Lecture 6 : Ship General Arrangement (GA)

A marine vehicle or structure has limited enclosed and exposed space that has to house all equipment required for the functioning of the product at sea and also provide space for accommodating various items including crew and passengers on board. Since the product is at sea, the space distribution becomes an important part of the design and is formally known as general arrangement (GA), and the drawings depicting this arrangement are called GA plans or GA drawings. Layout design includes defining spaces for various requirements, establishing boundaries for such spaces and also partitioning such spaces, locating equipment and facilities in each space and providing access to areas within each space and egress during emergencies.

The design of a ship's general arrangement is a continuous and iterative process that starts with concept design and is changing through different design phases. This is because GA is affected by the positioning of engineering systems and structural design arrangements. The GA of any ship usually consists of the following drawings:

- Profile View (generally looking from starboard side)
- Midship sections (looking from aft, and looking from forward)
- Main deck plan (also shows the accommodation layout)
- Navigation deck plan.
- Forecastle deck plan
- Tank and tank top plan

Since almost all ships have unique design features there is no specific procedure backed up by Classification Rules and/or Regulations. In fact, the process of developing the GA drawings varies amongst design firms, depending on their procedures and practices. However the underlying principle always remains the same: ‘‘*GA development is an iterative process, and the final GA is produced, after repeated approvals by the classification society and the owners party*’’.It is not within the purpose of this course to make define a conclusive GA for ship design. However, some of the key steps for successful GA development could be summarized as follows:

1. Decide ship type and define the ship's principal particulars followed by a basic ship profile view drawing.
2. Sketch a basic mid ship section and estimate the double bottom height as specified in the rules of the authorized Class Society Rules.
3. Specify the minimum bow height in accordance to IMO ILLC regulations. The ship's forecastle deck area should account for spacing for anchoring and mooring equipment.
4. Decide on frame type (longitudinal or transverse) and spacing according to Classification Society Rules. The frame spacing should be marked on the GA profile drawing and should be followed as the main scale of this drawing[6].
5. Position and size enclosed spaces such as holds, tanks and machinery spaces. As part of this process, the ship should be divided into a certain number of watertight compartments as recommended by the authorized Classification Society subdivision Rules. These Rules can help specify the total number of watertight transverse bulkheads that are necessary to maintain

- [6] In general, ocean going ships that are longer than 120 m are longitudinally strengthened. In practice frame spacing ranges between 500mm to 900mm, while web frame spacing could be on every 3rd or 5th frame depending on a ship's length. Frame spacing is usually constant along the ship's parallel body, but it might vary in the extremities of the hull (bow or stern regions).

watertight integrity of the ship. Once the number of bulkheads have been decided, the length and number of holds should be planned accordingly.

6. Accommodation and working areas should be designed to ensure smooth flow of working duties onboard and during emergency or evacuation. Aesthetics for the case of cruise ships may be critical. In case of bulk carriers, the slope of the tank top sloping bulkhead is to be taken care of. The tank slope must be more than the angle of repose of the cargo, which is generally around 30 degrees. The slope of the bottom tank is generally maintained at 45 degrees.
7. Include ballast, fresh water, void and oth er consumables tanks (e.g. fuel tanks)in a way that they well distributed all over the length and breadth of the ship to help her attain stability and trim requirements while empty or loaded.
8. Include cargo handling equipment for efficient cargo loading and unloading.
9. Check for structural continuity in overall hull locations but also in tanks and machinery arrangements. Design choices should enable ease of construction.

1. Additional considerations

Location of machinery spaces. Historically, the engine room of most general cargo ships and passenger ships has been situated at or near amidships. This has been a convenient choice from an engineering perspective as the space required for engines used on such ships can be provided most conveniently in way of amidships. On the other hand, tankers and coasters tend to have their machinery aft. Nowadays, cargo ships have either their machinery aft with all cargo holds forward or may have one small hold abaft the engine room. The former is ideal for slow speed vessels while the latter is better for relatively higher speed vessels with finer form such as container ships and refrigerated cargo ships.

Location of Deckhouse. For cargo ships, the number of decks and location of the deckhouse are critical. This decision should be based on the provision of adequate visibility from the wheelhouse over the forecastle and or over the maximum obstruction caused by containers or other deck cargo the ship is intended to carry. Traditionally the deckhouse is situated aft to ensure sufficient monitoring of the deck area and the ship's course. However, some ships that require a large open deck area such as offshore supply vessels have their deckhouse forward.

