No. 304
September 1986

ON PLACING OUR BETS FOR SURVIVAL: PRIORITIES FOR ATTEMPTING CHANGE IN MARITIME TRANSPORT

by

Harry Benford, Professor Emeritus of Naval Architecture
and Marine Engineering, The University of Michigan,
Ann Arbor, Michigan, USA

Fourth International Shipbuilding & Ocean Engineering Conference
Helsinki, Finland
September 7-10, 1986

Department of Naval Architecture
and Marine Engineering
College of Engineering
The University of Michigan
Ann Arbor, Michigan 48109

ABSTRACT

All of us recognize the need for improving the economic performance of our merchant ships. Improvements imply changes in hardware, in operations, and in government policies. All such modifications or innovations involve risk and many require extra financial investment. Clearly, we have neither the financial nor human resources to attempt change in all facets affecting the economics of marine transport. We must, therefore, be selective and target for change those segments that promise the greatest returns on what we invest in the attempt.

To help us place our bets in this endeavor, I have solicited the opinions of responsible managers of merchant fleets of many nations. As was to be expected, widely differing views exist, and yet there emerges a gratifying number of potential changes that attract high degrees of support. This paper focuses attention on those changes. It also catalogs a goodly number of specific suggestions volunteered by various respondents. Overall, certain patterns of thought occur and these are highlighted in the paper.

CONTENTS

	PAGE
INTRODUCTION	1
INTRINSIC AND EXTRINSIC FACTORS	1
ARENAS OF COMPETITION	2
RATIONALE FOR CHANGE	2
A MEASURE OF MERIT	3
RELATIVE WEIGHTS	4
SHIPOWNERS' SURVEY	9
OVERALL RESULTS	10
A PRELIMINARY INVITATION	10
ANNUAL COSTS OF CAPITAL RECOVERY: CONCLUSIONS	11
ANNUAL TRANSPORT CAPACITY: CONCLUSIONS	14
REDUCING CREW COSTS: CONCLUSIONS	15
REDUCING VICTUALING COSTS: CONCLUSIONS	15
REDUCING FUEL COSTS: CONCLUSIONS	17
REDUCING COSTS OF MAINTENANCE AND REPAIR: CONCLUSIONS	18
REDUCING OTHER OPERATING COSTS: CONCLUSIONS	18
INCREASING SAFETY: CONCLUSIONS	20
IMPROVING QUALITY OF LIFE: CONCLUSIONS	20
VEHICLES FOR INNOVATION: CONCLUSIONS	22
IMPROVING EDUCATION AND TRAINING: CONCLUSIONS	23
SOME FINAL SUGGESTIONS	23
RESULTS BROKEN OUT ACCORDING TO FLAG OR TYPE OF SHIP	24
CLOSURE	24
ACKNOWLEDGEMENTS	25
APPENDICES	27-30

INTRODUCTION

Shipowners whose companies survive the current worldwide depression in maritime commerce can pride themselves on having remained solvent during an exceedingly bleak span of years. Although we have reason to hope that the worst is now over, any hope for continuing survival must be based on a willingness and ability to live with change. I refer to changing demands for ocean transport, changing technologies to meet those demands, and changing methods to man and manage our ships. Indeed, the most successful shipowners will be those who not only know how to live with change but who are themselves the instruments of change. They are the ones whose instincts accord with this couplet ascribed to John Wilmot, Earl of Rochester:

> Since 'tis Nature's law to change,
> Constancy alone is strange.

INTRINSIC AND EXTRINSIC FACTORS

In the maritime world we can divide all manner of change into two major divisions: intrinsic and extrinsic to the ships themselves. My definition of intrinsic factors is broad enough to include the entire door-to-door transport system. This, in turn, includes managerial methods as well as all associated hardware: land and sea vehicles, port facilities, cargo boxes (where appropriate), and so forth. By extrinsic factors, I refer to such things as demand for ocean transport, availability of personnel, and political facts of life artificially impinging on the design and operation of merchant ships. These two major divisions are of course not fully independent

of one another. For example, operators of subsidized ships may hold one set of views on the virtues of designing ships for reduced manning levels. Operators of unsubsidized ships may hold quite different views.

For purposes of this paper, we shall for the most part confine ourselves to the intrinsic factors defined in the paragraph above.

ARENAS OF COMPETITION

The key to survival is the ability to compete--but against whom? The answer is almost everybody: other shipowners (both domestic and foreign) and other modes of transport. Even if no external competition existed one would need to compete with one's self lest complacency lead to stagnation and decay. For the sake of harmony in this conference we can take either of two extreme perspectives: competition with other modes of transport or self-competition. Either way, we find ourselves with common goals.

RATIONALE FOR CHANGE

Why change? The answer is simple: Our competitors continually find ways to lower prices (or offer better service). If we don't do the same we shall eventually find ourselves forced out of business. We may postpone bankruptcy by inducing government support in some form. Within democratic nations, however, that offers no permanent solution. Sooner or later the public will become aware of the hidden burden of such support and it will be withdrawn. Meanwhile, the protected shipowner probably will have lost all self-sufficiency and must quickly fall when the crutch is yanked away.

If we can agree on the importance of change, the next question pertains to the logic of figuring out exactly what ought to be changed. This brings us back to the definition of a merchant ship as an investment that earns its returns as a socially useful instrument of transport. What ought to be changed, then, are those factors that best promise to allow the shipowner to lower freight rates while still maintaining a reasonable level of profitability. (We encompass here primarily ships of the future, but many changes can and should be applied to ships already in existence.)

