SHIP DESIGN PROCESS

Scope of Ship Design

The procedures and ideas described for design can be applied immediately to the ship system. The four steps mentioned earlier forms the basis of ship design process:

Objectives
Concepts
Evaluation
Decision

At the highest level:

Objectives: Need for transportation
Concepts: Sea, air or land
Evaluation: Consideration of Economic, Technical and Social factors
Decision: Economics and time scale. However, increasingly political and national considerations play a strong role in the final choice.

At the lower level:

Assuming sea transportation is chosen:

Objectives: Transportation from A to B
Concepts: Ship type
Evaluation: Broad assessment of types, facilities, operating pattern. Variation of sizes, speed and number of vehicles.
Decision: Life cycle costs Assessment of competition.

At a more lower level:

Objectives: Ship type chosen for route. (Owners requirements)
Concepts: Geometries, powering types, dimension ranges

Evaluation: Obtain satisfactory main dimensions and geometry etc. and determine broad economics.

Decision: Best set of designs.

From the discussion it can be seen that ship design process means:

i) Considerations are not just based on technical but also take into account economics and operational factors.

ii) Ship design process is a spiral process.

**Ship Types**

There are an extremely wide variety of tasks to be performed by floating vehicles. The benefit of specialisation in a particular task or type of trade leads to a number of ship classes and types. Ship type has strong influence on design and the design process and therefore also affect their internal arrangements. To illustrate this, the diagrams attached show a broad breakdown of ships into functions and types. Also some examples of their internal arrangements are shown.

**INTRODUCTION TO SHIP**

Since World War II, size and shape of ship have gone through tremendous advancement. New technologies have push to a more complex and fast ship. Among those are using computer in ship design, automation in ship production, a more systematic fabrication and up righting process, and larger and greater transportation system.

With the introduction of these new technologies, various kind of ship has been built to cope up with the advancement of the world economy. A ship was designed to move on top, on, or below water. Based on this principal, ships can be categories into three groups, as seen in Fig. 1.1.

---

**Fig. 1.1 Vessels categories**
1.1 Ship Types

- bulk carrier
- container ships
- fishing vessels
- gas carriers
- general cargo
- high speed & light craft
- naval ships
- offshore vessels
- passenger ships
- ro-ro
- specialised ships
- tanker for chemicals
- tanker for oil
- Yacht

1.2 Various Merchant Ships

a) Container ships
b) Bulk carriers
c) Tankers
d) Ferries and Cruise ships
e) Specialist ships

a) Container ships

Carry most of the world's manufactured goods and products, usually through scheduled liner services
b) Bulk carriers
The work horses of the fleet, these transport raw materials such as iron ore and coal. Identifiable by the hatches raised above deck level which cover the large cargo holds.
c) Tankers
Transport crude oil, chemicals and petroleum products. Tankers can appear similar to bulk carriers, but the deck is flush and covered by oil pipelines and vents.
d) **Ferries and Cruise ships**

Ferries usually perform short journeys for a mix of passengers, cars and commercial vehicles. Most of these ships are Ro-Ro (roll on - roll off) ferries, where vehicles can drive straight on and off, making it a speedy and easily accessible way to travel. Demand for cruise ships expanded rapidly during the 1980s, leading to a new generation of large and luxurious 'floating hotels'.

![Ferry](image1.png)

![Cruise Ship](image2.png)
e) Specialized ships
Such as anchor handling and supply vessels for the offshore oil industry, salvage tugs, ice breakers and research vessels.
1.3 Small Craft

a) High speed & light craft

Patrol boat

b) Yachts
Effect of cargoes on ship types

Crude oil forms the largest single commodity transported by ships. It has a lower value per tonne than many other cargoes. This allows is to be transported in very large dedicated tankers with a relatively low speed. The tankers are designed for carriage of the oil in bulk to take advantage of the structural efficiency which can be obtained. However, due to the risk of pollution, legislation has enforced the carriage of ballast water in separate tanks thus increasing the first cost of tankers and reducing their efficiency.

Iron ore and grain are also low value cargoes and hence are normally carried in large bulk carriers. The carriers may be specialised towards one particular type of bulk commodity in which case they will be like tankers spending half their life in ballast or they may be designed to carry a variety of bulk commodities. A particular problem with ore is its very high density. This can create strength problems in certain loading conditions and will mean that the volume of the ship is never fully utilised in the fully loaded condition. Bulk carries generally have a unique transverse geometry; a single deck ship with upper and lower wing tanks. The wing tanks provide space for water ballast, the lower tanks aid discharging while the upper tanks reduce "free surface" of the bulk goods. To give added longitudinal strength, high double bottoms and large wing tanks are provided.

Chemicals, which are highly corrosive, present a special problem. As a result chemical carriers are designed to carry small "packages" of different liquids in bulk, each with completely separate pumping and cleaning arrangements.