Location of Cabins, corridors, and lifeboats on passenger ships. There are mainly two philosophies when deciding the positioning of passenger cabin locations. The first one considers cabins in a specific block where it is easy to meet the criteria for vibration and noise. However, passengers in the same area might cause congestion in passages and corridors. Another philosophy is the smooth distribution of cabins along the superstructure. In this way congestion is no longer an issue. However, it may be difficult to meet noise and vibration criteria in all cabins. Corridor paths mainly depend on the fineness of the ship. Full ships have straight corridors, very similar size cabins located in a straight fashion similarly to a land-based hotel. An exception to this is the bow area. Fine form ships feature some curvature in their corridors and are likely to have cabins with different shapes and sizes. Traditionally, lifeboats and their associated davits are positioned in the upper deck to avoid disturbance in passenger and crew flow. Recently, the trend has been to place lifeboats on the lower deck near to waterline in a large cutout of the superstructure. From a safety perspective, it is easier to launch lifeboats from a lower deck. Also, having lifeboats on a lower deck gives the designer additional flexibility and space for laying out ship facilities such as a swimming pool and various outdoor areas on the sundeck. (Cudahy, 2001).

Galley location. Although the location of the galley is not of great importance in cargo ships, it has a significant influence on the customer experience on passenger ships. This is because on a passenger ship, the position of a galley is attached directly with positions of food entertainment areas and consequently their access is controlled by stairs and lifts. The decision on the position of other public spaces such as shops, offices and public rooms using the same means is also critical. Thus, in order to ensure smooth supply of dry and refrigerated stores, their position should be near to the galley as much as that possible. A designer should keep these matters in mind when deciding on the position of the galley.

Bulkheads are partition walls which subdivide the ship interior into watertight compartments. They prevent or at least reduce the extent of seawater flooding in case of damage. They also contribute to ship strength. Types of bulkheads vary upon their usages and locations. For example, aft peak bulkhead is a bulkhead which forms the forward boundary of the aft peak tank; collision bulkhead is the foremost main transverse watertight bulkhead. It extends from the bottom of the hold to the freeboard deck or to the forecastle deck and is designed to keep water away from the forward hold in case of bow collision damage; aft peak bulkhead is the aft most main transverse watertight bulkhead. Similarly to the collision bulkhead, it extends from the bottom to the freeboard deck or the poop deck. The engine room bulkhead is a transverse bulkhead directly after or aft the engine room. More specialist types of bulkhead are : (a) portable bulkheads used to divide a long hold into separated sections; (b) corrugated bulkheads formed of corrugated plating used to eliminate the need for welded stiffeners;(c) fire bulkhead used to provide insulation for partitions in accommodation spaces. The Class Society Rules include formulae that can help you specify the minimum/maximum distances of the forepeak bulkhead aft of the forward perpendicular. It is up to the designer, to provide the forepeak collision bulkheads within the above limits, depending on the dimensions of the forepeak ballast tank, anchor equipment, and chain locker dimensions. The position of the engine room's forward bulkhead is fixed according the position and length of the holds. Once this is done, about four frame spaces need to be left out before placing the main engine aft of the engine room forward bulkhead. This helps leave space for maintenance and crew operations. The length of the engine room is decided based on the length of the main engine and the length of the intermediate shaft which is usually coupled with the propeller shaft via a flanged connection. The coupling flange between the intermediate and the propeller shafts should be housed within the engine room. The engine room aft bulkhead is positioned aft the coupling flange. In cases of oil tankers and container ships, decisions on longitudinal bulkheads are to be taken, with respect to prevention of free surface effect, ensure proper cargo distribution and handling characteristics.

Bottom and side structures. In the past, ships were constructed with single bottoms. Fuel, oil, and water tanks were separately constructed. Nowadays, only small vessels have a single bottom construction, and all sea-going and ocean-going ships have a double bottom construction which provides safety against grounding as well as spaces for liquid tanks. In 1992 the IMO MARPOL instrument was amended to make it mandatory for tankers of 5,000 dwt and more to be fitted with double hulls; double-side and double bottom. The same is required in some cases for ships operating

Cargo handling equipment is a matter of concern associated with the type of cargo being transported. For example, pumping equipment is needed for tankers to transfer liquid cargo in and out of tanks while cranes are provided onboard bulk carriers or container ships to transport cargo in and out of holds. All these items should be accounted for included on the GA.

