Stockholm Agreement – Past, Present & Future (Part II)

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ABSTRACT

This paper provides a succinct summary of the findings ensuing the undertaking of a dedicated EU-funded research project aiming to address the impact of the Stockholm Agreement (SA) on the EU Ro-Ro passenger ships. This is achieved by utilising the experience gained, the data and knowledge accumulated through the adoption of the Stockholm Agreement in NW Europe to form the basis for predicting the likely impact of introducing this Agreement to vessels operating in EU waters not covered yet by it. The background, including a historical overview and a detailed introspective look at the SA, together with an assessment of its impact on passenger Ro-Ro ships safety standards, design and operation are presented in a companion paper (Part I) in June 2002 issue of MT.

INTRODUCTION

Concerted action to address the water-on-deck problem in the wake of the *Estonia* tragedy led IMO to set up a panel of experts to consider the issues carefully and make suitable recommendations. However, the complexity of the problem and the need to take swift action to reassure the public that appropriate steps are taken to avoid a repeat of the *Estonia* disaster influenced to a large extent both the initial and final proposals. Following considerable deliberations and debate (obviously unresolved), a new requirement for damage stability has been agreed only among the northwestern European Nations to account for the risk of accumulation of water on the Ro-Ro deck. This new requirement, known as the *Stockholm Agreement* [1] demands that a vessel satisfies SOLAS ‘90 requirements (allowing only for minor relaxation) with, in addition, water on deck by considering a constant height calculated as shown in Figure 1. The term Hs, characterising the operational sea state, pertains to the average of one-third highest waves (significant wave height, typically of un undeveloped sea – hence narrow banded), a statistical average correlating very well with the average of observed wave heights for a given sea state.

The dates of compliance with the provisions of the agreement range from April 1, 1997 to October 1, 2002. However, in view of the uncertainties in the current state of knowledge concerning the ability of a vessel to survive damage in a given sea state, an alternative route has also been allowed which provides a non-prescriptive way of ensuring compliance, through the “*Equivalence*” route, by performing experiments in accordance with the SOLAS ’95 Resolution 14, [2].

Deriving from the above, numerical simulation models developed on the basis of systematic research over the past 15 years, [3] and capable of predicting with good engineering accuracy the capsizal resistance of a damaged ship, of any type and compartmentation, in a realistic environment whilst accounting for progressive flooding were also used, offering the ferry industry the attractive possibility of utilising such “tools” to assess the damage survivability of ferry safety, the so called “*Numerical Equivalence*” route. Numerical simulation readily allows for a systematic identification of the most cost-effective and survivability-effective solutions to improving ferry safety and hence offers a means for overcoming the deficiency of the physical model tests route in searching for optimum solutions and an indispensable “tool” for the planning and undertaking of such tests.

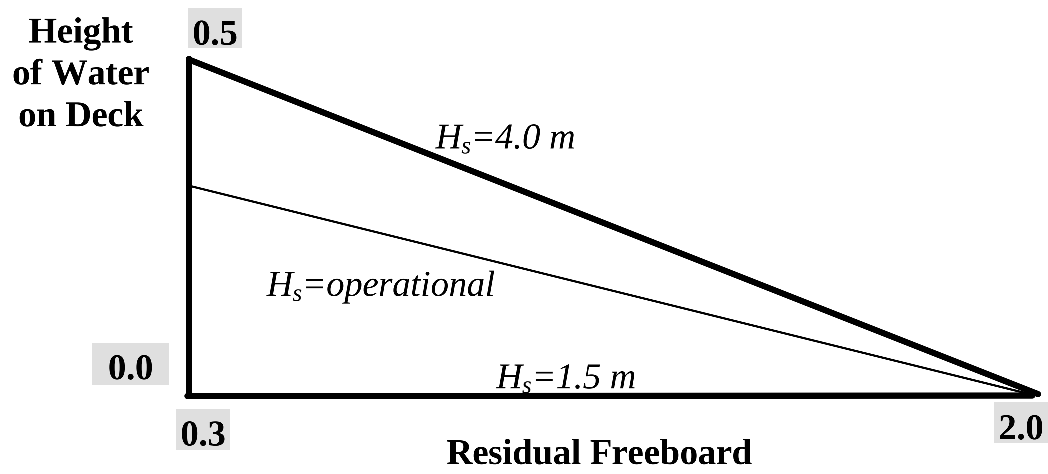

Figure 1: Stockholm Agreement (Height of water on Deck)

October 1 2001 has therefore marked the beginning of the final year of the period initially allowed for compliance with the Stockholm Agreement (SA) requirements, a period during which almost 80% of the Ro-Ro fleet in North West Europe has been subjected to calculations, model testing and numerical simulations on the way to meeting the new requirements pertinent to the Agreement. The experience gained has been invaluable in understanding better the problem at hand and is being utilised to shape new developments for future Ro-Ro designs. All relevant details are presented in a critical overview of Stockholm Agreement from its inception to its implementation and ensuing impact in a companion paper (Part I) in the June 2002 issue of MT.

The North-South divide, however, continues to cause unrest, particularly at European level. Efforts to assess the status quo in North West Europe and use the information amassed so far as a means to predicting the potential impact of introducing the SA in the South, led to a dedicated call by the Commission and to a contract being awarded to two closely collaborating research teams in the North and South Europe, one at the Ship Stability Research Centre of the Universities of Glasgow and Strathclyde and the other at the Ship Design Laboratory of the National Technical University of Athens. This study was finalised in March 2001 and a detailed technical report produced, describing comprehensively all the work undertaken, a brief account of which is presented here following an outline description of the background and aims of the study and of the methodology adopted in completing this work.

THE SSRC-NTUA COMMISSION STUDY

Background and Aims of the Study

At the conclusion of the second Stockholm Conference at which the Agreement was adopted, the Commission services issued a statement, taking note of the Agreement concluded and expressing the opinion that the same level of safety should be ensured for all Ro-Ro passenger ferries operating in similar conditions. Noting that the Agreement is not applicable to other parts of the European Union, the Commission announced its intention to examine the prevailing local conditions, environmental and operational, under which Ro-Ro passenger ferries sail in all European waters and that this examination will include the extent and effect of the application of the Agreement in the region covered by it. The statement concluded that in light of this examination the Commission would make a decision with regard to the need for further initiatives and this statement was confirmed at subsequent meetings of the Council highlighting the need to ensure the same level of safety for all Ro-Ro ferries operating in similar conditions was more precisely defined by referring to both international and domestic voyages.

Furthermore, in its latest proposal for Community legislation governing the safety of Ro-Ro passenger ships, the Commission included a draft provision that Ro-Ro ferries shall fulfil the specific stability requirements adopted at regional level, when operating in the region governed by such regional rules. This proposal was endorsed by the Council with a number of adaptations to clarify that host States shall check that Ro-Ro ferries "*comply with specific stability requirements adapted at regional level, and transposed into their national legislation,….provided those requirements do not exceed those specified in the Annex of Resolution 14 (Stability Requirements Pertaining to the Agreement) of the 1995 SOLAS Conference and have been notified to the Secretary-General of the IMO, in accordance with the procedures specified in point 3 of that resolution.*"

Taking fully into account the above elements, the Commission invited tenders to a study to examine the extent and effect of the application of the Stockholm Agreement concerning specific stability requirements for Ro-Ro passenger ships, and the suitability of extending its scope to European waters not covered by it. The contract to undertake this study was awarded to the NAME-SSRC/NTUA-SDL partnership. More specifically, the overall aim of the study was to assess the impact of the Stockholm Agreement on European Ro-Ro passenger ships by targeting the following two objectives:

A. Impact assessment on the extent and the effect of the application of the Stockholm Agreement concerning specific stability requirements for Ro-Ro passenger ships in the area covered by it.

B. Impact assessment on the extent and the effect of the application of the Stockholm Agreement concerning specific stability requirements for Ro-Ro passenger ships in European waters not covered by it.

Proposed Methodology

The methodology adopted in completing this work is shown in Figure 2, explaining for each of the two distinct areas A and B the scope and approach to be followed to attain the results sought. The study took one year to complete and produced two comprehensive technical reports addressing each one of the two areas separately, [4], [5]. The key findings of this work are summarised here for areas A and B respectively, following the format of the adopted methodology.

