Lecture 10 : Economic Assessment

1. Cost Categories

Engineering economic studies almost always involve an estimate of invested costs. For cost estimation and analysis, several costs are categorized into two main groups; the shipbuilding cost and the running or operating cost. The prime cost of a project is usually the single largest, hence most important, factor. Operating costs are to be further divided into voyage costs and daily costs. Although this information is out of the naval architects' responsibility, it is necessary to know how different costs are categorized and estimated.

Shipbuilding Costs. In preliminary design, naval architects usually have to choose between several alternatives based on ship performance and economics. This means that economics estimation models should be as simple as possible so that comparing different alternatives will be easy. Most of the cost estimating techniques fall into two major considerations; the **functional capability related costs** (e.g. costs related to deadweight and speed), or the **costs associated to technical characteristics** (e.g. major dimensions and power). The second family of techniques is usually more aligned to design.

Shipbuilding costs associated with functional capabilities can be estimated as follows:

$$P = C(DWT)^{B} \qquad (10.1)$$

where C is a coefficient and B is an exponent typically about 0.7-0.8. Both coefficients are derived from databases including information on similar vessels.

When technical characteristics are used as costing basis then lightship weight W_E is considered and the following equation is used :

$$P = C(W_E)^{0.87} \qquad (10.2)$$

Overhead costs comprise all the costs necessary for running the shipyard but cannot be associated with any ship under construction. There are two basic kinds of overhead costs, those that are not related to how busy the yard is which are fixed overhead costs and those that vary with the level of activity of the yard and are termed variable overhead costs. Examples include salaries for administration staff and managers, cost estimators, and watchmen. Bills for electricity, real estate taxes, income taxes, and depreciation also are included in these costing items.

Material costs are sometimes generalized and more accurately called outside goods and service costs as many shipyards use subcontractors. In addition, overhead costs in many estimation models are considered to be a percentage of the labor costs.

Nowadays, the worldwide shipbuilding competition has led shipyards to try reducing ship - building costs for profitability and increase the probability of acquiring more contracts. There are various means of reducing shipbuilding costs such as reducing labor costs or man-hours. However, there is an indirect yet efficient solution in reducing shipbuilding costs. New technologies and methods of production such as automated production of stiffened panels and laser cutting based on CAD designs may help reduce production costs. Even though the volume of ships being built simultaneously might be relatively low, in most cases, the volume of similar intermediate products is considerable. For example, if a yard is building a few ships all at once in a given time, they might have a steady weekly demand for structural stiffeners and stiffened panels.

For predicting **operating costs**, a basic step is to analyze the time involved in a typical round-trip voyage; the operational profile of such a ship. An imaginary representation of a typical voyage would include the estimated times. **Voyage costs** are those that are affected by the voyage in which the ship is engaged (e.g. fuel and lubricating oil). Fuel costs per trip are usually multiplied with the estimated number of trips per year and the result is the annual fuel costs. The same procedure is followed when estimating the annual costs of the lubricating oil. A separate profile should be used to estimate the amount of fuel required for generators as the variation of the main engines' power requirement differ from those of the electric generators. Other costs such as port or canal fees, tug service, pilotage fees vary widely and are difficult to generalize. For instance, pier charge may be based on the ship's length, and pilotage fees may depend on the draft. However, perhaps a one parameter can be used to relate all these costs which is usually the net gross tonnage or the cubic number. Another important category is the cargo handling costs, which depends on whether or not it is included in the shipping contract. If it were be included, then it would be considered as voyage costs. In addition to cargo handling costs and associated with it, there are also brokerage fees, cargo damage claims and hold cleaning costs. **Daily costs** are those that continue year around regardless of the voyage. Among the daily costs, are the crew wages and their benefits. In the past, crew numbers were related to the ship's size and power. Nowadays, they are independent of ship's size and power, and the trend has been to reduce the crew number onboard, and alternatively, they depend on the shipowner's vision on his business and his willingness to invest in automated equipment, more reliable components, and minimum maintenance equipment. In addition to their daily wages, there are many benefits paid to the crew. An example is the wages paid to the crew in their vacation times, as in ship operations there may be crew rotation schemes. There are also sick benefits, payroll taxes, and repatriation costs (travel costs from the ship to their homes and vice versa).

