, passenger ships, as well as research and hydrographic survey vessels. Smaller versions of each of these types of vessels are often called *coastwise* or *coastal vessels*. Even though these smaller vessels may be seaworthy enough to cross the ocean, it is generally not economically feasible for them to do so. Frequently, small coastal tankers, container-feeder ships, and tugs with barges are seen operating up and down the coast of any country. Within harbors, bays, and sounds, ferries and water-taxi service vessels are often utilized. In this setting, tugboats and other support vessels are engaged in commerce. Though one- or two-person rowboats and sailboats have been known to cross the world's oceans, commercial interests usually support much larger crafts. During colonial times in America, the clipper sailing ships spirited across the Atlantic in weeks rather than the months it took square-rigged barques to make the same passage. These clippers did not have a great deal of cargo capacity but were able to deliver the mail, spirits, and other goods from England to the settlers in America. For the purpose of our discussion, oceangoing vessels will be more than 300 feet long and displace more than 2000 tons.

Going back to the interstate highway analogy, local delivery trucks share the highways with the long-haul truckers just as the coastal vessels sail alongside the huge liner service container ships. The smaller coastal vessels are able to pull into ports that will not or cannot handle the larger oceangoing ships. Large oceangoing ships may at times be ordered into small roadstead ports, especially those located on distant islands and other remote locations. However, this would be more of an exception than a rule for economic reasons. On American highways, special freight may be transported over great distances in a small delivery truck so that additional handling can be avoided. In the same way, smaller ships often are engaged to haul some unique or valuable cargoes across the ocean.

Transporting people and cargo over water has been accomplished for centuries. The rafts, boats, and ships have evolved over the years. With very few exceptions, there have not been tremendous technological innovations during the past 100 years. Nearly all ships and boats are propelled through the water by a submerged propeller. Most ships and boats displace one ton of water for each ton the vessel actually weighs. In the commercial world, the internal combustion diesel engine is the standard means of driving this propeller. For a period of time, the steam turbine engine was the power plant of choice. Since the steam was generated from boilers, any fuel could be used. Coal and oil were the most common. In the 1960s, nuclear power was experimented with, but it never gained commercial acceptance. Marine gas turbine engines, which are larger versions of jet airplane engines, are widely used in military vessels but have found only limited applications with merchant ships. Some engines are configured to directly drive the propeller(s), while others make use of reduction gears or may use the engine to generate electricity, which, in turn, powers a large motor that drives the propeller. In most circumstances, it is the internal combustion engine that prevails in the shipping world.

For the past 30 years, the slow speed diesel engine has been gaining wide acceptance in marine applications. The engine is mounted so that the crankshaft is directly in line with
the tail shaft and propeller hub. A direct connection is made between the crankshaft and tail shaft without the use of a reduction gear. The crankshaft is turning at the same speed as the propeller. Top speed may be 125 rpm. To go into reverse, the engine is stopped and the firing order of the pistons is changed; the propeller then turns in the opposite direction. This type of engine tends to run most efficiently at 90% of rated horsepower.

The Panama Canal itself is used when classifying oceangoing ships (see Figure 1-32). The Canal’s locks limit transit to ships less than 1000 feet long and 106 feet in beam or width. Because the canal was constructed in the early 1900s, most ship builders have restricted their ship designs in order to meet these requirements. Ships barely able to fit through the canal were known as Panamax. In the late 1960s, tankers were the first commercial vessels constructed in excess of these design restrictions and are now referred to as post-Panamax vessels. These huge tankers were first classified as very large crude carriers or VLCCs. When the world’s demand for oil increased even more, it became economical to build even larger tankers known as ultra-large crude carriers or ULCCs. These vessels, as their names imply, carry only crude oil as cargo. Smaller product tankers

FIGURE 1-32 The Panama Canal.
are used to transport refined petroleum products such as jet fuel, diesel fuel, heating oil, and gasoline. Over the years, these product tankers have so greatly grown in size that many of them can no longer transit the Panama Canal.