2. GA Examples

The 50,200 GT Crystal Symphony **passenger ship** GA is shown in Figure 15. The ship operates in the premium segment of RCCL with different itineraries depending on the season of the year. The length of cruise product she offers are between 7 and 19 days. The ship has 480 passenger cabins and 960 lower beds (double occupancy). The maximum passenger capacity including sofa beds is 985 persons. The number of crew is 545 persons. The ship has 9 decks for passenger use. The passenger functions start on Deck 1, where the side doors to the quay are situated. The rest of Deck 1 and the deck below are allocated to the crew and service functions. The diesel-electric machinery, pump rooms and tanks are located on the double bottom. Many public spaces are on Deck 3 with a dining room and an entrance hall below on Deck 2. The show lounge is forward and the secondary lounge is amidships above the dining room. Aft Deck 3 there are several smaller public spaces, such as a special dining room with Japanese cuisine. On Deck 4 an outdoor promenade all around the ship is provided. This is also the embarkation deck for the lifeboats. Most of the passenger cabins are in the narrow super-structure. Between the cabins are the air-conditioning rooms. All cabins are outside cabins. The balcony cabin ratio is 58%.

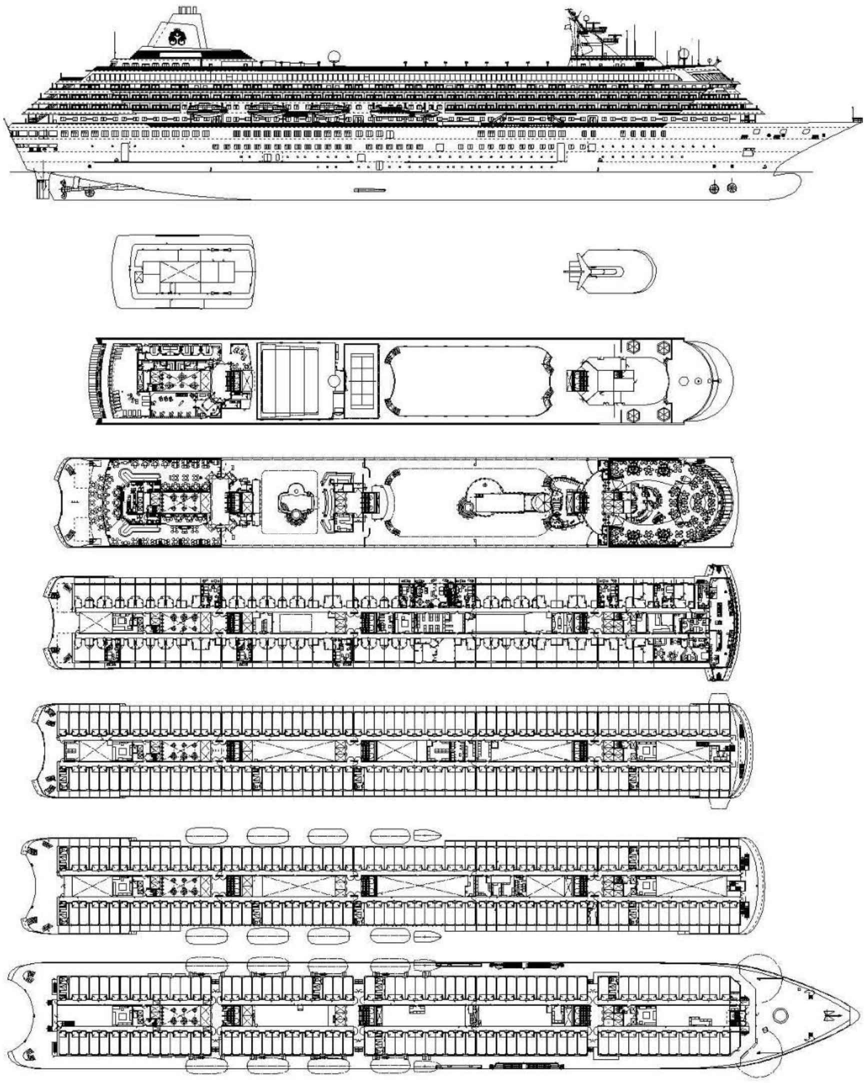


Figure 15.1 Crystal Symphony General Arrangement. Image Credits: (Thomas, 2003)