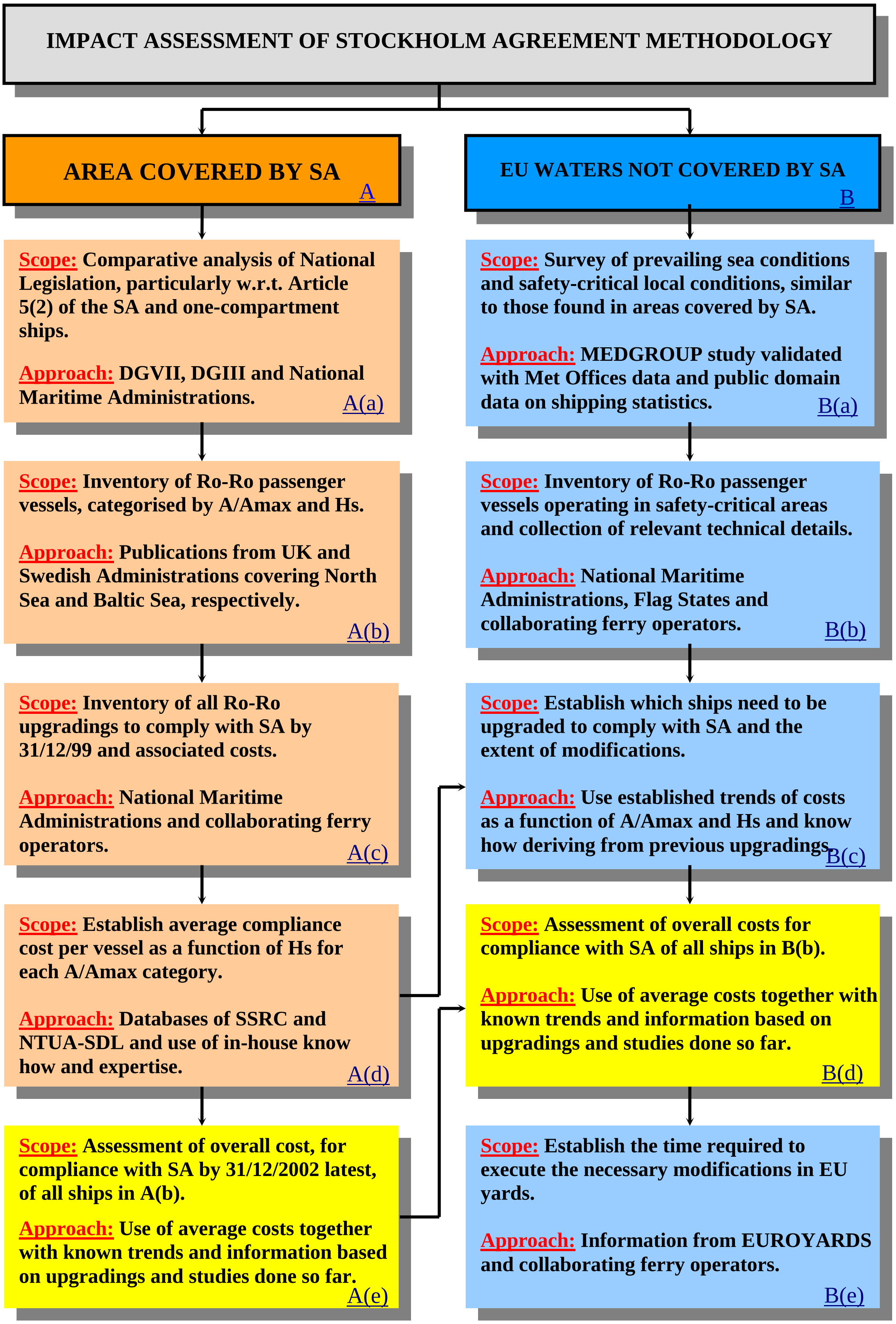

Figure 2: Adopted Methodology for the SA Study

AREA COVERED BY THE STOCKHOLM AGREEMENT

Key Findings

As shown in Figure 2, the study comprises five tasks, each forming part of the methodology adopted as explained therein and summarised here below:

Comparative Analysis of National Legislation A(a): The National Legislations of the counties being parties to the SA were elaborated upon, aiming to: ascertain if the application of the SA is extended to Ro-Ro passenger ships entitled to fly the flag of States non-parties to the Agreement; assess the extent to which parties to the SA are bringing one-compartment Ro-Ro passenger ships in compliance with technical requirements of the SA as a matter of priority; identify if Contracting Governments to the SA apply earlier implementation dates than those specified in Annex 2 to the Agreement for ships trading between their ports.

The main results from task A(a) showed that, in the main, all countries affected by the SA have applied it without alterations. Exceptions to this are the UK and Norway. In the first case, it is interesting to note that the UK also applies the Stockholm Agreement requirements to Ro-Ro passenger ships operating on comparable domestic seagoing routes (Class II(A)). In addition the UK decided that every ship to which the Merchant Shipping (High Speed Craft) Regulations 1996 apply in so far as it implements Chapter 2 Part B of the High-Speed Code shall comply with the requirements of the Agreement relating to specific stability standards. In the second case, the Stockholm Agreement requirements apply to any Ro-Ro passenger ship to which SOLAS apply. As a result, every Norwegian Ro-Ro passenger ship should comply with the requirements of the SA on any voyage whether or not it is within the geographical area of the SA. Furthermore, additional requirements apply on the design of deck barriers. In all cases, no pertinent information can be discerned addressing specifically issues pertaining to bringing either one- or two-compartment vessels in compliance earlier than the compliance dates specified in Annex 2 to the Agreement. Also, it is to be noted that France is the only EU country, which whereas it is not one of the signatories of the Agreement, it is partly affected by the latter, taking into account that a large number of French vessels operating in the channel were to be modified to comply with SA requirements.

Inventory of Passenger Ro-Ro Vessels A(b): General information on Ro-Ro Passenger ships was collated, along with relevant technical data, including information on compliance with relevant stability standards. The vessels were categorised by A/Amax and operational Hs. A comparison between the databases corresponding to North EU (NEU) and South EU (SEU), respectively, led to the following conclusions: the NEU fleet is generally younger (Figure 3) and has on the whole higher stability standards than the SEU (Figure 4); it is also shown that the value of A/Amax of the North European fleet has risen considerably during the last five years, as a result of about 30% of the relevant vessels having already been upgraded to SOLAS ‘90 and to Stockholm Agreement standards by the beginning of the year 2000; by contrast, operational significant wave heights values are generally evenly distributed throughout the EU fleet and are marginally higher in NEU than the SEU (Figure 5, to be contrasted against Figure 10). As a general comment, it has been noted that the experimental route to compliance with the Stockholm Agreement is normally preferred (77% experimental route to 23% calculation route based on 79 upgraded vessels), since opting for this alternative enables ship owners to obtain a margin on the attained Hs for their vessels, without increasing the complexity or cost of the upgrading. This margin is particularly valuable to ship owners, as it is likely to influence positively the resale value of their vessels.

Inventory of Passenger Ro-Ro Vessels Upgrading and Related Costs A(c): A comprehensive inventory was undertaken of the technical modifications and adaptations carried out to all ferries, which had to comply with the SA by 31/12/99 or earlier, and of the associated costs. This part of the study showed that although a large number of the ships affected by SOLAS '90 and SA need major modifications in order to comply with these stability standards (80% major, 13% minor and 7% none based on 61 vessels), a good part of these is due to the specific requirements related to SOLAS '90 standard. Although this is not necessarily the case if larger values of operational Hs need to be attained, in practice this indicates that the main effect of the SA in the NEU has been to accelerate the schedule of compliance with SOLAS '90 requirements.

Distributions of major and minor modifications are shown in Figure 6 whilst the cost distribution is presented in Figure 7, this varying from €60k to €5.5M with an average of €2.1M per vessel, based on 58 vessels.

Average SA Compliance Cost for NEU Ro-Ro Vessels A(d): Studies aiming to establish average compliance cost per vessel as a function of the operational sea state and A/Amax category for a given vessel were undertaken, based on the experience accumulated by the application of the SA in the NEU. Statistical trends in this respect were established, which provided a useful input for evaluating the extent of modifications required by the SEU fleet. The results of this task (Figure 8), showed that: in the NEU there are comparatively more ships belonging to the lower upgrading cost brackets than to the higher ones; there is good correlation between average overall cost of upgrading and GDP per capita (GDP per capita referring to the country in which the ship was upgraded or – in absence of this information – the country where the ship operates from); cost of upgrading and A/Amax values are well correlated and since there is good correlation between age and A/Amax, it is reasonable to use the first as an indicator of a ship stability standard, all other data being unavailable; the variation of cost of modification with ship size is generally best represented by a logarithmic law, GT seemingly giving the best fit to the data available; it is virtually impossible to detect a trend of variation of cost of modification versus significant wave height. It is to be noted that since the sample data available for achieving this task was limited, the regression linking the cost of upgrading to GT and A/Amax implied an unacceptably large error. For this reason, this analysis was repeated and verified in greater detail, as explained next.

