REDUCED MANNING TO INCREASE FLEET COMPETITIVENESS[1]

Harilaos N. Psaraftis
Department of Naval Architecture and Marine Engineering
National Technical University of Athens
Greece

ABSTRACT

The merchant fleets of many countries worldwide have experienced a significant decline of competitiveness over the years. Phenomena such as national fleet shrinkage and "flagging out" have been the main manifestations of such a decline. Realizing that manning costs are frequently a major percentage of ship operating costs, one of the measures that has been contemplated in order to reverse this trend has been the design, development, and operation of highly automated ships manned by reduced crews. The purpose of this paper is to present the results of an analysis that addresses the question to what extent and under which scenarios can advanced technologies that reduce manning improve merchant fleet competitiveness. The analysis is the product of a European Commission project, and, as such, focuses on the fleets of European Union member states. However, we also attempt to generalize the conclusions to other fleets of the world.

KEY WORDS: Ship automation, reduced manning.

1. Introduction

The merchant fleets of many countries worldwide have experienced a significant decline of competitiveness over the years. Loss of competitiveness is due to the fact that ships in these fleets are generally more expensive to operate than other ships, and shippers prefer the latter because of cost considerations.

Such a decline in competitiveness has been manifested in a number of ways. The first is a net reduction of the number of ships in the fleets plagued by such a problem. Such has been the fate of many of the fleets of the member states of the European Union (EU)[2] over the years. According to Eurostat (1991), the total EU fleet numbered 11,023 ships in 1980, but only 6,431 ships in 1989. The share of EU fleet as a proportion of the world fleet dropped from 27% to 16% during the same period. A similar (or sometimes more severe) downward trend has been experienced by other fleets, such as for instance the one of the United States. According to Cuneo (1993), the percentage of US commerce carried on US flag vessels was 42.6% in 1950,

[1] Presented at the IMLA-9 conference, Kobe, Japan, October 1996.

[2] In this paper the term EU (European Union) collectively refers to the 12 member states of the European Community *before* the 1995 enlargement, that is: Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom. The EU was enlarged to 15 member states on 1/1/1995, when Austria, Finland, and Sweden joined.

dropped to 5.3% in 1970, and was just 4.1% in 1990. The number of US flag ships was 3,408 in 1950, dropped to 1,708 in 1970, and was just 635 ships in 1990.

A related phenomenon (reflecting essentially the same problem) has been what is known as “flagging out”, that is, registering a ship not with the flag of the country of the shipowner, but with another, foreign flag. Flags such as Liberia, Panama, Malta, the Bahamas, and Cyprus have been responsible for much of the flagging out that has occurred over the years. The phenomenon of flagging out is pervasive in many merchant fleets worldwide. Thus, in 1992, whereas the EU owned fleet numbered 6,735 ships, the EU flag fleet was only 3,573 ships. The fleets of the United States (1,021 vs. 469 ships) and of Japan (2,835 vs. 1,128 ships) faced similar problems (source: Lloyds Register of Shipping; ships of 1,000 GRT and above).

Realizing that manning costs are frequently a major percentage of ship operating costs, one of the measures that have been contemplated in order to help reverse this trend has been the design, development, and operation of highly automated ships manned by reduced crews. The rationale for such a measure is that under appropriate circumstances the savings realized by a reduced payroll could, over the ship's lifetime, offset the additional capital cost of the automated ship, and hence make that ship more competitive than an equivalent conventional ship, even if the latter is manned by a low-salary crew.

Can a ship's crew be arbitrarily small in size? National and international regulations are quite specific on minimum allowable crew requirements as functions of ship type, size, and technology (e.g., engine room crew may be a function of engine type or horsepower). The purpose of these regulations is mainly to ensure a *minimum standard of safety* for the ship. The International Maritime Organization (IMO) through the International Convention for the Safety Of Life At Sea (SOLAS) has adopted various measures on the principles of safe manning (resolution A.481(XII)). In addition, the 1978 Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW Convention) has adopted standards for crew training, certification, and watchkeeping. It should be noted here that such guidelines specify only the *minimum* levels that are allowed. For various reasons (e.g., maintenance, training, etc.) a ship may have a crew composition that is *larger* than these minimum levels. If this is the case, no further certification or approval is necessary. On the other hand, there may be cases for which the shipowner wishes to employ a smaller crew than the one stipulated by the regulations. In such cases, the proposed reduced crew composition has to get special approval by the appropriate national maritime authorities.