Examples of GA for **cargo ships** are given in Figures 6.2 – 6.3. For example, Figure 6.2 shows the GA of a panamax type **container ship**. Such ship is very large in size. Having cargo-handling equipment onboard such ship may be inefficient. The containers themselves are simply reusable boxes made of steel or aluminum. The cargo-carrying section of the ship is divided into several holds with the containers racked in special frameworks and stacked one upon the other within the hold space. Containers may also be stacked on hatch covers and secured by special lashings. Cargo holds are separated by a deep web-framed structure to provide the ship with transverse strength. The structure outboard of the container holds is a box-like arrangement of wing tanks providing longitudinal and torsional strength. The wing tanks may be used for water ballast and can be used to counter the heeling of the ship when discharging containers. A double bottom is fitted which adds to the longitudinal strength and provides additional ballast space. The accommodation location ensures compliance with IMO visibility criteria. Machinery spaces are located aft leaving the maximum length of full-bodied ship for container stowage. Automatic birthing equipment is located both aft and forth the ship.

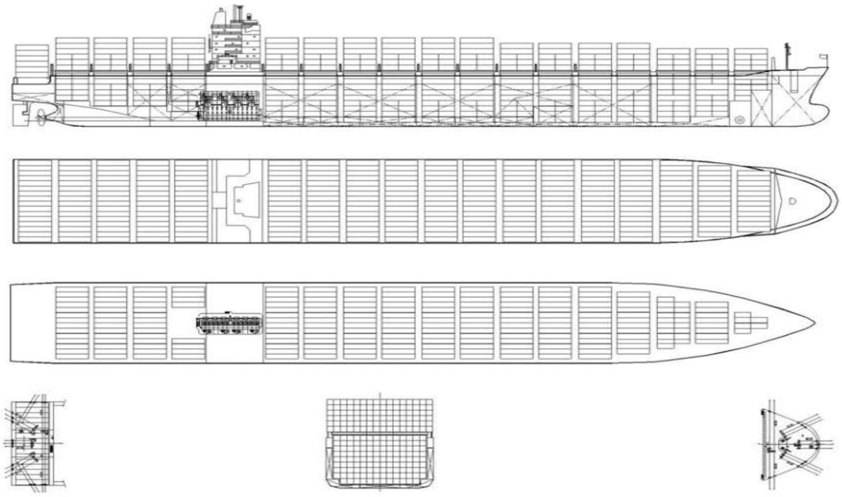


Figure 6.2 Post-panamax container ship. Image Credits: (Thomas, 2003)

The GA of a **bulk carrier** requires a compromise among many conflicting requirements. For dry cargo bulk carriers, volume of cargo space and machinery are basic requirements. In addition, the required volume of fuel, oil, ballast, and freshwater tanks should be considered. Their configuration should satisfy acceptable draft and trim requirements for maximum and minimum cruise range at preliminary design. Cargo space of a dry bulk carrier consists of regular length holds having hatches for handling of cargoes by grab or by blower for grain cargoes. Figure 6.3 shows an example of a 25,000 DWT bulk carrier. This is common dry bulk carrier that has a clear main deck with the machinery room and superstructure. Hatches with unrestricted access to holds are designed on the main deck with steel hatch covers to facilitate easy loading and discharge of cargo. Three deck mounted cranes that have 360 degree access and can load and discharge cargo from the holds immediately forward and aft are available. The fore peak tank in the bulbous bow is used to control and maintain the trim of the vessel and to ensure complete propeller immersion. Ducted keels provide enough space for the passage of pipelines. The ship is longitudinally stiffened, that is the stiffeners on the plates run in a longitudinal direction. This is because the loads may cause longitudinal bending moments. Hence the failure of the hull girder due to longitudinal bending becomes more probable.