Another specialized type of tanker is the chemical ship. Some of these ships may carry 25 or more unique products. They are often constructed with stainless steel tanks and separate pumping and plumbing systems that prevent comingling of the cargoes. The variety of chemicals is overwhelming. It is not unusual for a ship to have liquid acids in some tanks and caustic products in others. Dry-cleaning fluids and chemicals used in the ink-printing business may also be onboard.

A final specialized type of tanker is known as the fleet oiler. It is normally a military vessel used to refuel other military vessels while underway at sea.

Containerization may go down in history as one of the most significant events in ocean shipping commerce. Historians will likely rank it up there with the advent of the clipper ships and the evolution to steam-powered ocean liners. In 1956, a trucking company entrepreneur named Malcom McLean decided to load 38 containers onboard a converted tanker and sailed them from Newark, New Jersey, to Houston, Texas. This was the humble beginning to what was to become the world’s premier container shipping line, Sea-Land Service, Inc. But McLean was not the first to attempt intermodal shipping. In the 1920s, SeaTrain Lines carried rail cars from the East Coast of the United States to Cuba and later to other destinations until the 1970s. In spite of McLean’s innovations, the major shipping lines of the day were slow to embrace or adopt containerized shipping. Most of the European and American steamship lines continued to operate exclusively conventional freighters until the late 1960s. However, from time to time, containers would be stowed on their decks.

The longshoremen also resisted handling containers. They were concerned about the loss of jobs and perks. Since containers were loaded great distances from the ports and not opened until they reached the final destination, the longshoremen were prevented from actually handling or seeing the cargo. It was widely known along the waterfront that some of the longshoremen’s unreported income was from an “occasional damaged” case of cargo that had fallen off a pallet. In ports that received Scotch whiskey, for instance, one unopened case was routinely “set aside” for the longshore boss, thus guaranteeing the remaining cargo would be safely unloaded.

In the early years of containerization, there was not any standardization. McLean’s company, Sea-Land Service, adopted 35-foot containers. Matson Lines, which sailed between the West Coast of the United States and Hawaii, decided on 24-foot long containers. During the next few years, dozens of container sizes appeared in America and Europe. Finally in 1970, at the urging of McLean, some standards were proposed and adopted by the International Standards Organization, with the 20 and 40 footers becoming the basic units. As we have seen with the 8-track audio players and the betamax videocassettes, the initial innovators are not always the standard bearers. Sea-Land was forced to change its entire fleet in the 1970s from a 35-foot standard to the internationally adopted norm. By 1985, all Sea-Land ships were capable of handling 20s and 40s. Sea-Land had either purchased or converted its vessels to accommodate the standard container sizes.
Containerization has truly revolutionized cargo shipping. Specialty containers have been constructed to handle nearly all cargoes from toxic chemicals, to airplane parts, to automobiles, to hanging garments, bagged sugar and grains, case lots, as well as a huge variety of refrigerated and frozen products (see Figures 1-33 to 1-35). Today, between 90 and 95% of all nonbulk goods are shipped in containers. The U.S. military has also adopted container shipping for a major portion of its deployment logistics.

**Figure 1-33** The interior view of a standard reefer (refrigerated) container.
FIGURE 1-34  The exterior of a reefer container, with a view of the cooling unit.

FIGURE 1-35  Containers, 20-foot and 40-foot, loaded on the deck of a ship.
containers from various nearby ports and deliver them to their destination or another port where a liner-service ship can reload them.

Earlier, we discussed the different means used when describing the size of a ship. For charterers, the net carrying capacity is an important consideration—whether it is determined by weight or volume. Another measure used in the containership industry is the 20-foot equivalent unit, or TEU, capacity. A 20-foot container is counted as 1 TEU. A 40-foot container is counted as 2 TEUs. A 45-foot container would be counted as 2.25 TEUs. So, a container ship is defined—and measured—by how many TEUs it holds.