Numerous “ship of the future” projects have been launched in several countries (e.g., “Schiff der Zukunft” in Germany and “Projekt Skib” in Denmark), with the aim of developing shipboard technologies that would ensure an efficient and safe ship operation while drastically reducing manning onboard the ship.

Technologies such as integrated ship control, position fixing devices, satellite navigation, unmanned machinery room, automated cargo handling, automated docking and mooring, voyage management, planned maintenance, fault diagnosis and alarm handling, and others, receive a prominent focus on such ships. A direct product of “Projekt Skib” was the development, design and subsequent operation of a series of four highly automated reefer ships of 21,680 m^3 (765,650 ft^3) capacity. These ships are owned by Danish shipowner J. Lauritzen A/S. They were initially designed to be operated by a crew of six. Their “minimum safe manning document” authorizes operation with a crew of seven, although in actual practice nine crew positions are used. This is indeed a drastic reduction, considering that a conventional vessel of similar size typically has at least 25 crew positions.

The European Commission (Directorate General for Transport -DGVII), realizing the need for applied R&D in this area, sponsored project ATOMOS, within its EURET transportation R&D programme. ATOMOS stands for “Advanced Technology to Optimize Manpower Onboard Ships” and consists of a consortium of 9 partners from 4 EU countries. The project started in early 1992 and was completed in late 1994. Its scope has been to develop advanced shipboard technologies that would enhance the competitiveness of the fleet of the EU, while maintaining an adequate level of safety.

Describing the entire results of ATOMOS is way beyond the scope of this paper. These results are fairly extensive and can be found in other publications. Rather, the purpose of the paper is to present in a concise way the results of the *cost-benefit analysis* of the ATOMOS project. This cost-benefit analysis aimed at investigating the possible impact of reduced manning and ship automation technologies on merchant fleet competitiveness. As the analysis is the product of a European Commission project, it focuses on the fleets of EU member states. However, we also attempt to generalize the conclusions to other fleets of the world.

3. The Analysis

Before we proceed with the analysis, we note that the general subject of ship manning has been examined in the literature from various twists and angles. Holder and Moreby (1986), NRC (1990), Pollard et al (1990), ISL (1993), and Grossmann (1993) can be cited as some relevant references on this subject. However, with the possible exception of Marcus and Weber (1994), the specific subject of *cost benefit analysis* of advanced shipboard technologies and reduced crews has not received extensive attention, particularly their impact on fleet competitiveness.

One of the questions to the ATOMOS project has been to ascertain to what extent and under what conditions advanced shipboard technology systems (such as those developed in the project) would enhance the competitiveness of the fleet of the EU. In order to answer this question, a comprehensive cost-benefit analysis is warranted. The cost-benefit analysis would essentially compare two equivalent ships, one of conventional technology and crew composition, and one of advanced technology and reduced manning, in terms of some competitiveness criterion such as Required Freight Rate (RFR). An appropriately defined sample of ships would be necessary in order to draw some conclusions.

Notice the use of the RFR as the competitiveness criterion. The RFR is the break-even freight rate for which the Net Present Value (NPV) of the time stream of the discounted differences between revenues and expenses over the lifetime of a ship is zero. This criterion is widely used in evaluating and comparing maritime transportation investment alternatives. Additional competitiveness criteria were defined in Psaraftis et al (1992).

In spite of the apparent simplicity of such an approach, the actual implementation of such a methodology is by no means easy. Several kinds of difficulties are important. For instance,

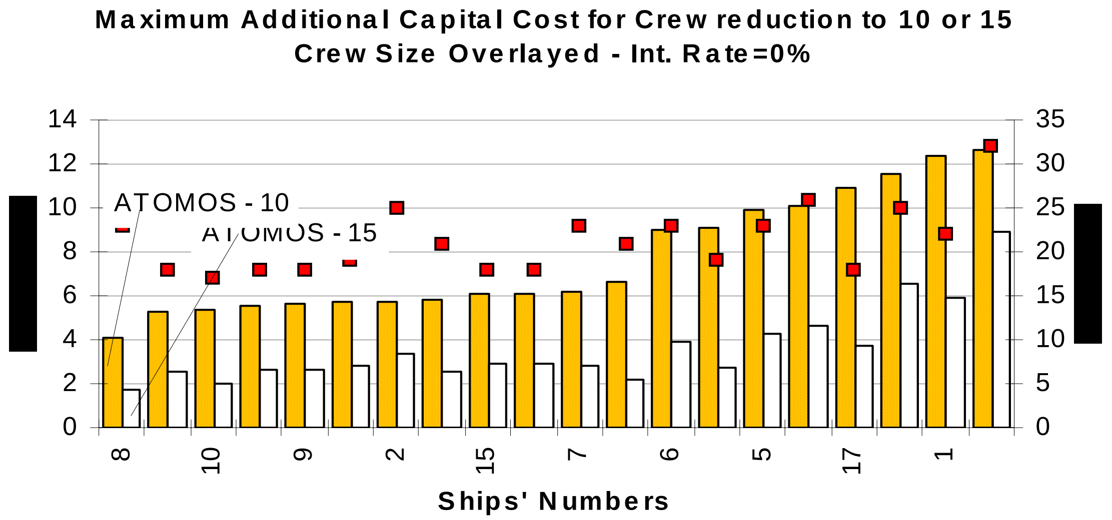
- The amount of data necessary for doing a comprehensive analysis along the above lines is immense.
- Some of the necessary data is difficult to collect, may be incomplete, or sometimes simply nonexistent.
- Calculating some components of the cost- benefit equation is extremely difficult or even impossible.