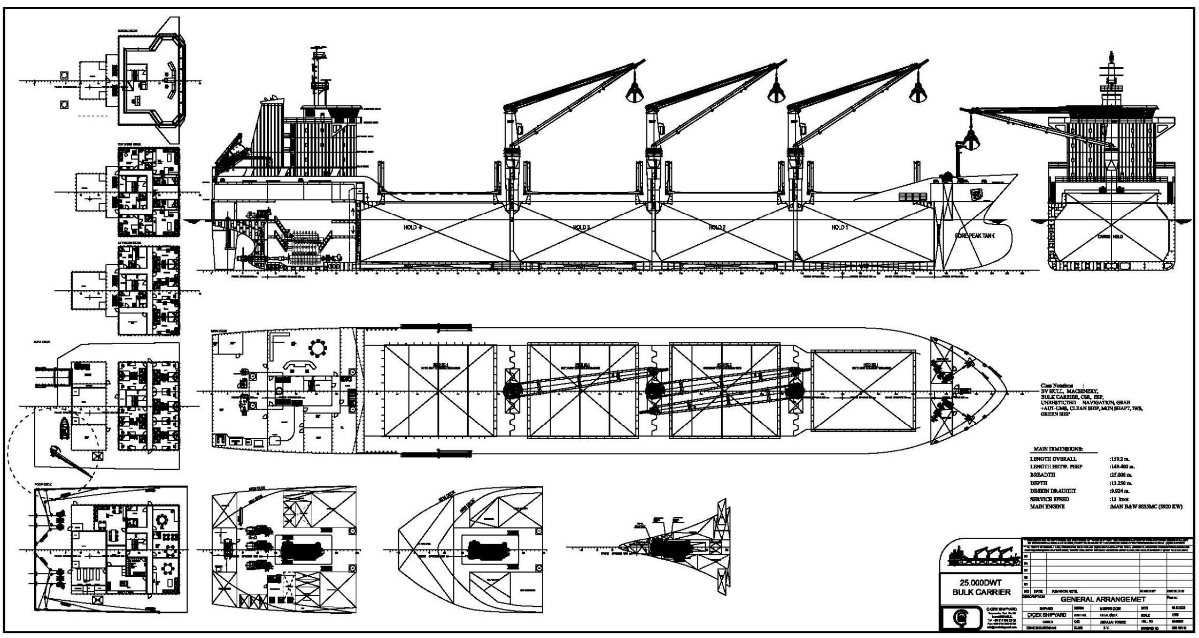
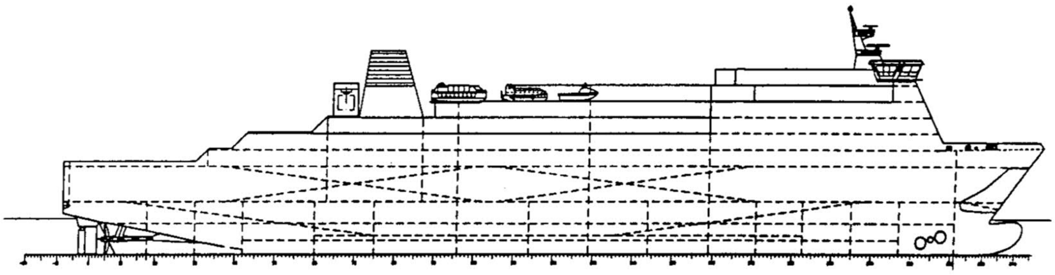


Figure 6.3 Bulk Carrier General Arrangement. Image Credits (Cicek Shipyard)

3. Questions

1. Describe the most important factors affecting the general arrangement of a passenger ship (or your project ship).
2. Describe the various possibilities to locate the cargo space on RoPax vessels and what the benefits and drawbacks for each possibility.
3. Describe the various possibilities to locate the cargo space on container vessels with respect to superstructure and what are the benefits and drawbacks for each possibility.
4. Describe the main issues affecting the positioning of the machinery space in ship general arrangement.
5. Identify and justify 3 strengths and 3 weaknesses in the general arrangement of the ship below. In case you need to implement LNG as the fuel and/or battery technology for auxiliary propulsion, in which place would you position the fuels tanks and betteries ? Discuss the factors affecting these choices. Define at least four general design objectives and criteria for the general arrangement of a ship.



6. You are designing a medium-sized container vessel. Describe the various possibilities to locate the deckhouse. Mention at least four criteria or measures of performance based on which you can compare the merits of the various options.
7. Define at least four general design objectives and criteria for the general arrangement of a ship. 2p