Freighter is a general term encompassing a wide variety of oceangoing ships. Until the end of World War II, freighters usually had their own booms (ship cranes) and rigging to load and discharge cargo. Most of the cargo was in boxes or bags stacked on pallets. Loading and unloading was a very slow and tedious job. In some cases, the ship remained in port for weeks at a time only to load 6000 to 8000 tons of cargo. Today, it is possible for a container ship to load 4000 or more tons of cargo in an hour.

Currently, few of the conventional freighters remain in service. Instead, specialized ships are built for particular trades. A ship needed to sail to Third World or developing countries may be fitted with one or two cranes to load and discharge 20-foot containers and perhaps have a ramp that allows for automobiles and farm equipment to be driven off the vessel. The importing and exporting of automobiles has become a huge global business, and as a result, specialized freighters called car carriers have been built during the past 25 years. These vessels have ramps that allow automobiles to be driven directly onboard. Decks are equipped with hydraulic rams that facilitate the raising and lowering of the individual decks in order to maximize the number of vehicles carried. Thousands of automobiles are often carried onboard one of these ships. It is not unusual for hundreds of longshoremen to be employed during the cargo operations. The longshoremen drivers are then loaded into a bus and returned to the main parking area to drive more cars back to the ship. This goes on for hours at a time. These ships tend to maintain a fairly set schedule and operate often between only a few ports. For instance, one automobile manufacturer has a final assembly plant in Nagoya, Japan, and several times a week ships sail to Oakland, California. From a security standpoint, this ship could be more at risk than a bulk carrier or an oil tanker whose schedule has not been finalized until it has sailed from the loading port.

Bulk carriers, or bulkers, are designed and built to usually carry but one type of cargo at a time. The products include fertilizers, iron ore, coal, gypsum, and grain, to name just a few. Most of these ships do not have the capability to load and discharge the cargo without the assistance of shore-based cranes, conveyors, or suction devices. It takes very few individuals to load and discharge one of these ships. An independent inspector and a ship’s officer examine the cargo holds prior to and after the completion of cargo operations. Since these are commodities traded on the open market, the cargo may be bought and sold several times during a voyage. The destination port often changes throughout the voyage. From a security standpoint, this carrier would be considered as one of the last types of vessels that a terrorist would use to carry out a hostile mission.

Oceangoing tugs are used for several different types of undertakings. They may be contracted to tow a disabled vessel, a barge, or an oil rig. Weather has a major effect on their schedules, and with very few exceptions, these tugs are not on a set schedule. But
since some have larger engines than ships and a very small crew, they may pose a security
threat if their operation were taken over by a hostile faction.

**Tankers**

In this section we begin to discuss in more detail the various classes of oceangoing ships.
The first main category is oil tankers. Often when you see an advertisement on television
for an oil company, you see mostly the image of a very large tanker navigating across a
beautiful blue sea. The type of ship usually pictured is an ultra-large crude carrier, or
ULCC. These mammoth ships are generally more than 350,000 dwt. Most of them
exceed 1000 feet long, have a beam or width of more than 150 feet, and require or draw
more than 60–80 feet of water. With these dimensions, there are few ports in the world
that can receive these large ships. As a result, many of them call at offshore oil terminals,
which to the untrained eye appear to be oil rigs sticking out of the water. The pipelines
leading to offshore moorings or terminals are submerged in the sea bed and run to tank
fields that are usually miles away on the shore. It is common for the tank farms to be
positioned on hillsides or even mountaintops, which allow the force of gravity to be used
for loading oil onto the tankers. All that is required of the chief mate is to open the valve,
wait for the oil to fill the tanker, and close the valve. This simple method of liquid cargo
loading helps to prevent spills and other environmental impacts rather than serves as a
means of conservation of energy (see Figures 1-36 and 1-37).

Very large crude carriers, or VLCCs, generally are between 100,000 and 350,000
dwt in size (see Figures 1-38 and 1-39). These are very large ships by any measure, but
since they often draw only 50–60 feet of water, it is possible for them to come into some
of the world’s larger ports. The typical VLCC is about 1000 feet long but may have a
beam of 125–150 feet. Both of these types of ships have a top speed under 15 knots. In
recent years, the diesel slow-speed engine has been the choice of most shipbuilders.