Assessment of Overall SA Compliance Cost for NEU Ro-Ro Vessels A(e): In this task it has been attempted to further demonstrate and better quantify the link between upgrading cost and relevant parameters such as A/Amax and GT, continuing from the results presented in A(d) by using a sample representing about 70% of the NEU fleet that needs to comply with the SA. On this basis, statistical trends were established, representative of the present status of the implementation of SA in the NEU, to be used for estimating on the whole the possible effect of introducing the SA to SEU. Furthermore, an estimate of the cost of the modifications still required to complete the SA upgrading in NEU was provided. In general this part of the project corroborate all the findings of part A(d), offering a better regression formula linking A/Amax and GT to overall cost of upgrading (Figure 9). Moreover, a detailed analysis of the cost of each type of modification has also been attempted, leading to similar results in terms of overall cost of modifications per ship. On the basis of this analysis and estimating that about 28 vessels were still undergoing upgrading in the NEU, the total cost of the outstanding upgrading was calculated to be approximately €11.7M. This raised the total cost of upgrading of the NEU fleet to about €85M, with 36% of the fleet not requiring any upgrading and about 69% of the vessels having been upgraded for less than €1.0M.

EU WATERS NOT COVERED BY THE STOCKHOLM AGREEMENT

Key Findings

As shown in Figure 2, the study comprises five tasks, each forming part of the methodology adopted as explained therein and summarised here below:

Survey of Prevailing Sea Conditions and Safety-Critical Local Conditions B(a): The prevailing sea conditions and other safety-critical local conditions in SEU geographical areas not covered yet by the SA were investigated. The wave heights were determined following two alternative, yet essentially complementary, approaches. In the first approach the main ferry routes between ports involving at least one SEU state were analysed. In the second approach, whole geographical regions have been associated with characteristic wave height values. Results of this study show (Figure 10) that relevant significant wave heights (Hs) in the Mediterranean are generally lower than 3.0m, with the exception of the region west of the island of Corsica where the obtained Hs was approximately 3.25m. However, larger wave heights, even exceeding 4.0m, were noted in the Atlantic routes to Madeira and the Azores. Concerning other, possibly safety-critical local conditions, such as wind, air and sea surface temperatures, visibility, traffic densities and other similar conditions it can be concluded, based on the collected data, that the local sea conditions are less safety-critical, when compared to the corresponding conditions in NEU waters, due to the higher average air and sea surface temperatures and the generally less significant traffic densities in the pertinent local areas.

Inventory of Passenger Ro-Ro Vessels in SEU Waters B(b): A comprehensive inventory was undertaken of Ro-Ro passenger vessels operating in SEU, along with relevant technical data, including information on compliance with relevant stability standards. The vessels were categorized by means of a variety of technical, stability sensitive characteristics and economic indicators. It is to be noted that since information on A/Amax values for several registered vessels was very limited (not available or not reliable), the relevant analysis was mainly based on the stability standard of compliance, thus providing indirectly an indication of the actual A/Amax values of the vessels under consideration. Results are shown in Figures 3 and 4, where they are contrasted against results from NEU vessels.

Ships to be upgraded to Comply with SA B(c): The scope of this task was to establish which of the ships that operate in SEU would need to be upgraded to comply with the provisions of The SA and the possible extent of required modifications. Based on the inventory of the ships under investigation (Task B(b)), their current stability standard of compliance, area of operation (Task B(a)) and corresponding A/Amax values, the results provided a categorisation of the affected ships according to their current stability standards of compliance, relevant A/Amax values and year of built or major modification. On this basis, it was established which ships need to be upgraded in order to comply with the SA, the extent of the required modifications in relation to relevant provisions of the SOLAS regulations and the expected dates of compliance (if formally the requirements of the presently valid SOLAS '90–2 compartment standard are met independently of a possible extension of the provisions of the SA to EU regions not covered by it), (Figure 11). Based on the technical characteristics and the area of operation of the affected ships it was concluded that the techno-economic effort to upgrade these ships to SOLAS '90, 2-compartment standard, would not deviate much from the effort required to ensure compliance with the provisions of the SA.

Assessment of Overall Cost of SEU Vessels for Compliance with SA B(d): The objective of this task was to assess the costs associated with the necessary modifications of SEU Ro-Ro passenger ships, identified and analysed under B(b) and B(c), for compliance with stability requirements similar to those of the SA. Taking into account that SEU Ro-Ro passenger ships are generally operating in waters of comparably lower Hs and also available scientific evidence indicating that ships complying with the SOLAS '90 standard will survive SOLAS damages of at least 2.5m Hs, as derived from model tests according to the "Equivalent Model Test Procedure" of Resolution 14, SOLAS '95, it has been concluded that the modification cost of SEU ships for compliance with the provisions of the SA will be approximately the same as the associated cost for compliance with the requirements of the SOLAS '90 2-compartment standard. Based on the results of a detailed cost analysis of modifications for the NEU ships (task A(e)) and the derived regression formulae therein, the A/Amax values and GT values of the inventory ships and the GDP of the flag state, the itemised cost/ship as well as the overall cost for the SEU ships has been deduced. Based on this, the total modification for the whole SEU fleet (264 ships) is estimated to range between a minimum of €106M and a maximum of €250M. It is to be noted that these estimates do not consider the possible removal from service of aged SEU ships, which is to be expected since it might prove economically more advantageous for ship owners to replace some of these ships with new buildings instead of undertaking onerous extensive modifications.

Assessment of Modification Time for Compliance of SEU Vessels with SA B(e): The objective of this task was to assess the time required to execute the necessary modifications for the affected SEU ships, identified and analysed under B(b), B(c) and B(d), considering the capacity of European shipyards, anticipated delivery times and the need to ensure continuity of service. Taking into account the fact that the process of upgrading the affected ships is not a continuous function of time and that the relevant shipping companies will rather choose to wait until it is absolutely necessary to modify ships, it is concluded that the time required for the modifications will be strictly following the 'phase in' procedure for compliance with the provisions of Stockholm Agreement, to be decided by the European Council. Therefore, the present task has been based on the assumption of an accelerated compliance schedule for the affected SEU ships with the full provisions of SOLAS '90 (Reg. 8-1 and Reg. 8-2) based on the deduction outlined in B(d) above. The assumed time schedule, ranging from 1 October 2002 for ships with lower values of A/Amax, to 1 October 2005 for those in the highest A/Amax category, appears feasible in all respects, as this compliance schedule does not deviate from the existing compliance with Regulation 1 of SOLAS '90 (provisions for one compartment standard compliance). More importantly, this holds true for the large majority of existing vessels (78.1%, 235 out of 301 existing ships), whereas for the remaining ships already complying with Regulation 1, SOLAS '90 (21.9%, 66 out of 301 ships) the impact is considered to be less severe and feasible within the set accelerated time schedule. From the point of view of availability and capacity of European shipyards in order to accomplish the requested modifications and the seamless continuation of service, it can be concluded that, since the time schedule for compliance with the provisions of SOLAS '90 is practically unchanged, no additional negative effects would result from the introduction of Stockholm Agreement in SEU. However, the feasibility of the first compliance date being 1 October 2002 would need to be critically examined, considering that 59% of the ships identified for upgrading would be affected.

CONCLUDING REMARKS

The North-South divide concerning safety of Ro-Ro passenger ships continues to trouble shippers and regulators alike and a way forward is actively being sought. Serving this need, an SSRC-NTUA partnership has undertaken on behalf of the European Commission a study to assess the impact of the Stockholm Agreement on the areas covered by it with the view to evaluating the likely impact of introducing it to areas not covered by it. This introspection on the Stockholm Agreement led to the following key conclusions:

- SOLAS '90 ships appear to be capable of surviving sea states at least 2.5m Hs and that SOLAS '90 is a "good" standard reflecting meaningfully the safety of Ro-Ro vessels.