2. Economic key performance indicators (KPIs)

As previously mentioned, in early design stages, there is a series of alternative designs and a decision has to be made on which of them is the best alternative operationally and economically. In an economic basis, there is no universally agreed upon technique for weighing the relative merits of alternative designs. That's because the criteria of a successful design might be affected by the shipowner's perspective. For example, business managers may agree the aim of designing a commercial vessel is to maximize profitability, but they may fail to agree how to measure profitability. On the other hand, government officials who are responsible for designing non-commercial vessel such as military vessels may find it difficult to decide on an alternative. Accordingly, several economic KPIs might be used, each of which has its benefits and the role of a designer is to know how to handle each of them. Noted that only two out of several known KPIs are discussed in this section.

The **net present value** (NPV) is one of the most popular and easiest measures of merit to understand and use. NPV requires an estimate of the future revenues and it assigns an interest rate for discounting future cashflows. NPV is simply the present value of the projected cash flow including investments. Costs and revenues are projected on an annual basis over the lifetime of ship and the net cash flow is calculated (accounting for capital repayments including resale value, income and expenditure). These annual uniform cash flows A are then discounted back using interest rate r and over the ships lifetime n. The net present value is given by:

$$NPV = A\frac{(1+r)^n - 1}{(1+r)^n} - P \tag{10.1}$$

If P is a single lump investment NPV is calculated for each alternative and the higher the NPV, the better the alternative. Noted that if NPV is a negative value, the project would be rejected.

Example 1. A ship design alternative A has an estimated uniform cash flow of €2 million, a ship's expected lifetime of 25 years and a lump investment of €5 million. Another alternative B has a uniform cash flow of €1.5 million, an expected lifetime of 30 years and a lump sum of €3 million. The minimum required interest rate is 12%. State which of the two alternatives is the best using NPV.

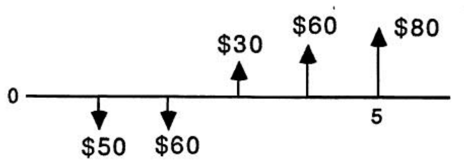
Solution. Using equation (10.1) the following values for each alternative can be obtained in a tabular format:

Project	Annual Cash flow (€)	Lifetime (years)	Interest rate (%)	Lump sum (€)	NPV (€)
A	2 M	25	12	5 M	10.7 M
B	1.5 M	30	12	3 M	9.1 M

Since project A has a higher NPV value, then it is the best alternative. Perhaps the annual cash flow is complex and non-uniform, and in such cases, NPV can be found using a year-by-year table in which each single future cash flow to be returned as a present value at the year zero using the following equation and the net present value can be then obtained as follows :

$$P = F(\frac{1}{(1+r)^n}) \tag{10.2}$$

where *F* is the future cash flow of each year. Consider, for example, a project that is expected to involve the investments and after-tax returns shown in this diagram:



Year	Cash flow	PW @ 9%
1	€50	€45.87
2	€60	€50.5
3	€30	€23.17
4	€60	€42.51
5	€80	€51.99
		Net present value = €21.30

Table 8 Annual cash flow

The **required freight rate (RFR)** provides a criterion which does not require an estimation of the revenue. It is the rate the shipowner must charge the customer if the shipowner is to earn a reasonable return on the investment. The theory is that the owner who can enter a given trade route with a ship offering the lowest RFR will best be able to compete. It establishes a freight rate by calculating annual costs (operating voyage, cargo handling, capital and repayments) and dividing them by the annual tonnage of cargo to be transported. The required freight rate is; therefore, a relative unit transport cost and its lowest value provides the most economical solution. It is therefore a good method for comparing various designs. Beware, however, of the fluctuations of fuel and interest rates, particularly if they are important factors in the design. This measure could be applied to different types of cargoes such automobiles per year for a ferry, tons of fish per year for a trawler, passengers per year for a passenger ship, and so forth. Assuming a single invested amount P at year zero, uniform annual operating costs A, annual tons of cargo C, interest rate r and a ship's lifetime n, the equation for the required freight rate becomes:

$$RFR = [P(\frac{r(1+r)^n}{(1+r)^n - 1}) + A]/C \tag{10.3}$$

Example 2. Assume a proposed ship that can move 3.5 million tons of cargo over a given trade route each year. Its estimated first cost is €40 million, and its economic life is 20 years. the annual operating costs are estimated at €2.5 million. The owner stipulates a yield of 12%. What is this ship's required freight rate?