![An ultra-large crude carrier, also referred to by its initials ULCC.](image)
These tankers carry just one type of cargo—crude oil. To prevent the collection of explosive gasses in the tanks, an inert gas system is required by international convention. When the oil is loaded, the inert gas is purged off at the discharge terminal. Fresh inert gas becomes a byproduct of the ship’s generators and is pumped into the tanks as the oil is pumped ashore. At all times, the excess tank capacity is filled with inert gas. This is done for two reasons: first, this is done to maintain an atmosphere in the tanks during

**FIGURE 1-37** The single mooring buoy (SMB) is an offshore transfer site where tankers load or unload their product, which is connected to the land-based location by underwater pipes.

**FIGURE 1-38** A VLCC or very large crude carrier.
loading and discharge that cannot sustain combustion; and second, the tanker is always carrying the same cargo as it is being discharged—therefore, the tanks are automatically washed with pressured crude oil that is sprayed on the insides. This procedure is referred to as **crude oil washing** and allows for nearly all the oil cargo to be discharged ashore. As an added bonus, this inert gas also prevents most crude oil tankers from being desirable targets for terrorists. Inert gas systems have been installed on crude oil tankers for about 50 years. Their development had everything to do with safety and efficient tanker operations, and little consideration was given to terrorists back in the early 1970s.

Another type of tanker that is generally much smaller than most is the **product carrier** (see Figures 1-40 and 1-41). These ships can range from just a few thousand tons to nearly 70,000–80,000 dwt. Those used in ocean service tend to be more than 50,000 tons and range from 500 to 900 feet long with a beam of less than 110 feet and a draft of less than 40 feet. They often are segregated in such a way as to be able to carry three or four different grades of oil without comingling the cargoes. The pump rooms of these product tankers have several different systems, allowing multiple cargoes to be discharged simultaneously. The smaller size of these ships enables them to sail from a refinery to the destination port desired. Segregated ballast tanks allow for clean salt-water ballast to be taken onboard, while the oil cargo is being discharged ashore. This ballast is not contaminated with the oil and can be discharged later without causing pollution. At the loading port, the clean ballast is pumped out as oil is loaded. Cruising speed may vary from 15–19 knots generally. This type of ship could be a target for terrorist activities due to its slow speed and low **freeboard**—the distance from the water line to the main deck—which may permit easier boarding from a smaller vessel.
FIGURE 1-40 Product tankers carry multiple types of bulk cargoes.

FIGURE 1-41 A product carrier discharging cargoes in port.
LNG Tankers

The next type of tanker is called liquefied natural gas (LNG) ship (see Figures 1-42 and 1-43). Natural gas is cooled as it is loaded onboard these specially constructed vessels. The gas is refrigerated the entire time it is onboard while being held in pressurized tanks. Special insulation and large segregated ballast tanks surround these tanks. The LNG ships are rather complex and ideally operate from isolated terminals away from major populated centers. They tend to range from 900 to 1100 feet long with a beam of more than 120 feet. The water depth required for these ships needs to be more than 50 feet. Since the Panama Canal most likely would not allow their transit, most builders have built the ships wider than the 106-foot Canal limitation. Although it may seem that such tankers would be a prize for terrorist organizations, the ship’s outer hull as well as the ballast tanks and void spaces surround the pressurized tanks that are normally built out of stainless steel, making it very difficult for penetration.

Chemical Tankers

Chemical tankers carry many different grades of petroleum and liquid chemical cargo (see Figures 1-44 and 1-45). It is not unusual for one of these ships to have more than 30 different piping systems and tanks, allowing for 30 or more different cargoes to be carried at any given time. In the industry, these ships are often called floating drugstores. On one particular ship, it is not unusual to carry cargo ranging from inks used in the food packaging industry to acids used in the beverage industry to chemicals used in the dry-cleaning industry. These ships tend to be much smaller than the other tankers—only 5000 to 25,000 dwt and 200–400 feet long.
FIGURE 1-43 An LNG tanker underway.