- The Stockholm Agreement appears to be unrealistically stringent, in general demanding levels of safety well beyond those determined through performance-based methods and, at times, simply unattainable.

- Considering that a SOLAS '90 ship survives 2.5 m Hs and accounting for the comparative lower Hs distribution in South European waters, it would appear that the upgrading cost to Stockholm Agreement would not be dissimilar to the cost and time for upgrading to SOLAS '90 2-compartment standard.

- Projections based on the upgrading experience and incurred costs in North Europe reveal that the estimated overall cost of upgrading the South European fleet would be between €106M and €250M.

ACKNOWLEDGEMENTS

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REFERENCES

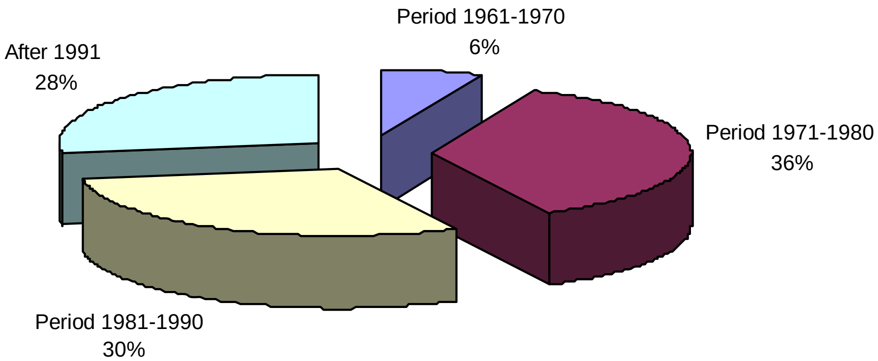
[1] **IMO Resolution 14,** "Regional Agreements on Specific Stability Requirements for Ro-Ro Passenger Ships" **–** (Annex: Stability Requirements Pertaining to the Agreement), adopted on 29 November 1995.

[2] **IMO Resolution 14,** "Regional Agreements on Specific Stability Requirements for Ro-Ro Passenger Ships" **–** (Appendix: Model test method), adopted on 29 November 1995.

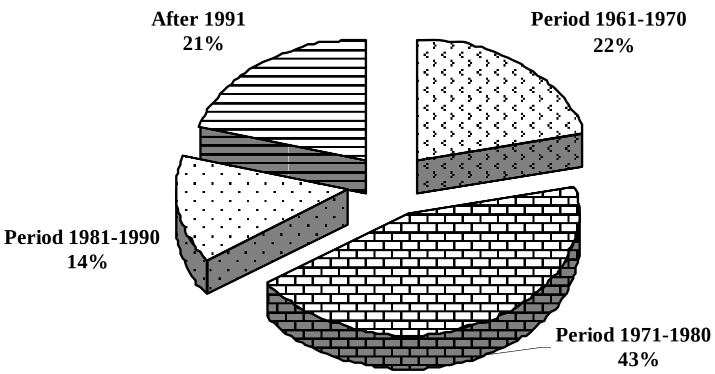
[3] **Vassalos, D, Pawlowski, M and Turan, O**, "A Theoretical Investigation on the Capsizal Resistance of Passenger/Ro-Ro Vessels and Proposal of Survival Criteria", Final Report, The Joint North West European Project, University of Strathclyde, Department of Ship and Marine Technology, March 1996.

[4] **D. Vassalos, O. Turan, L. Letizia and D. Konovessis,** "Impact Assessment of Stockholm Agreement on EU Ro-Ro Passenger Vessels Covered by it", (B99-B2702010-SI2.144738), Final Report Part I, NAME-SSRC, March 2001.

[5] **A. Papanikolaou, K. Spyrou, E. Eliopoulou and A. Alissafaki,** "Impact Assessment of Stockholm Agreement on EU Ro-Ro Passenger Vessels not Covered by it", (B99-B2702010-SI2.144738), Final Report Part II, NTUA-SDL, March 2001.

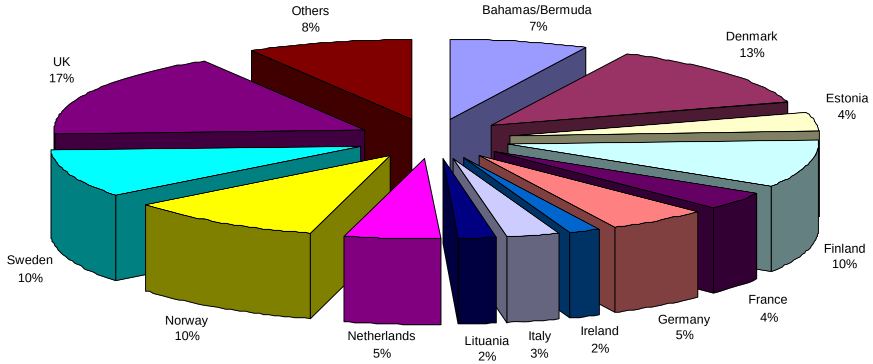


(NEU - 286 sampled vessels)

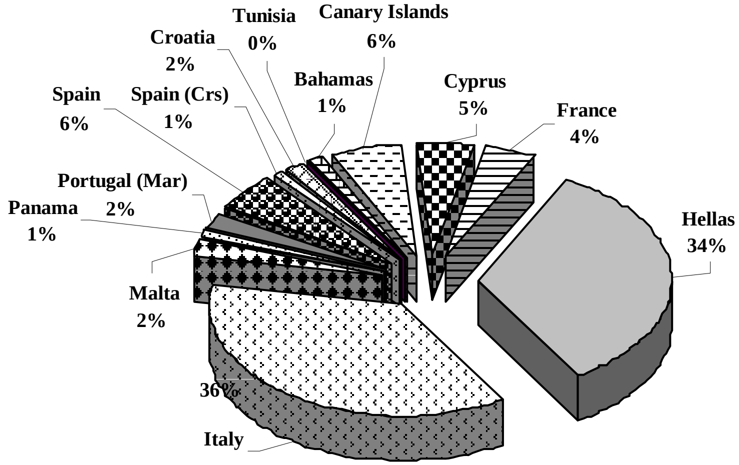


(SEU - 302 sampled vessels)

Figure 3a: Distribution of Year of Built

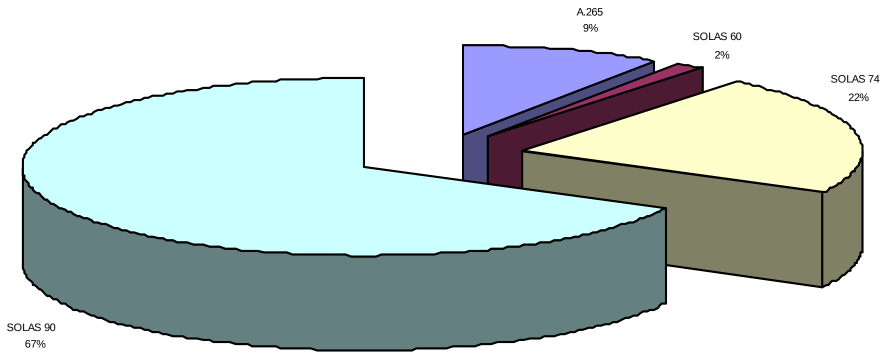


(NEU - 295 sampled vessels)

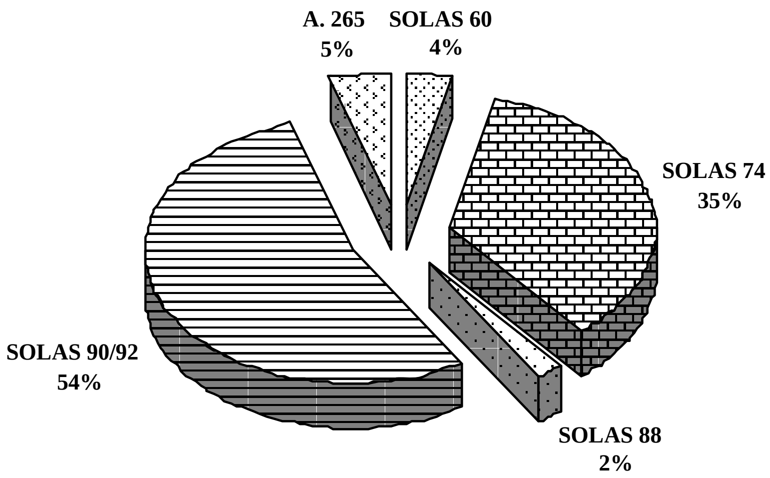


(SEU - 302 sampled vessels)

