Self-Unloaders — Evaluating the Economic Advantages

David B. Fortier, Canada

Summary

Too often the economic evaluation of self-unloading ships is done by comparing their rates with those of conventional ships. The objective of this article is to show that the economic evaluation of a self-unloader relative to conventional ships requires that all relevant costs be considered, not just the shipping costs.

1. Introduction

Self-unloaders are becoming more popular as more are built for North American markets. They are also beginning to make an appearance in Europe and Asia. And, they are becoming a more common subject of trade journals; witness the reference to them in five articles in the North American Special — Part 1, of **bulk solids handling**. I would like to directly address the economic evaluation of self-unloaders versus conventional ships using a specific North American example.

A cut-away view of a self-unloader is illustrated in Fig. 1 showing the main elements. The tank-tops are not flat but are angled to form hoppers which enclose gates at the bottom. When these gates are opened, which is done in a controlled sequence, the cargo drops onto the conveyor belt beneath and is carried aft. Then, an elevating device, usually a loop-belt, lifts the cargo from below the holds to above the deck level and onto a boom conveyor. The boom conveyor, which can be of varying lengths, allows the cargo to be deposited well away from the side of the ship. This type of ship-unloading system permits rates of cargo discharge of between 1,000—10,000 t/h, but the most common unloading rates range from 2,000—5,000 t/h.

In essence, the self-unloader provides a mode of bulk handling that goes beyond simple marine transport, therefore the economic evaluation must go beyond the simple comparison of one shipping rate with another. Fig. 2 shows the CANADIAN PIONEER, the latest addition to the Upper Lakes Shipping fleet.

2. Economic Appraisal of Shipping Costs

The appropriate economic concept requires that the total relevant costs for the transportation *and handling* of the commodity from its origin (place of production) to its destination (where it is used) be compared. For simplicity's sake, I shall assume that the costs are the same to the port of loading and aboard the ship and shall ignore them, focusing on the cost from the time the commodity has been loaded on the ship until the time at which it arrives at its final destination.

There are two parts to this definition of the appropriate economic concept. The first part deals with "total costs". These total costs can be broken into capital, maintenance and operating.

The total capital costs are the amount of investment to build the required facilities. Generally, this expenditure must be made prior to the initiation of shipment. To distribute these costs over the years, it is common to look at the debt service per year as being the annual capital cost. If the life of the facility is substantially longer than the financing period, it is appropriate to look at the amount of capital investment tied up in the asset over its expected life, assuming a reasonable interest charge.

Table 1 provides a range of annual capital costs given certain estimates of life and interest rates. These annual capital costs are given as a percentage per year of the original capital cost.

Maintenance costs are those involved in maintaining facilities in an operable condition. For example, these would include: periodic dredging to maintain water depth, surfacing of piers or docks and overhaul of unloading equipment and conveyors.

Operating costs are direct costs of using the facilities, such as: stevedoring, other labour costs, fuel/electricity and the rental of required equipment.

When evaluating the economic advantages of self-unloading ships, one must consider the total costs of transportation *and handling*. Unfortunately, most evaluations look only at the cost of marine transportation and ignore all of the costs involved in handling the commodity ashore, such as:

— docks/piers
— unloading equipment
— transportation to storage
— storage
— transportation to usage site.

1. WHEELHOUSE
2. TUNNEL CONVEYOR RETURN BELT
3. 'A' FRAME
4. LOOP BELT CASING
5. DISCHARGE CHUTE
6. INNER LOOP BELT
7. BOOM SLEWING ACTUATOR
8. TRANSFER CONVEYOR
9. TRIANGULAR BOOM CONVEYOR
10. HATCH COVERS STOWED
11. HATCH COVER CRANE
12. CARGO
13. TUNNEL CONVEYOR BELTS
14. HYDRAULIC BOOM LUFFING CYLINDER
15. WING BALLAST TANK
16. UNLOADING GATES
17. CARGO HATCHES
18. UNLOADING & BALLAST CONTROL ROOM
19. TUNNEL CONVEYOR BELT TAKE-UP
20. BOW THRUSTER
21. BALLAST TANKS