An extensive effort was undertaken to collect the vast amount of data necessary for the analysis (see Psaraftis et al., 1994a for details). Due to lack of complete homogeneity in the quality of data collected , it was decided that our cost-benefit analysis methodology should be structured into three hierarchical levels: I, II, and III. Due to space limitations this paper cannot present details of the analysis in all three levels (the reader is referred to Psaraftis et al (1994b) and Psaraftis (1996) for more details on the methodology, especially on Levels I and II). Here we focus more on Level III which can support some general conclusions, and present only a summary of findings of levels I and II.

<u>Level I</u> analyzed only one ship (specifically a 1992 newbuilding gas carrier flying the Italian flag), and aimed at illustrating, by means of a detailed example, the complete procedure one should follow to assess the competitiveness improvement resulting from the implementation of advanced technologies onboard that ship. Several technologies (such as an Integrated Ship Control package), that would result in specific crew reductions, were examined, and the corresponding changes in the ship's RFR were calculated. However, since only one ship was examined, obviously no conclusions on any competitiveness issue were drawn from Level I alone.

Level II analyzed a sample of 20 EU ships, for which accurate cost data was obtained via questionnaires. Questionnaires were sent to about 800 shipping companies worldwide, and answers for 78 ships were received, of which those that were valid *and* concerned EU ships were 20. A sample of the Level II analysis is show in Figure 1 below. For each of the 20 ships of the Level II analysis, Figure 1 represents the maximum additional capital cost a shipowner would be willing to pay in order to own an ATOMOS-type ship (manned either by 10 or by 15 people) instead of the actual conventional parent ship (the figure also depicts crew size for each of the 20 parent ships - shown by a square dot and measured on the right-hand scale).

Figure 1



An observation from this figure is that as the estimated additional cost of an ATOMOS ISC is between 1 and 2 million USD, in most cases above such a ship would be preferable over its equivalent conventional one (on the basis of cost). Of course, due to the small sample, no general conclusions from Level II can be drawn.

Level III was based on a much broader sample of ships (1,487), but was rather drastic in the simplifying assumptions it made in order to work with this sample. In fact, in Level III manning costs and capital costs were the only categories of cost that were taken into account, and these costs were *estimated* rather than actual. Then comparisons were made among (a) each of the parent ships selected, (b) an ATOMOS-type ship, and (c) a cheap-crew ship, all appropriately defined. Details follow.

The total number of ships in the world ship database at our disposal (supplied by Lloyds Register) was 25,058. From these ships we selected those that flew (a) the 12 flags of all EU countries, as defined earlier, that is: Belgium, Denmark (including DIS), France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, and United Kingdom; or (b) the flags of Finland, Norway (including NIS), Sweden, Japan, and the US.

We next discarded all ships for which the Lloyds ship database had no information on crew size or horsepower, and the ones which had crew size less than 11. The remaining ships after all these screens were 1,487. Each of these 1,487 ships was labeled a "parent ship". For each parent ship, two equivalent (identical in terms of capacity and speed) *hypothetical* ships were considered:

a) An "ATOMOS-10" ship, manned by 6 officers and 4 ratings. It flies the parent ship flag, and is manned by flag nationals. Such a configuration resembles closely the one used in the Lauritzen reefers.

b) A "cheap-crew" conventional ship. This cheap-crew ship flies also the flag of the parent ship. It differs from the parent in that *only the captain and the first officer are flag nationals*, the rest of the crew being (non-EU) nationals paid *a very low salary*. The reason for examining this alternative (which may be unrealistic or even illegal in some countries under current national legislation- the most notable example being the US) was to assess it as an alternative to an ATOMOS-type ship. Such an alternative is under discussion in several countries as a means to control manning costs, and so we thought it would make sense to see how it would compare with an ATOMOS alternative.