Figure 3b: Current Flag Distribution



(NEU - 128 sampled vessels)



(SEU - 85 sampled vessels)

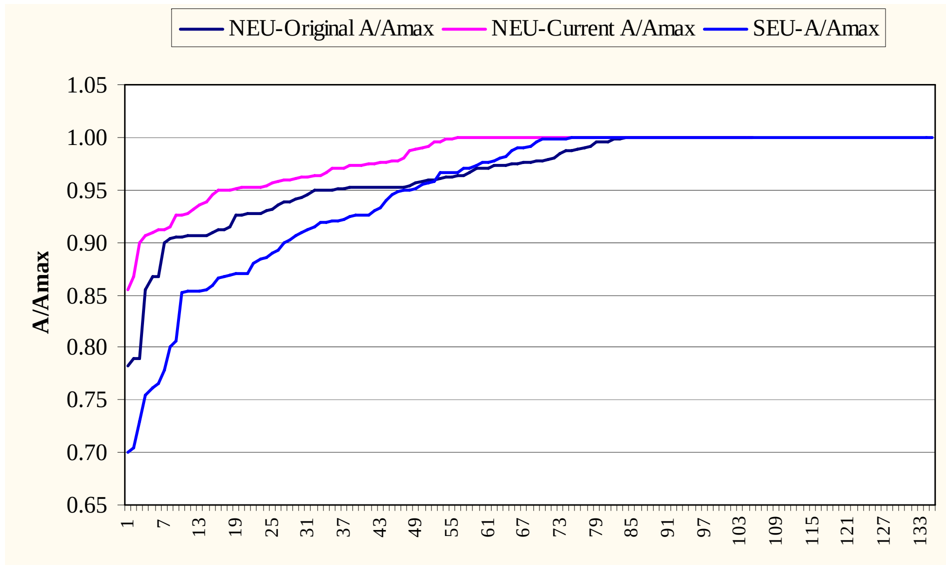
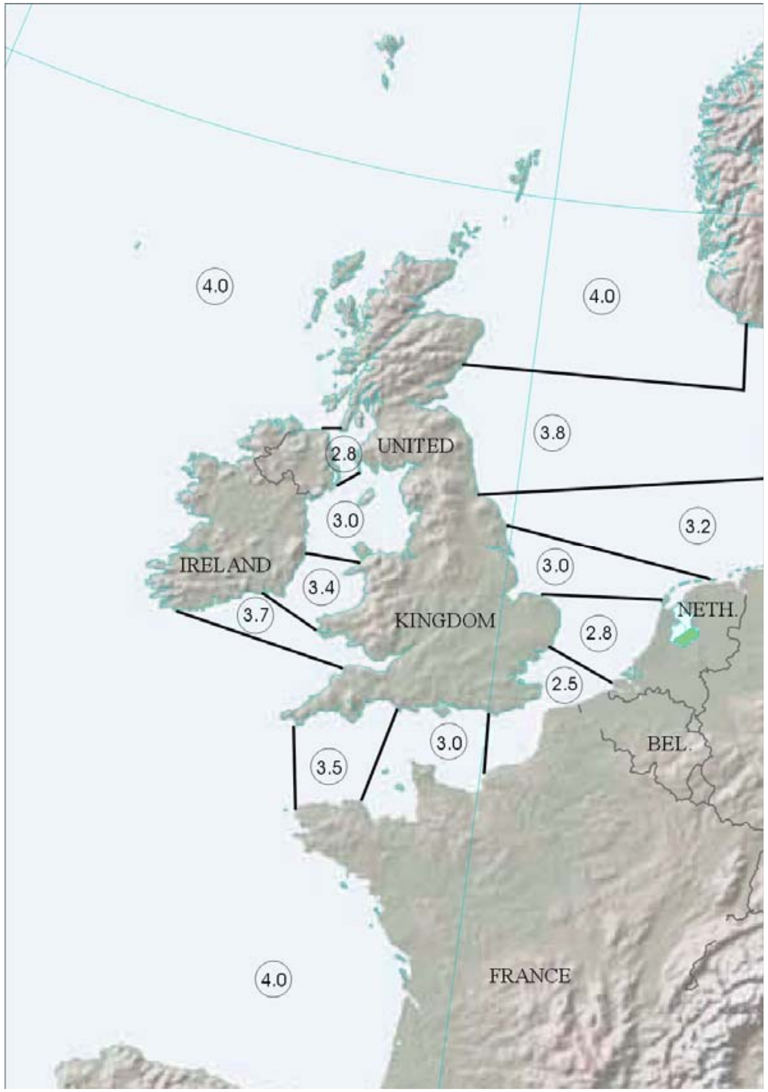


Figure 4a: Compliance with SOLAS Regulations

Figure 4b: Distribution of A/Amax



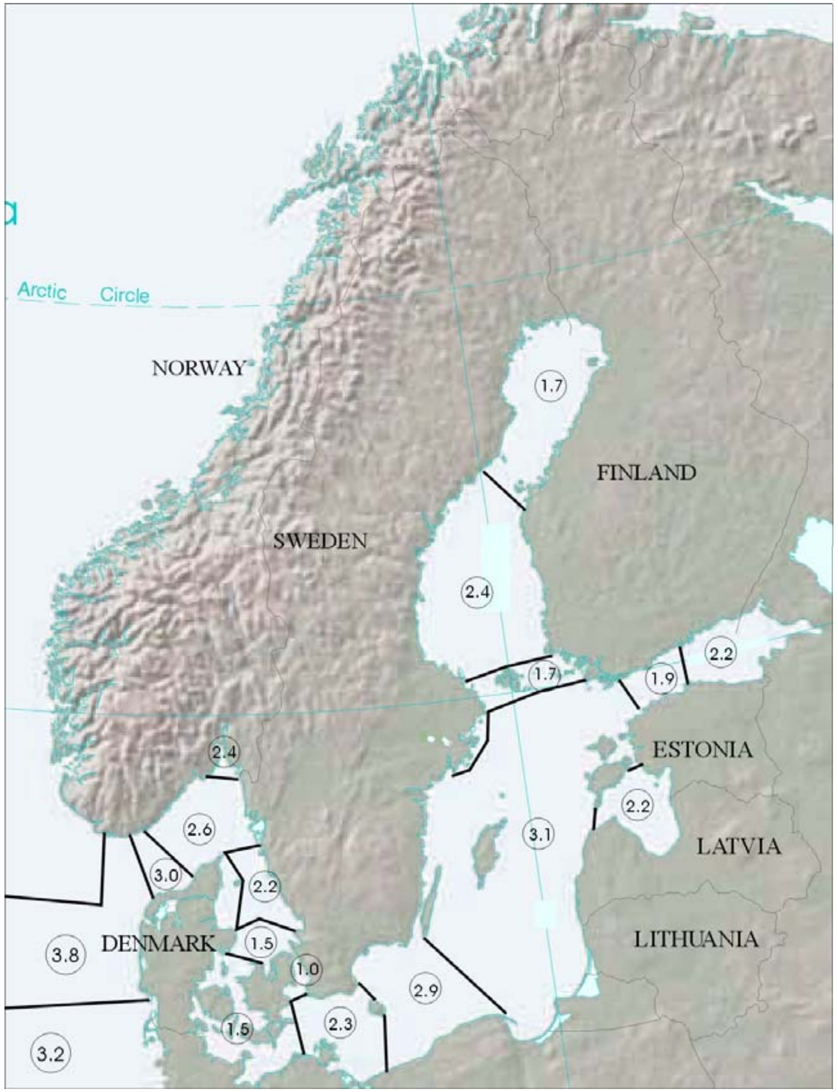


Figure 5: Distribution of Hs is NEU

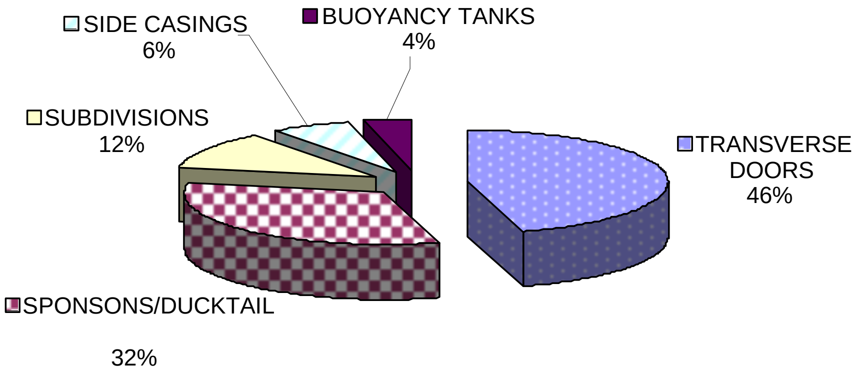


Figure 6a: Distribution of Major Modifications (NEU - 49 vessels)