Solution. Using givens in the example, the required freight rate can be obtained as follows:

$$RFR = [€40M \times (\frac{0.12(1+0.12)^{20}}{(1+0.12)^{20}-1}) + €2.5M]/3.5M\ ton = €2.24/ton$$

3. Shipyard Practice

It should be obvious for a designer that the shipyard capabilities and facilities affect several choices in design and construction. For example, small shipyards may do not have the capabilities and the workmanship for producing complex curvature-shaped ship, in such case, the choice of a planning hull is more considerable. It is also wrong to assume that the same design can be built with the same productivity and efficiency in different shipyards unless they are identical.

The **layouts of shipyards** have been developed over decades as both the ships being built, and the shipyard technology have changed. Such a shipyard layout should suit the environment surround the shipyard. The natural land topography found along riverbanks or sea cost influenced the shipyard layout. There are two basic examples of shipyard layouts shown in (Figure 10.1) and (Figure). Some shipyards were established beside restricted water yet deep frontage such as shown in (Figure 10.1). This layout is known by the narrow straight-line flow arrangement. Where there were steep hills or rocky nature of the land on which the shipyard is built, shipyards were squeezed onto the banks or shore and stretched along them to provide the needed land area as shown in (Figure). This type of layout is called the lateral wide or turning flow arrangement. It is clear in this type that the material flow is not ideal especially with shipyards that use large block construction. Where the river is not wide the building berths/launch-ways were set at an angle to the river in order to build and launch as large a ship as possible. Where the river is even narrower, shipyards used side launching instead of end lunching.

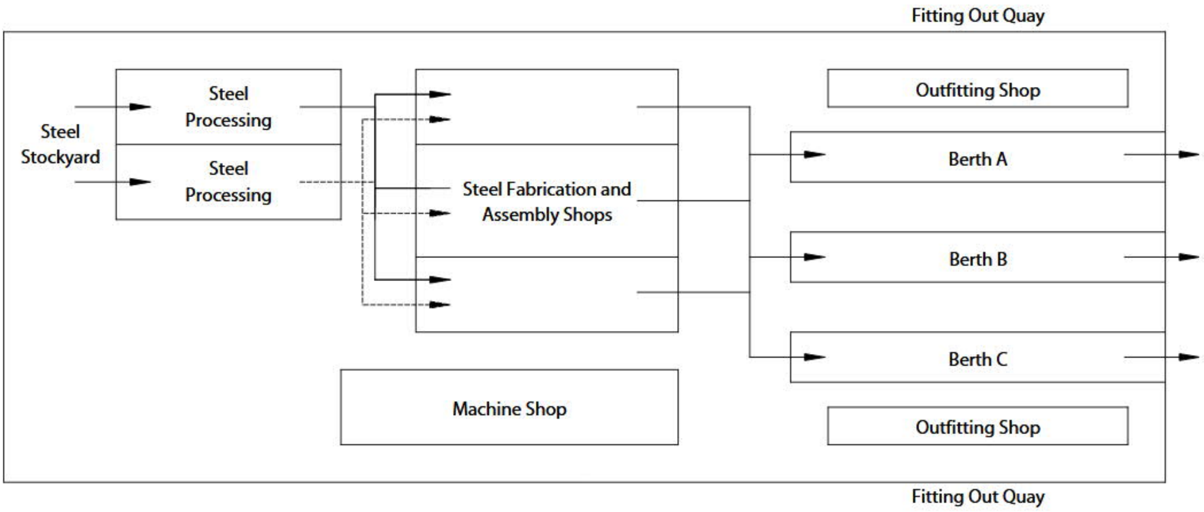


Figure 10.1 Straight line flow arrangement. Image credits: (Thomas, 2003)

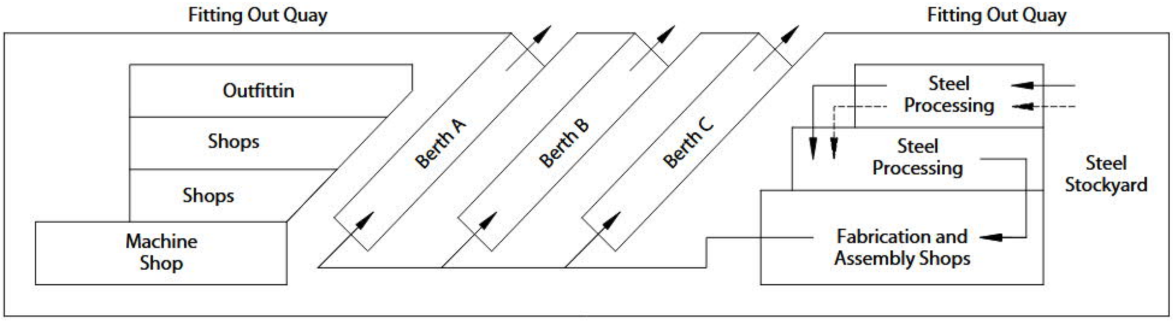


Figure 10.2 lateral wide or turning flow arrangement. Image credits: (Thomas, 2003)