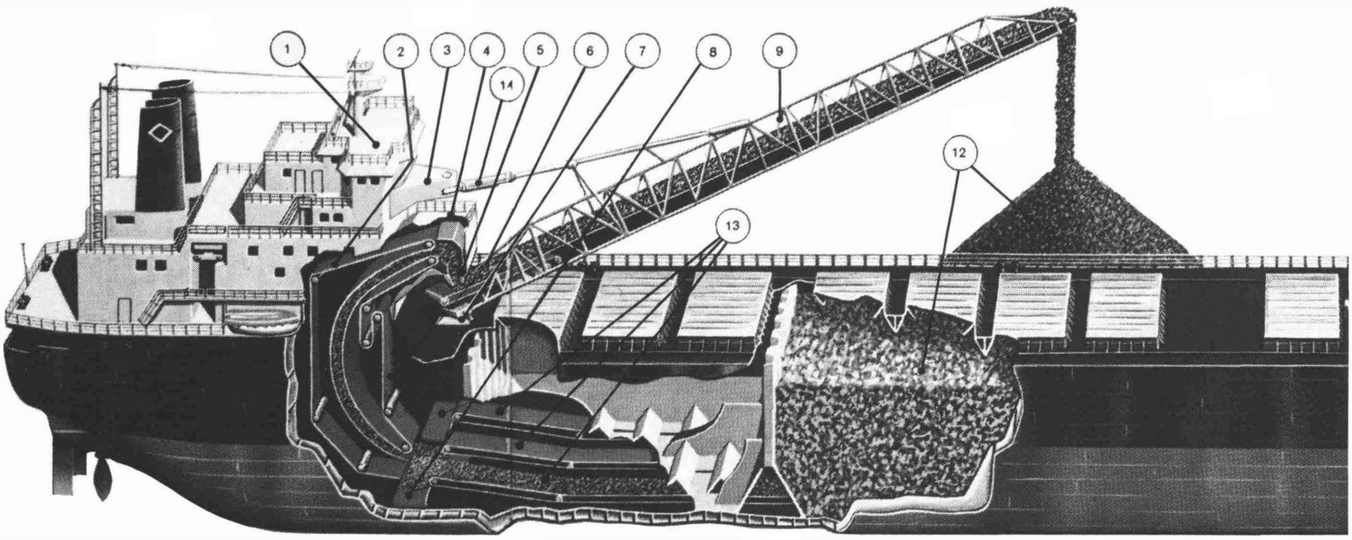


Fig. 1: Hopper type self-unloading bulk carrier

Fig. 2: CANADIAN PIONEER — the latest addition to the self-unloading ocean fleet of Upper Lakes Shipping Ltd., Toronto, Canada

Table 1: Annual Capital Cost (Expressed as a percentage of the original capital cost)

Years	Interest Rate (%)					
	7.5	10	12.5	15	17.5	20
	percentage of original capital cost					
10	14.56	16.17	18.06	19.93	21.86	23.85
20	9.81	11.75	13.81	15.98	18.22	20.54
30	8.47	10.61	12.88	15.23	17.64	20.08

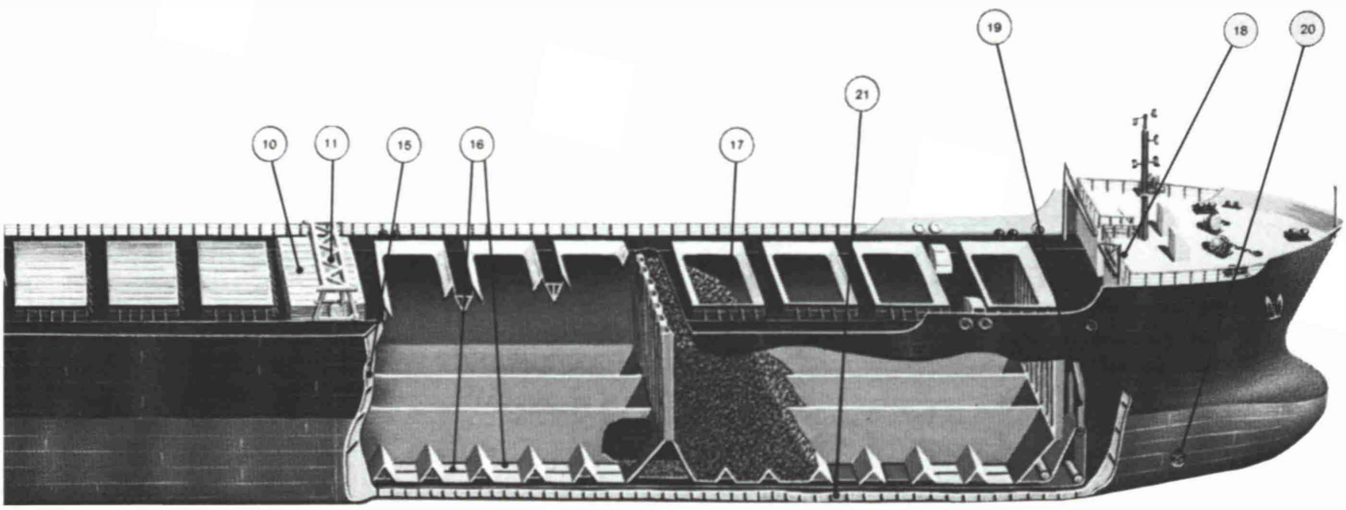
Note: Beyond 30 years, the annual capital cost percentage approximates the interest rate.