General cargo covers a very large variety of different products carried throughout the world. To obtain flexibility, this requires a number of different cargo areas with access to many of them for part loading and discharge. Also because specialised ports are not always available, the ships are able too handle all their own cargo through derricks or deck cranes. Where perishable foodstuffs are carried, refrigerated spaces are also provided. The different variety of cargoes carried leads to different designs:

- Cargo liner
- Container ship
- Refrigerated cargo ship
- Roll-on/roll-off ship
- Barge carrier

Each attempts to tackle the problem of efficient cargo carriage/handling in a different way.

Another important class of marine vehicle is those designed for hydrocarbon exploration. The major requirements of those vessels are to be able to carry the specialised equipment for drilling while at the same time have the characteristics of:

- Maintain station in a given location
- Have little motion response
- Self sufficient from external services
- Reasonably mobile

Two most important floating concepts are the drill ships and the semi-submersible.
### SHIP CLASSIFICATION

<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategory</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSPORT</td>
<td>General Cargo Unitised</td>
<td>Container</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ro-ro Barge</td>
</tr>
<tr>
<td></td>
<td>General Cargo Breakbulk</td>
<td>Tanker</td>
</tr>
<tr>
<td></td>
<td>Bulk</td>
<td>Dry Bulk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Timber</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ore Products</td>
</tr>
<tr>
<td></td>
<td>Passenger</td>
<td>Liner/Cruise Ferry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ro-ro</td>
</tr>
<tr>
<td>MARINE RESOURCES</td>
<td>Fish</td>
<td>Trawler Factory</td>
</tr>
<tr>
<td></td>
<td>Hydrocarbons</td>
<td>Semi-submersible Jack-up</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drill Ship Platforms</td>
</tr>
<tr>
<td></td>
<td>Science</td>
<td>Survey Research</td>
</tr>
<tr>
<td>SUPPORT/SERVICE</td>
<td>Hydrocarbons</td>
<td>Supply</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Derrick Barge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pipelay Barge</td>
</tr>
<tr>
<td></td>
<td>Ports</td>
<td>Diving Support</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tug</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dredgers</td>
</tr>
</tbody>
</table>

Some Typical Ship Geometries
No 4 hold suitable for filling with water ballast.
General Cargo

Drill Ship
Semi-submersible
**Design Modeling**

To evaluate design, 3 types of models are generally required:

i) Operational model  
ii) Technical model  
iii) Economic model  

An example of parameters used in the models is:

**Operational**  
- Distance between ports  
- Turn round time at each port  

**Technical**  
- Ship Deadweight  
- Ship Speed  
- Load Factor  

**Economic**  
- Bare boat charter factor  
- Ship operating cost factor  
- Port Usage cost factor  

- The models described must be prescribed **numerically** to represent the characteristics of the system and to observe the interactions.  
- A vital part of successful modeling is to make **simplifications** so that only the most significant parameters are included.  
- This result is a good understanding of the characteristics of the system and indicate **directions** to be taken in looking for improvements.

**Design Relationships**

To present a numerical model, relationships between the parameters or variables have to be established.

In practice relationships may be expressed in graphical, numerical or even a descriptive form. The use of computers in ship design has shown its advantage in processing information within a short time. Thus, the need for transforming relationships into numerical form.

Relationships used in ship design can be divided into 4 main types:

i) **Physical**  
- The relationships follow physical laws such as physics.  

ii) **Empirical**  
- Independent parameters are related to the dependent parameters by a logical physical relationship.
iii) Statistical - The relationship between the parameters are developed purely from statistical information and will therefore reflect existing (or past) practise.


Care must be taken in the use of (ii) and (iii) relationships:

i) The range of applicability and dependence of the parameters.

ii) Equation may sometimes cannot be inverted or use in the opposite directions.

A Simple Bulk Transportation Model

a) Operational - Dist. bet. ports - m
    - Turn-round time at each port - Tp

b) Technical - Ship Deadweight - Dwt
    - Ship Speed - V
    - Load factor - L.F.

c) Economic - Bare boat charter factor - A
    - Ship Operating cost factor - B
    - Port usage cost factor - C

Assuming the relationship:

Bareboat charter rate/day (Cs) = A \cdot Dwt^{2/3} \cdot V^2
Ship operating cost/day (Co) = B \cdot Dwt^{2/3} \cdot V^3
Port usage cost/day (Cp) = C \cdot Dwt^{2/3} \cdot V^2

Decision Function is based on the lowest value of Cost/Tonne-m i.e. \( C_t/AQU-m \)

Where:

\[ C_t = \text{Total Annual Cost} \]
\[ = Cp \times \text{No. of days in port} + Co \times \text{No. of days at sea} + Cs \times 365 \]
\[ m = \text{Distance traveled by goods} \]
$V = \text{Ship’s Speed}$

$AQU = \text{Quantity of goods/year}$

$= \text{Dwt x L.F. x No. of round trips / year}$

$= \text{Dwt x L.F. x } \{ \frac{365 \times 24}{2 \times \frac{m}{V} + 2 \times Tp} \}$

**TUTORIAL 2**

Develop a computer program to evaluate the cost (Cost/Tonne-m) of transporting bulk cargo between Port Kelang and Port Johor.

Program should be written either in FORTRAN or MATLAB. Marks will be given for realistic values. Sample results should be given with Flow chart and Source Code (hardcopy and soft copy) of the program.