In Level III manning costs for each of the crew ranks and nationalities assumed were based on information on collective labor agreements in various countries, multiplied by a user-defined "surplus factor" (whose default value is assumed to be 1.3 to account for the fact that actual wages are typically higher than those stipulated in the collective labor agreements). Psaraftis et al (1994a) provides details on how such wage data was obtained.

The wage data was grouped into nine (9) databases: One for the German flag, one for the Danish, Norwegian, Swedish, and Finnish flags, one for the Dutch, French, Belgian, and Luxembourg flags, one for the British and Irish flags, one for the American flag, one for the Japanese flag, one for the Portuguese and Spanish flags, one for the Italian flag, and one for the Greek flag. A separate wage database for the cheap-crew ship was formed. This was called the "Russian database" because it contains salary levels for officers and ratings that are of Russian nationality. The reason this nationality was selected is that it constituted the cheapest wage level found from all wage data that was collected.

All these wage databases were connected with the Lloyds ship database. Crew composition for each ship was estimated using the Official Manning Regulations of the flag of the ship. Hotel crew was not part of the manning cost equation for passengers and ferries.

The first question in the Level III analysis was for which, among all these 1,487 ships, the NPV of the time stream of manning cost differentials between the parent ship and the equivalent ATOMOS-10 ship, taken over 25 years, exceeded the additional capital cost of the ATOMOS technologies. For those ships, the ATOMOS ship is more competitive than the parent ship.

The answer to this question depends on two factors: (a) the additional capital cost of the ATOMOS technologies, and (b) the real cost of capital i (or discount rate), defined as the difference between the nominal interest rate and inflation. We examined capital costs ranging from $1 million to $5 million, and i ranging from 0% to 10%. The complete picture for the $2 million, 10% case for every type/flag combination is as follows.

1) Taken by flag/register, the percentages among the 1,487 ships in which an ATOMOS ship is more competitive than its parent ship are: Belgium: 100% (1 ship out of 1); Denmark: 100%; USA: 100%; NIS: 98%; Greece: 94%; Japan: 94%; Finland: 93%; Norway: 87%; Germany: 87%; France: 86%; Sweden: 85%; Italy: 83%; Luxembourg: 82%; UK: 82%; Spain: 81%; Portugal: 80%; DIS: 79%; Ireland: 43%; Netherlands: 42%.

2) Taken by major ship type, the percentages are: Ferries: 100%; OBO carriers: 100%; Passenger ships: 99%; Bulk carriers: 94%; Containerships: 93%; Roros: 87%; Tankers: 86%; Other types: 83%; LNG carriers: 82%; General cargo ships: 43%.

It should be stressed again that all of the above percentages only refer to the $2 million, 10% case (Psaraftis et al (1994b) presents some other cases too). None of these figures would decrease (in fact, most or all would increase) for lower values of either one of the above two parameters.

These results tend to support the following general conclusion:

<u>Conclusion No. 1:</u> *Over a broad sample of ships, ship types, and flags (all EU flags included), an ATOMOS-type ship manned by a crew of 10 is likely to realize significant lifetime cost savings over its equivalent conventional parent ship. This means that ATOMOS-type technologies are likely to significantly improve the competitiveness of these ships.*

The other major question in Level III was the comparison between an ATOMOS-10 ship and its equivalent cheap-crew ship (as defined earlier). To answer this question, we investigated for which parent ships from the database of 1,487 ships *the manning cost* of the equivalent ATOMOS-10 ship was lower than the manning cost of the equivalent cheap-crew ship. We called such ships "ATOMOS-favorable." Obviously, since in the definition of an ATOMOS-favorable ship only manning costs (but not capital costs) were taken into account, *the possibility that a ship is ATOMOS-favorable does not necessarily mean that the corresponding ATOMOS ship will be more competitive than the equivalent cheap-crew ship.* The reverse however is true, because if a ship is *not* ATOMOS-favorable there is no way that the ATOMOS-10 ship can be more competitive than the equivalent cheap-crew ship.

The results on the ATOMOS-favorability question were as follows:

1) Percentages of ATOMOS-favorable ships by flag/register: Belgium: 100% (1 ship out of 1); Greece: 89%; UK: 81%; Luxembourg: 71%; Italy: 62%; France: 60%; Ireland: 43%; Spain: 30%; Portugal: 25%; Netherlands: 21%; Germany: 17%; Denmark, DIS, Finland, Japan, Norway, NIS, Sweden, and USA: 0%, or very close to 0%.