Some of these costs may be separable into capital, maintenance and operating elements or they may all be grouped together in the form of a rate as is generally done for shipping.

The second part of the definition of the appropriate economic concept deals with the "relevance" of the costs. The important idea here is that there is no one cost that is correct for use in all circumstances or for all decisions. Certain elements of cost are relevant for one decision but not for another. Thus, for some decisions, both fixed and variable costs may be relevant; while for others, only variable costs will be relevant.

Furthermore, some costs may be relevant at one time but not at another. An example of this would be the cost involved in a capital facility. Before the decision to build this facility is made, that capital cost is relevant; once the facility has been built, that cost is "sunk" and is no longer relevant.

Finally, there exists the question of determining to whom a cost is relevant. Often, there is a division of responsibility for various cost elements so that nowhere is the total cost analyzed. An example of this difficult situation is often found with respect to capital facilities which a government installs on a non-cost recovery basis. There is a tendency to look upon these facilities as "free", since the authority paying for these is not involved in decisions with respect to their utilization. However, capital costs are a cost to someone at some point in time. A further example arises when an individual is responsible, say, for shipping and another individual for the subsequent handling of the commodity. In many cases, the desire of the first to reduce his shipping cost forces a high cost mode for the subsequent handling resulting in a higher overall cost.



To recapitulate, the appropriate standard for economic evaluation of self-unloaders is the delivered cost per ton. This is important as the daily rate for a self-unloader is substantially higher than that of a gearless bulk carrier. If one were only to compare the time-charter rates, the choice would be a conventional ship. The following example of a real situation shows that unless all costs are considered, uneconomic, high-cost decisions may result.

3. An Example of Economic Appraisal

The example involves a North American movement of coal for a thermal-generating station with an initial requirement of 400,000 t/year rising, ultimately, to one million t/year. In this example, I shall break down the total cost into the various elements. In those areas in which the cost via self-unloader is different from that of a conventional ship, the amounts are entered in Table 2.

In this instance, there was no available space in the port, so that the construction of a finger-pier and certain other civil works was required. The cost of the works was estimated at U.S. $ 20 million. On the assumption that subsidized financing would be available, I shall use the lowest percentage from Table 1 for computing the annual capital cost. $ 20 million at 8.47% results in an annual cost of $ 1,694,000.

By contrast, the dredging, dolphins, etc. required for a self-unloader at a different site, would cost only $ 750,000 for an annual capital cost of only $ 63,000.

It is realistic to expect that the maintenance cost of a $ 20 million facility will be substantially higher than that of a $ 750,000 facility. However, I have no estimate of these amounts and therefore have made no entry on Table 2.

Three unloading cranes with a nominal capacity of 300 t/h and an average actual capacity of 150 t/h will unload about 7,000 t per 16-hour day. A potential supplier estimated that the installed cost of these would be about U.S. $ 12 million for an annual capital cost of slightly over a million dollars. I have assumed a maintenance and operating cost combined for this unloading equipment of $ 1.00/t.

There is no unloading cost with a self-unloader as this is part of the shipping rate.