FIGURE 1-44 A chemical tanker can carry up to 30 different types of liquids.
Container Ships

Container ships vary greatly in size and speed. Most container ships are in liner service, referring to their published schedule service. Shippers are able to plan their shipments months in advance, knowing exactly when the cargo needs to be ready for transit and when it will arrive at the port of destination. Most oceangoing container ships stack the containers six to eight high below the main deck and up to six high above the main deck. The corners of these containers have socket fittings sporting special twist locks. These twist locks hold the containers to each other, making a rigid stack. Shore-based gantry cranes lift the containers on and off the ship. These automated and expensive marvels lift containers weighing 35 tons or more. The operator can snatch and drop with great speed and accuracy up to 50 containers per hour.

The newly built liner service ships tend to be faster and larger than those constructed only 10 years ago. The average liner is about 3700 TEUs, but several companies are constructing mammoth ships that are able to load 14,000 TEUs. Ships carrying fewer than 4000 containers can generally transit the Panama Canal. As mentioned previously, those just meeting the Panama Canal’s limits are known as Panamax container ships. The large container ships are referred to as post-Panamax, which means they are too large to transit the Canal.

The container business has grown so large that it is now possible for companies to maintain fleets that trade exclusively in the Atlantic or Pacific Oceans. The Suez Canal was built without the need for locks like the Panama Canal. As a result, in recent years, major container shipping companies have instituted around-the-world service. The voyage may start in Los Angeles, loop through a few Asian ports, and proceed through the Straits of Malacca before calling in Oman; then transit the Suez Canal, stop in Mediterranean ports located in Italy, Spain, and perhaps France; head up to northern Europe; and cross the Atlantic to some American ports before reversing the entire route. The entire round trip may be accomplished in just 60 days.
Container ships are some of the fastest ships with service speeds ranging from 21 to 25 knots. Schedule reliability is a major selling point for the companies in this business. Since most storms track at less than 15 knots, these ships are able to avoid or outrun many storms. Also with such speeds, the crossing from Rotterdam to New York can be accomplished in less than 5 days. Nearly every container ship built in the past 20 years has been diesel powered.

The Panamax ships are about 900 feet long with a beam of 105 feet and a deep draft of less than 40 feet. The post-Panamax ships are being built to more than 1100 feet long with a beam of about 150 feet. They require ports that have been dredged to about 45 feet. It is not cost effective to have these large container ships calling at a large variety of ports on each side of the ocean. Generally speaking, the larger the ship, the fewer ports of call it will make. Feeder or shuttle ships are smaller versions of these large container ships and are able to call at nearby ports, picking up and delivering containers. This is much like what you undoubtedly have experienced with airlines in the United States, where regional jets bring passengers to the major hubs so they can board a transcontinental flight. Also, some ships are LO/LO (loading containers on and off) and RO/RO (transport trailers). Another variation is referred to as island hoppers or self-unloading container ships. They have one or more cranes onboard which can be used to load and discharge the ship. Though much slower than the large gantry cranes found at container terminals, these island hoppers are able to work ports that just a few years ago they may have bypassed.

Before reading this chapter, you may have thought merchandise found on store shelves arrived via cargo airplanes. In a few rare cases, this happens. But keep in mind that only one or two containers can hold as much merchandise as an entire 747. Air-freight is reserved for extremely valuable or time-sensitive shipments. One of the concepts that has driven the expansion of containerized shipping is that the goods are secure and concealed from all but the shipper. From a security perspective, there is a large opportunity for criminal or terrorist entities to ship explosives, persons, or equipment via containers (see Figures 1-46 through 1-52).