In general, there are two basic forms of organization; the functional organization and the product organization. Other forms of organization are hybrid such as matrix organization. The functional organization gather resources into common activities. For instance, engineers and production workers are organized per function to produce a ship. On the other hand, the product organization is based on group-technology concept; multiple product line. The functional organization is the better when only one or a few ships are built in such a shipyard. Traditionally, the shipbuilding community looks at the ship as an entire end product. However, modern shipyards nowadays breakdown the ship into subassemblies together create a larger assemblies(blocks) and which are assigned for production to the most cost-effective producers inside the shipyard or by using subcontracting.

4. The shipbuilding contract

A contract for building of ship/ships is a consequence of a decision by the shipowner to acquire a vessel or a series of vessels to achieve the objectives of his organization. Examples of these objectives are a favourable return on investment, a public service (ferries, research or rescue ships), acquiring a transportation link through a larger logistics system, or scientific research.

After the decision to acquire a new vessel is made, there are basic follow-on steps necessary. An important step is to decide on the ship's technical specifications and technical drawings which define the physical ship that will meet the owner requirements. This step forms the contract specification part in the shipbuilding contract. Besides, there are also non-technical decision to be made such as selecting the naval architectural company or consultancy office to develop the technical requirements, identifying qualified shipyards to be invited to submit bids or proposals, selecting the flag of registry and the classification society that will be involved in ship design, construction, and operation.

To sum up, the shipowner enters a shipbuilding contract to acquire a ship to satisfy his needs. On the other hand, the shipyard wants to construct a ship within its shipbuilding capabilities to earn a return on its investment in shipbuilding facilities.

Contract Specifications and Contract Plans define the unique features of a vessel and other non-unique features that are not already addressed by the appropriate regulatory requirements and classification rules. Generally, there are three main types of specification to be defined:

- Design and end product specifications,
- Performance specifications,
- Procedural specifications.

The contract specification may have more than one type of specification and may include the three types as this part comprises all the different aspects of such a ship. A design or end product specification is a representation, by either drawings or verbal descriptions or both, of what that aspect of the ship should look like upon completion. For example, contract specifications may define the type, composition and colour of the coatings, as well as perhaps the manufacturer, and then go on to define the thicknesses of each of the primer, undercoat and topcoat. In addition, contract plans may define the final hull form of the ship. A performance specification, on the other hand, does not in any way describe what the object will look like, but instead will describe how it is to perform. A specification for the ballast pumps on a ship, for example, could state that the two ballast pumps shall each separately be capable of pumping into and out of the ship's ballast tanks a certain number of tons of ballast water per hour. A procedural specification usually supplements one of the two other forms of specification by defining part of the procedure that is to be followed in achieving the other part of the specification, either in the design process or the construction stage. An example of a construction procedural specification pertains to coatings: the design specification for the coatings, may be supplemented by a procedural specification that requires the Contractor to apply the coatings in accordance with the practices recommended by the coating manufacturer pertaining to surface preparation, air temperature, steel temperature, relative humidity, direct sunlight, wind speed, etc. It is necessary to know that there are some main specifications must be included in a shipbuilding contract whatever the type of specification they lie in. There are for instance the ship's main dimensions, deadweight, capacity, sea trial speed, and limit for noise and vibration.

5. Questions

1. A €5 M investment on a ship promises annual returns of €700,000 over 20 years. Find the net present value based on 9% interest.
2. Find the NPV at 8% for this cash flow: €1000 expense now, €2000 expense a year from now, €2000 income two years from now, and €2000 income three years from now.
3. Find the required freight rate for a dry bulk carrier that has an initial cost of €80 million, annual operating costs of €1.85 million, and an annual transport capacity of 4.25 million tons. The ship's life is 20 years, and the interest rate is 14%.

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