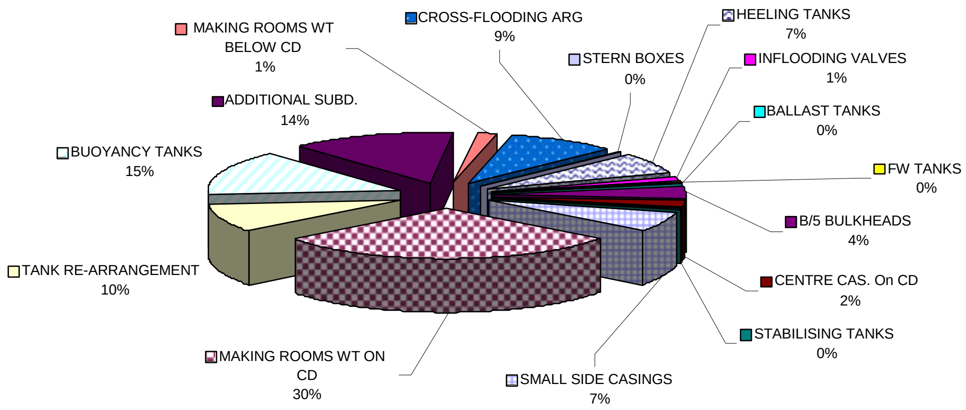


Figure 6b: Distribution of Minor Modifications (NEU - 53 vessels)

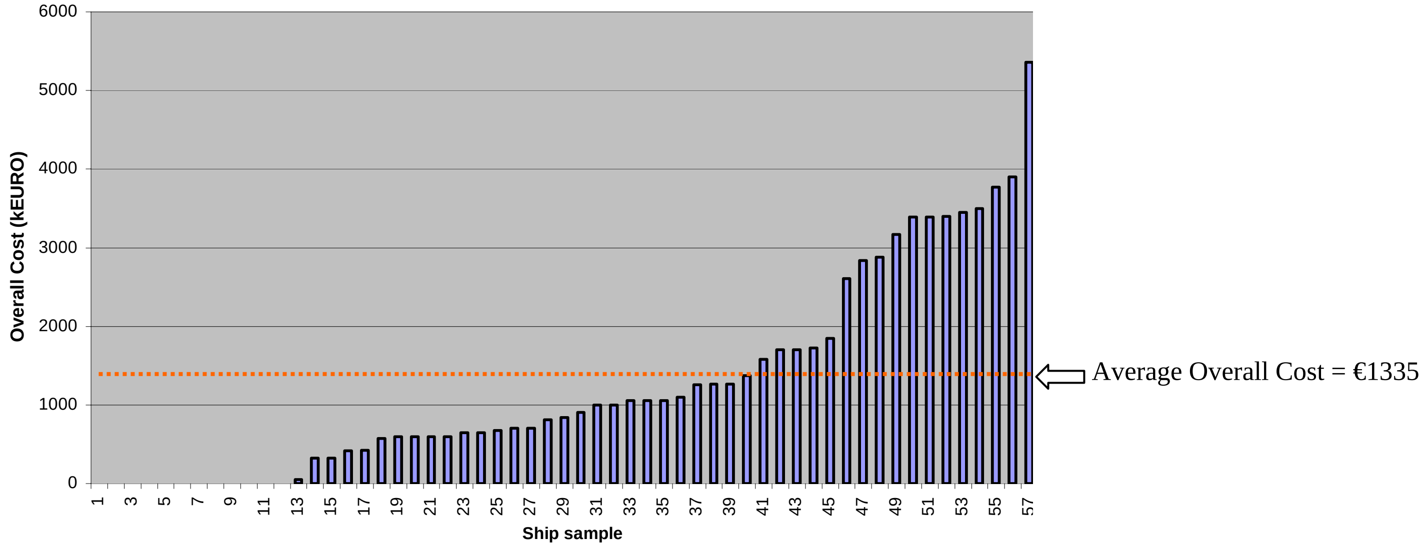


Figure 7: Distribution of Overall Cost of Upgrading (NEU – 58 sampled vessels)

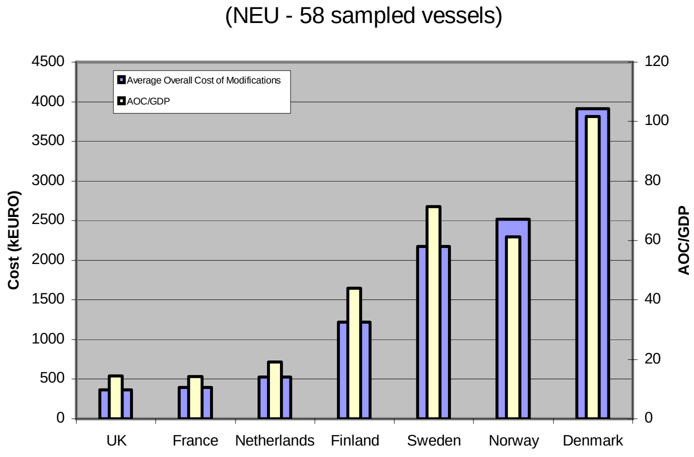


Figure 8a: Cost and Normalised Cost Distribution with Country

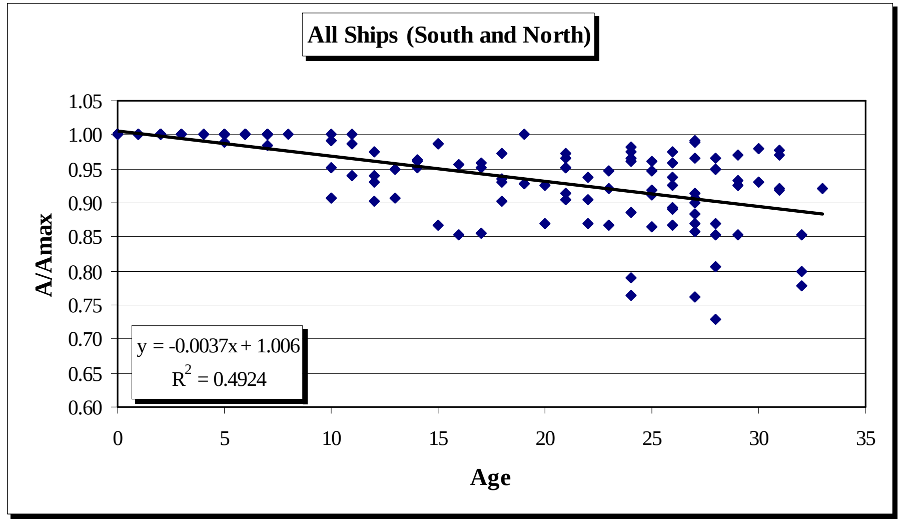


Figure 8b: A/Amax Vs. Vessel Age

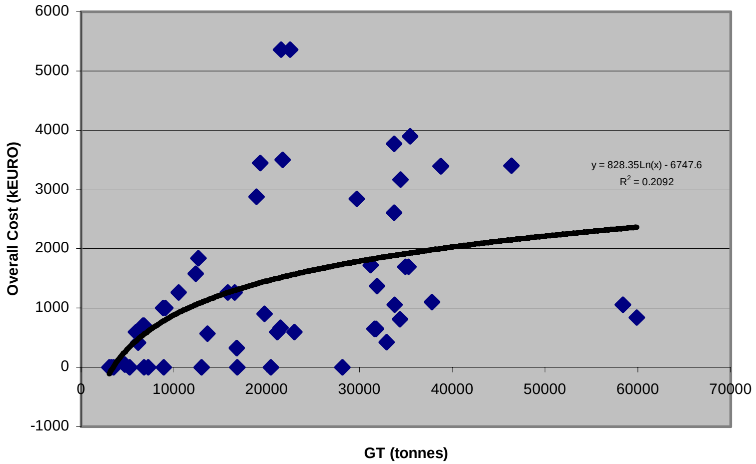


Figure 8c: Cost of Upgrading Vs. GT (NEU - 40 sampled vessels)