Freighters

Before the advent of containerships, goods, merchandise, food, machinery parts, automobiles, and just about every consumer good was transported across the world’s oceans on board freighters. Today, few of these “conventional” freighters remain in service. Freighters now are used in specialized trades or call in ports in the Third World. Often these ships are fitted with special equipment to load or unload the cargo where shore-based facilities are lacking. Or, they are fitted onboard with special stowage compartments to protect and transport unusual types of cargo. These freighters tend to be shallow draft vessels requiring less than 25 feet of water to safely navigate. As far as size goes, they range the spectrum. Because of the unique cargo situation, you may sight a 300-foot-long freighter heading across the South Atlantic Ocean bound for the Canary Islands. The population and trade of these islands do not justify a stop by a large container ship (see Figures 1-53 through 1-55).

Bulkers

Thousand of tons of raw materials are imported, exported, and transported every day in our country and to every other nation around the world. Gypsum, a white powdery
substance, is used to make dry wallboard. Iron ore is used to make steel. Coal is used to generate electricity. Farmers everywhere need fertilizer that comes in powder form. Cement is powder used to make concrete. In small quantities, these cargoes can be hauled over the road in hopper trucks. But the majority of this cargo moves from ships to railcars, by barges, or sometimes directly into pipelines or used at the port of discharge. Unless you
FIGURE 1-48 Many container ships carry the containers of multiple shipping lines.

FIGURE 1-49 This specially designed and built container ship has "open-top" cargo bays and high-speed ship cranes, eliminating the requirement of shoreside cranes.
FIGURE 1-50 A view inside the hatch of the “open-top” cargo bay reveals the guide rails and easy access to the reefer motor of the container.

FIGURE 1-51 An RO-RO/LO-LO combo vessel.
FIGURE 1-52 A view of the interior deck of an RO-RO ship and the tying down of trailers and containers mounted on chassis.

FIGURE 1-53 View of several conventional “freighters,” which travel the coasts of the Americas and through the Caribbean.
live close to a rail line or frequent the banks of a major river, these bulk cargoes are hidden from sight. The ports tend to be noisy, dusty operations in the industrial part of town.

Bulk carriers, or bulkers, are built similar to tank ships. There is normally no requirement for high-speed transits, so the service speed is only around 15 knots. The ships range in size from 50,000 dwt to 200,000 dwt. Some need a 60-foot deep channel
to safely navigate. Like tankers, bulk carriers have a segregated ballast tank that is flooded as the cargo is being discharged. At the loading port, these same ballast tanks will be pumped out as cargo is loaded. It is not unusual for a bulk carrier to be 1000 feet long. Some can discharge cargo with fitted equipment. But many require shore-based conveyors, bucket scoops, and suction systems to load and discharge the cargo.

These ships are designed to carry a great deal of cargo. Since it takes days or even weeks to load and unload, tight schedules are not maintained. Weather and adverse sea conditions also affect the schedule. Since commodities often change ownership during an ocean crossing, a change in destination port is probable. Due to the nature of this type of shipping, such vessels are an unlikely target for terrorist actions. The cargo itself is rarely dangerous, and a terrorist wouldn't know when or where the ship would call on next (see Figures 1-56 through 1-59).

Oceangoing Tugboats

Tugs are used in harbors to assist with the mooring and unmooring of ships and barges. Oceangoing tugs are generally too large and heavy to be used with ship-assist operations. There are two main purposes for really large tugs: salvage and towing. Maritime disasters occur every day. The salvage tug is dispatched to make an attempt to save the ship and cargo from even greater loss. Charters are negotiated with tug operators to tow just about anything that floats from one port to another, although tugs have also towed submerged objects great distances. The more common long hauls are oil rigs, ships bound for a shipyard for repair or modification, ships bound for the “breaking yard” at the end of a useful life, floating dry docks being delivered to a new “home,” and cargo barges. Salvage tugs head off on a voyage never knowing if the owners will earn any money. Like some attorneys, salvage tugs are generally compensated only after a successful outcome. The rule is “No Cure—No Pay.” If the salvage is a success, the tug’s owners will share in part of
the value of the ship as well as part of the value of the cargo onboard. This is much different than ocean towing, where the charter party or contract will provide financial payments to the tug's owners if certain conditions are successfully met.