Noting that as these percentages are *upper bounds* on the percentages of cases for which an ATOMOS-10 ship is more competitive than an equivalent cheap-crew ship, these results tend to support the following general conclusion:

<u>Conclusion No. 2:</u> *For those ships that are manned by expensive crews, an ATOMOS-type ship manned by a crew of 10 is likely to be <u>less</u> competitive than an equivalent conventional ship that flies the same flag, has flag nationals only for the captain and first officer position, and low salary personnel for the rest of the crew.*

2) Percentages of ATOMOS-favorable ships by ship major type: Ferries: 64%; Passenger ships: 53%; OBO carriers: 41%; Bulk carriers: 38%; Tankers: 24%; Containerships: 19%; Other types: 18%; General cargo ships: 16%; Roros: 16%; LNG carriers: 13%.

We feel that no general conclusion from the latter figures can be drawn. Passengers and ferries are favored again here, but it is precisely for these types of ships (which still operate in cabotage-restricted trades in many countries) that the cheap-crew alternative described in Level III is the least likely to be implemented.

4. Discussion

We believe that the overall analysis of this paper supports the general premise that ATOMOS-type technologies would add to the competitiveness of many merchant fleets in the world. The “cheap-crew” alternative in Level III was presented more as an exercise to see how really competitive is an ATOMOS ship, and less as a proposal for policy implementation.

Our analysis has centered on costs and benefits that could be quantified with some confidence, with a focus on those that are *directly* impacted by crew reduction and the introduction of new technologies. However, more research is needed to investigate the *indirect* impact of such technologies, such as on maintenance and repairs, loading and unloading, and other aspects of a ship’s operation. In addition, *cost criteria* such as RFR received a prominent focus in our analysis. But competition in shipping is not always based on cost alone. *Service* competition is sometimes important too, particularly in the liner and passenger/ ferry markets (as much as it is not that important in the charter market which is price competitive). This aspect should be looked at too as a topic of further research.

Which shipowners might invest in ATOMOS-type technologies? We believe that the analysis reported here sheds some light on this issue. On the one hand, it is perhaps obvious to expect that the greatest economic benefits from an ATOMOS-type ship should be realized on a “high-salary” ship (in terms or higher lifetime crew cost savings). This means that shipowners in *expensive* EU flags such as Denmark and Germany would have the greatest (among other Community shipowners) economic incentive to invest in such technologies. The NPV of the savings they would realize over the lifetime of the ship would be the highest, among other EU shipowners. The same is true for other expensive flags, including other Scandinavian countries, Japan, and the United States. On the other hand, our analysis has strongly indicated that it is mainly in *lower-salary* EU flags that ATOMOS-type ships have the greatest chance of beating the competition, that being conventional low-salary non-EU ships. Since the lower-salary EU flags are the ones that are the closest to the foreign competition (in terms of cost), this brings them in a better position to close the “competitiveness gap” by crew reduction, given the gap is smaller for them than it is for higher-salary EU flags.

A question then is what might be an appropriate incentive structure in order for ATOMOS technologies to be adopted by EU shipowners who operate lower-salary ships (such as Greeks, for instance). As much as this would have the greatest chance of beating conventional cheap-crew non-EU ships, this would also be the least likely scenario to occur if a “laissez faire” policy is followed, since such EU shipowners would have the least incentive in making this happen.

An important caveat: An assumption in all of our analyses has been that ATOMOS-type crews have received appropriate training and certification. This means that it might be impossible to implement such ships in countries that cannot supply crews adequately trained for this purpose. Another important ramification of this assumption is that a highly skilled crew will generally be more expensive in terms of salary than a conventional crew, implying that an ATOMOS-type ship that is also a low-salary ship may be unlikely to occur.

We finally believe that countries suffering from flagging out should look into the possibility of adopting more flexible manning regulations. These would allow ATOMOS-type ships to be manned by a mixture of flag and non-flag nationals, so as to achieve a lower manning cost structure. The declining supply of seafarers worldwide would provide an additional reason for looking seriously into such an alternative.

Acknowledgments

Project ATOMOS was funded by the Commission of the European Communities, Directorate General for Transport (DGVII), Contract Number 8101-CT91-2301. ATOMOS partners were: DSB Ferries- (project leader), Danish Maritime Institute, Aalborg University, Logimatic, Danish Maritime Authority, National Technical University of Athens, STN Atlas Elektronik, Lloyds Register of Shipping, and Lyngsoe Marine.

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