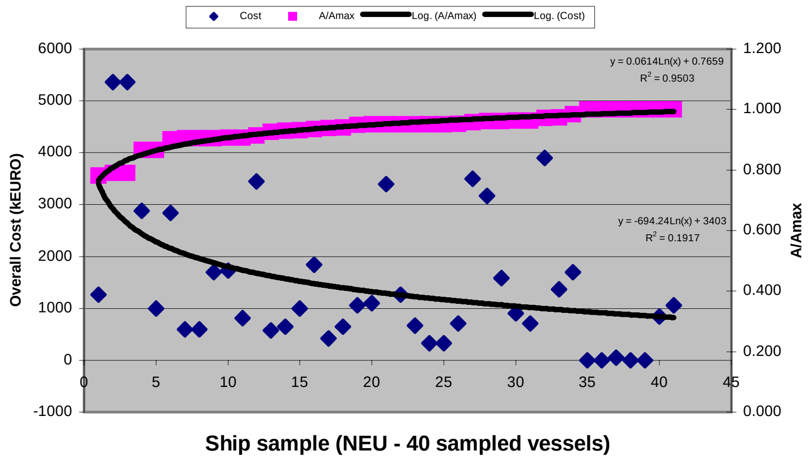


Figure 8c: Cost of Upgrading and A/Amax Distribution

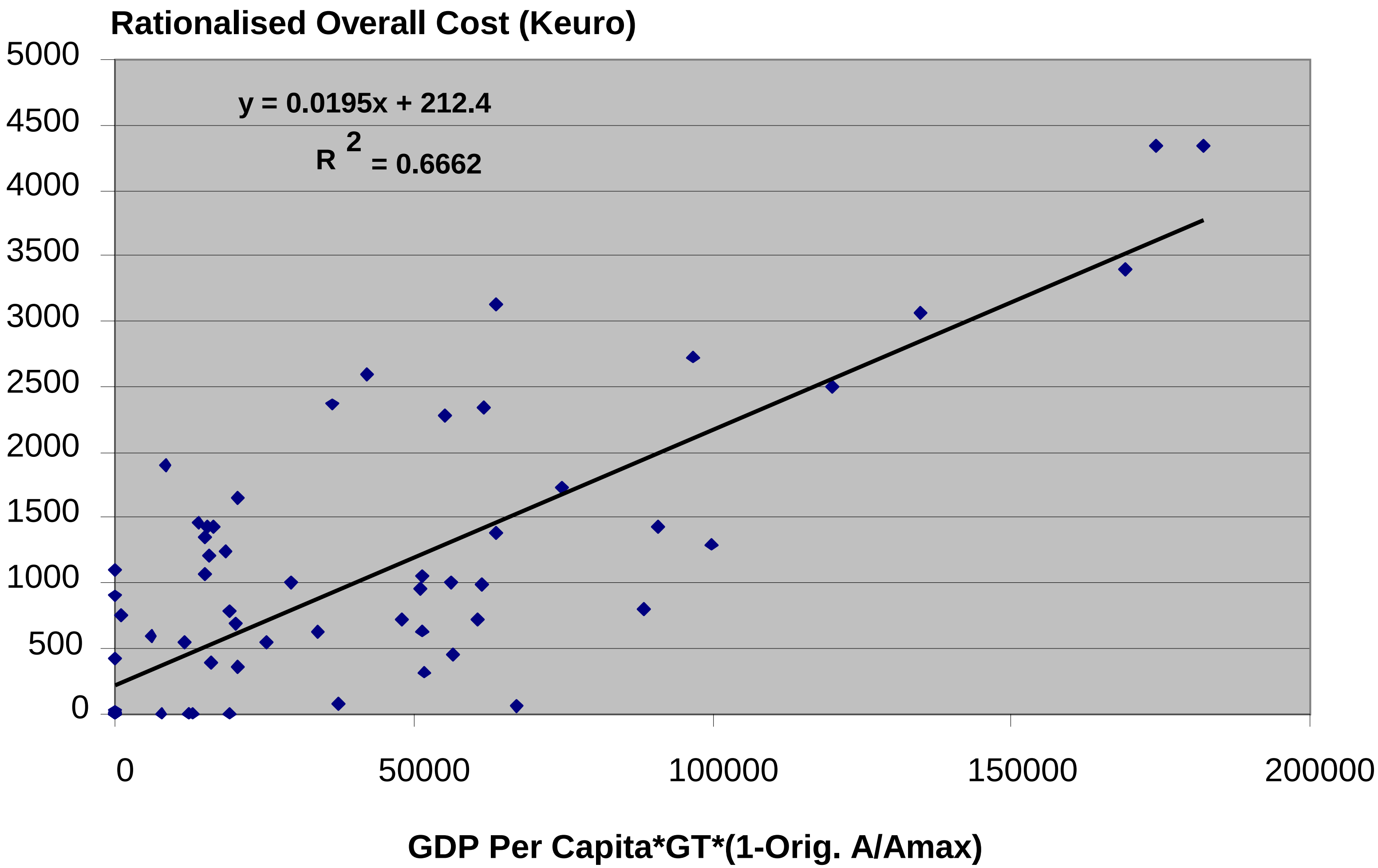


Figure 9: Rationalised Overall Cost of Upgrading vs. GDP*GT*(1-A/Amax) (NEU - 84 sampled vessels)