From a terrorist point of few, tugboats and their relatively small crew may be an easy target. But determining a schedule may make them less reliable as a suitable
platform to stage an attack. Tugs are seldom as fast as ships but may be far more powerful. It is not unusual for some tugs to have 15,000–20,000 hp engines. A ship three times the length, displacement, and/or gross tonnage may have a less powerful engine. The typical oceangoing tugboat is 125–250 feet long; has a raised bow or forecastle, allowing it to head into heavy seas; draws 15–20 feet of water; and may have as few as eight in the entire crew. Whereas most ships have just one propeller, nearly all tugboats are fitted with two or sometimes three. These propellers are driven by medium- or high-speed diesel engines. From a security standpoint, the sheer power to tonnage ratio of these vessels could be a concern (see Figures 1-60 through 1-62).

Cruise and Passenger Ships

Cruise ships and passenger ships, while sounding similar, are actually quite different from one another. Cruise ships have become very popular in the vacation business. Cruise ships can be defined as destination vacation spots. Though they make ports of call, most of the passengers have selected this mode of transport for the shipboard experience. It is common for these ships to have nearly as many crewmembers onboard as passengers, and their jobs are to serve and comfort their guests during the voyage. Compare this to a passenger ship, which can be defined as a means to move people from point A to point B. Though many of these ships are comfortable, the crew-to-passenger ratio is usually low, and the guests remain for only a short period of time. Passenger ships are common in Asian, European, and African waters and at one time were the main means for crossing the Atlantic, although, with the advent of jet airline travel, true passenger ships disappeared from the Atlantic Ocean in the 1970s. On a cruise ship, the crew will have a
chance to really become familiar with their assigned passengers. On a passenger ship, this isn’t always the case. On a passenger ship, the attire may vary greatly among the passengers. Some may be traveling businessmen. Others may be very common folk traveling by ship since they cannot afford to fly. Still others may be college-age people traveling to a destination only served by ship (see Figures 1-63 through 1-66).
FIGURE 1-62 Ocean tugs are equipped with engines that each generate 15,000–20,000 hp.

FIGURE 1-63 A modern, very large cruise ship in port.
FIGURE 1-64 A cruise ship underway.

FIGURE 1-65 This passenger ship also carries RO/RO trailers.
The shipping industry is an integral and vital part of our society and culture. Every facet of life is greatly affected by the cargo operations that occur within shipping terminals on a daily basis. Security, commerce, and defense are directly linked with shipping terminals and ships around the world. A nation that has strong commercial shipping capabilities is capable of creating more revenue than a land-locked country. Equally important, ports provide a platform for a strong sea-based military navy. A naval vessel leaving its home port and taking up station off a foreign coast is called power projection. That naval vessel then becomes a platform of operation and an extension of the country it represents. As technology improves our way of life and the way we do business, terminal operations will become more and more specialized. The race to improve efficiency of operations and the speed with which cargo is handled will create new and improved ways to get cargo from one point to another. The need for new terminals and vessels is a direct reflection of the laws of supply and demand. As demand for certain items changes, so do the means by which they are delivered. History has shown that maritime commerce is key to the success of a nation’s economy.

Summary

The shipping industry is an integral and vital part of our society and culture. Every facet of life is greatly affected by the cargo operations that occur within shipping terminals on a daily basis. Security, commerce, and defense are directly linked with shipping terminals and ships around the world. A nation that has strong commercial shipping capabilities is capable of creating more revenue than a land-locked country. Equally important, ports provide a platform for a strong sea-based military navy. A naval vessel leaving its home port and taking up station off a foreign coast is called power projection. That naval vessel then becomes a platform of operation and an extension of the country it represents. As technology improves our way of life and the way we do business, terminal operations will become more and more specialized. The race to improve efficiency of operations and the speed with which cargo is handled will create new and improved ways to get cargo from one point to another. The need for new terminals and vessels is a direct reflection of the laws of supply and demand. As demand for certain items changes, so do the means by which they are delivered. History has shown that maritime commerce is key to the success of a nation’s economy.