The transportation to storage from the finger-pier required a conveyor system approximately one kilometre long. Given the terrain, this cost was estimated at U.S. $ 6 million for an annual capital cost of $ 510,000. I have made no entry on Table 2 for the maintenance and operating cost for this transportation system. Although such costs would definitely exist, I had no estimate as to their amount.

In this case, the self-unloader coal could be stored at the unloading site, so there was no cost for transportation to storage.

The conventional system would require a stacker of some sort at the storage site which would result in capital, maintenance and operating costs. No estimate was available of these amounts. No stacker was required for the self-unloader as the boom on the ship would act as the stacker.

For the conventional system, there was no storage space immediately adjacent to the thermal-generating station so that the storage was still quite some distance from the plant site. The self-unloader storage was a few hundred metres farther from the plant site. In both instances, a similar system would have been used: loading trucks with a front-end loader. Again, no estimate was available of these

Table 2: Economic Evaluation of Self-Unloader (Utilizing Differential Costs) (U.S. $)

	400,000 t/year				1,000,000 t/year			
	Conventional		Self-Unloader		Conventional		Self-Unloader	
	Annual Cost (000)	Per Tonne	Annual Cost (000)	Per Tonne	Annual Cost (000)	Per Tonne	Annual Cost (000)	Per Tonne
Dock/Pier								
— capital	1,694	4.24	63	0.16	1,694	1.69	63	0.06
— maintenance	N/A	N/A	N/A (—)	N/A (—)	N/A	N/A	N/A (—)	N/A (—)
Unload Equipment								
— capital cost	1,016	2.54	nil	nil	1,016	1.02	nil	nil
— maintenance and operation		1.00		nil		1.00		nil
Transport to Storage								
— capital	510	1.28	nil	nil	510	.51	nil	nil
— maintenance and operation		N/A		nil		N/A		nil
Storage								
— capital	N/A	N/A		nil	N/A	N/A	nil	nil
— maintenance and operation		N/A		nil		N/A		nil
Transport to Usage Site								
— capital	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
— maintenance and operation		N/A (—)		N/A		N/A (—)		N/A
Shipping Rate		7.50		10.50		7.50		10.50
TOTAL DETERMINABLE RELEVANT COSTS OF TRANSPORTATION AND HANDLING		16.56		10.66		11.72		10.56
EXCESS COST		5.90				1.16		

N/A = These costs were not estimated as the advantage of self-unloaders was overwhelming without their specific consideration.

costs, but the additional distance for the self-unloader tonnage would have resulted in a slightly higher cost.

The estimated long-term rate required by a gearless ship to handle this movement was between $ 7—$ 8. I have taken the figure of $ 7.50. The self-unloader rate was $ 10.50.

Table 2 provides a summary of the significant differences in cost between the two systems. Some of these costs were estimated on a per-ton basis, some were known to be nil and for some (marked N/A) although there was known to be a cost, no estimate of it was available.

Considering the 400,000 t/year scenario, the conventional system results in a cost of $ 16.56 plus six items for which there was a cost but for which no estimate was available. In contrast, the self-unloader resulted in a cost of $ 10.66 plus three unknown amounts, one of which was the same as, one of which was significantly less and one of which was slightly more than the corresponding amount in the conventional system.

The bottom line of this table shows that the conventional system would result in an additional cost of $ 5.90 per ton (plus the differences in cost for which no estimate was available) at a volume of 400,000 tons and a minimum of $ 1.16 at the million ton volume. These differentials are applicable only when a subsidized interest rate of 7.5% is used. If a commercial rate of, say, 17.5% were used, the differentials would increase to over $ 12.00 per ton at the 400,000 volume and over $ 4.00 per ton at the million ton volume.

4. Conclusions

This article has presented the idea that the proper basis for the economic evaluation of self-unloading ships is the total cost of the transportation and handling of the commodity. This includes the capital, maintenance and operating costs not only for the shipping but also for all of the handling ashore from the ship's hold to the ultimate usage site of the commodity.

An example of how to use this concept in an actual situation has been provided. In this particular instance, although the self-unloader shipping rate was higher, the total costs of transportation and handling were substantially lower for the self-unloader because of the substantial cost savings involved in the reduction or elimination of:

- capital spending on docks, unloading equipment and facilities for transfer to storage;
- the maintenance and operating costs involved in having such facilities.