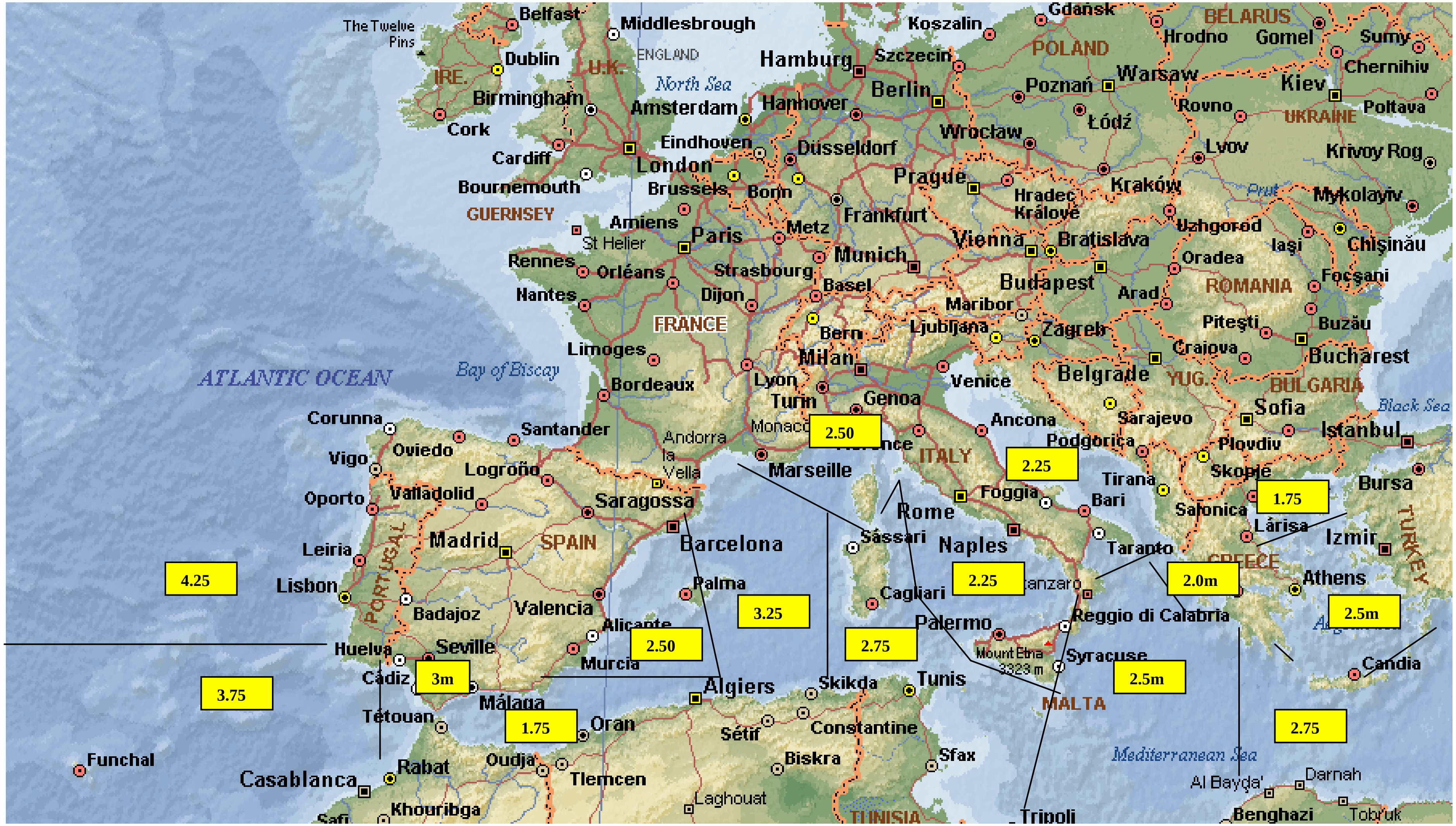


Figure 10: Distribution of Hs in SEU

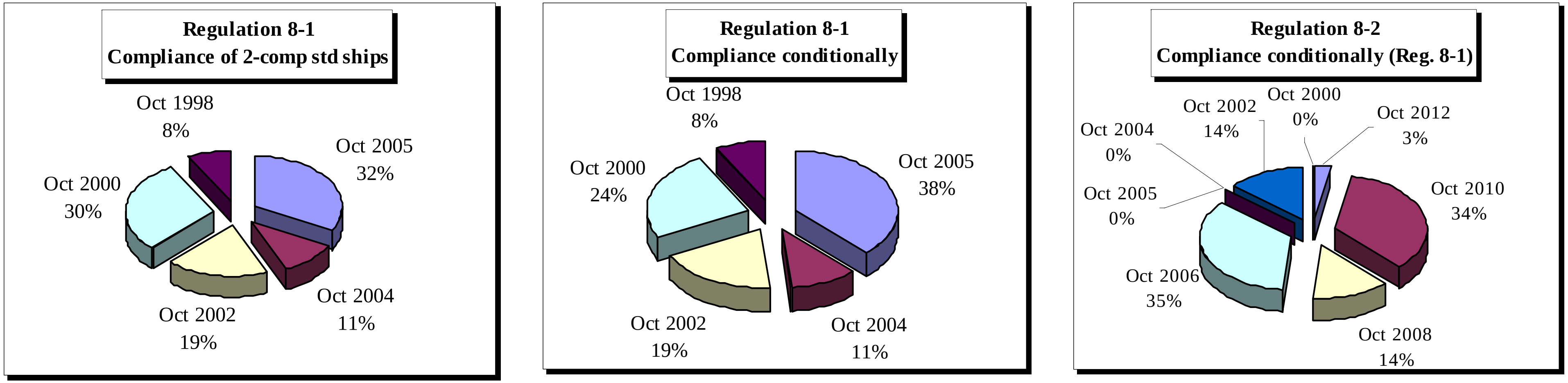


Figure 11a: Ships with Recorded A/Amax Values (37 2-compartment standard ships out of 54 with conditional compliance)

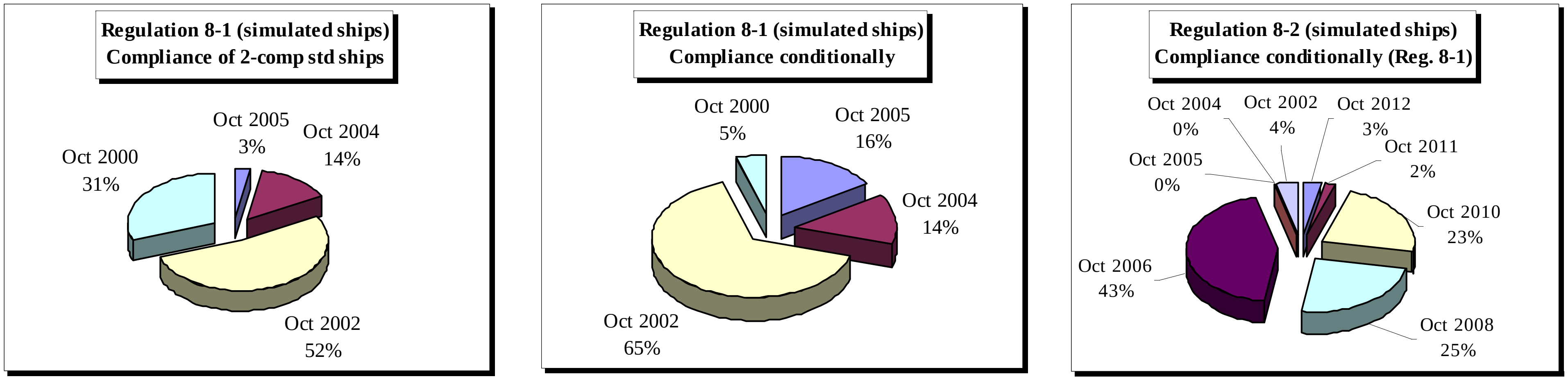


Figure 11b: Ships with Simulated A/Amax Values (101 2-compartment standard ships out of 148 with conditional compliance)

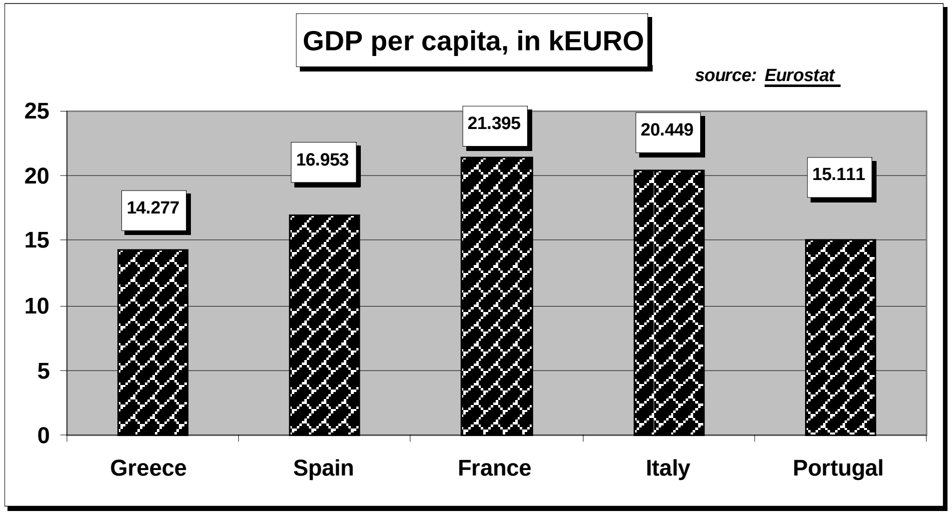


Figure 12a: GDP per Country in SEU

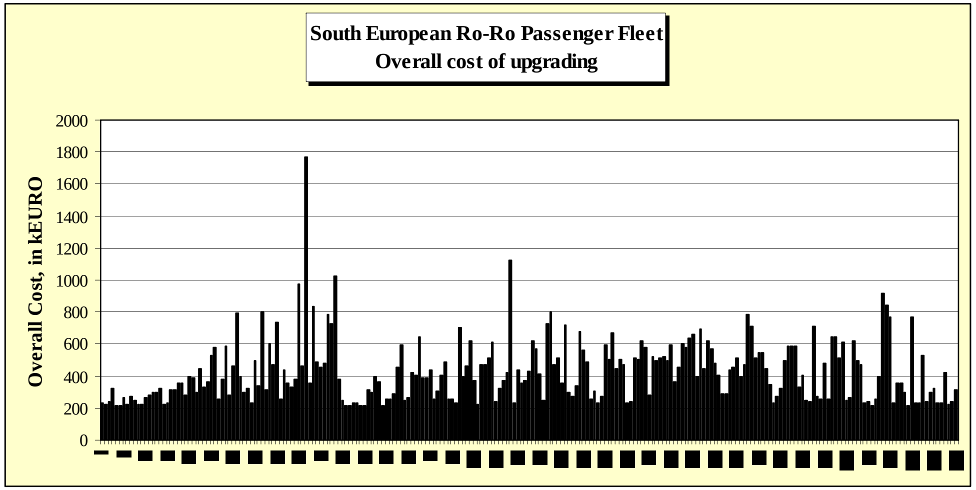


Figure 12b: *Overall Cost of Upgrading = 0.0195*(GDP Per Capita *GT*(1- A/Amax))+212.4±610.2*