A MEASURE OF MERIT

Qualitatively, we have established as the purpose of change the ability to offer ever-lower freight rates to our customers while earning reasonable returns on our investments. Quantitatively, this can be equated to what we call the required freight rate (RFR), a criterion much used for making decisions in ship design. The philosophy behind the concept is that the best ship for any given trade will be the one that can offer the lowest freight rate while still earning reasonable after-tax returns. In its basic form we have:

$$RFR = \frac{ACCR + Y}{C}$$

where

ACCR = annual cost of capital recovery

= (CR)P

in which

P = initial invested cost of ship

CR = capital recovery factor, used to convert the initial cost to an equivalent uniform annual cost over the life of the ship

and

Y = annual operating costs of all kinds (assumed to be uniform)

C = annual transport capacity on some specified trade route, usually in tonnes.

Like other economic measures of merit, RFR cannot of itself pinpoint optimal designs. The decision maker must additionally weigh intangible considerations, such as quality of life for the seafarer. Matters of safety and reliability must also be given thought, for the prudent shipowner will not unthinkingly accept minimum legal requirements as maximum design criteria.

RELATIVE WEIGHTS

Table 1 shows some typical numbers entering into the computation of RFR for an 18000 dwt dry bulk carrier on a 6400-mile one-way trade route. We assume a tax-free operation appropriate to open registry. Other assumptions are specified in Table 17, in Appendix I.

Table 2 shows corresponding figures based on the same assumptions as those used in Table 1 except that, going to the other extreme, we assume a U.S.-built ship operating under U.S. flag without benefit of subsidy. An effective tax rate of 35 percent is assumed.

For those of you whose economic environments fall somewhere between the extremes of Tables 1 and 2, Table 3 sets the results side-by-side for easy interpolation.

Let me stress that my object in presenting these numbers is only to give some rough indication of the relative scale of the various factors entering into the required freight rate. Figure 1 will make these comparisons easier to comprehend.

TABLE 1

REQUIRED FREIGHT RATE UNDER OPEN REGISTRY, TAX-FREE CONDITIONS

ACCR: Annual Cost of Capital Recovery

P, Investment = $11.5 million
CR: Capital recovery factor: (CR-10%-20) = 0.1175
ACCR, Annual cost of capital recovery, = (CR)P

= (0.1175) $11.5 million = $1.35 million

Y: Annual Operating Costs

	$1000 year	Proportion of Y	Proportion of AAC
Crew wages and benefits	550	23%	15%
Maintenance and repair	145	6%	4%
Stores and supplies	50	2%	1%
Hull and machinery insurance	165	7%	4%
Protection and indemnity insurance	15	1%	nil
Overhead and miscellaneous	200	8%	5%
Port charges	10	nil	nil
Fuel and lube oil	1260	53%	34%
Y: Total annual operating costs	2395	100%	63%
AAC: Average Annual Cost = ACCR + Y			100%

= $1.35 million + $2.395 million = $3.745 million

C: Annual Transport Capacity

C = cargo deadweight x round trips per year

= 18,075 x 8.33 = 150,600 long tons per year

RFR: Required Freight Rate

$$RFR = \frac{ACCR + Y}{C}$$

$$= \frac{\$1.35M + \$2.395M}{150,600}$$

$$= \frac{\$3.745M}{150,600}$$

= $24.87 per long ton

Table 2

REQUIRED FREIGHT RATE UNDER U.S.-FLAG,
U.S.-BUILT CONDITIONS

Annual Costs of Capital Recovery

P, Investment = $23 million

CR' = Capital recovery factor after tax = 0.1175
(same as in Table 1)

$$CR = \text{Capital recovery factor before tax} = \frac{CR' - \frac{t}{N}}{1 - t} = \frac{0.1175 - \frac{0.35}{20}}{1 - 0.35} = 0.1538$$

Note: t = effective tax rate

ACCR: Annual Cost of Capital Recovery = (CR)P

= (0.1538) $23M = $3.537 million

Y: Annual Operating Costs

	$1000/year	Proportion of Y	Proportion of AAC
Crew wages and benefits	2900	57%	34%
Maintenance and repair	290	6%	3%
Stores and supplies	60	1%	1%
Hull and machinery insurance	335	7%	4%
Protection and indemnity insurance	15	nil	nil
Overhead and miscellaneous	200	4%	2%
Port charges	10	nil	nil
Fuel and lube oil	1260	25%	15%
Y: Total annual operating costs	5070	100%	59%

AAC: Average Annual Cost = ACCR + Y =

= $3.537 million + $5.070 million = $8.607 million — 100%

RFR: Required Freight Rate

$$RFR = \frac{ACCR + Y}{C} = \frac{\$3.537M + \$5.070M}{150{,}600}$$

$$= \frac{\$8.607M}{150{,}600}$$

= $57.15 per long ton

Table 3

TABLES 1 AND 2 COMPARED

	Economic Environment			
	Open Registry and No Tax		U.S.-Flag and 35% Effective Tax	
	$1000 per yr.	Proportion of AAC	$1000 per yr.	Proportion of AAC
Crew wages & benefits	550	15%	2900	34%
Maintenance & repair	145	4%	290	3%
Stores & supplies	50	1%	60	1%
Hull & machinery insurance	165	4%	335	4%
Protection & indemnity ins	15	nil	15	nil
Overhead & miscellaneous	200	5%	200	2%
Port charges	10	nil	10	nil
Fuel and lube oil	1260	34%	1260	15%
Y: Total annual operating costs	2395	63%	5070	59%
ACCR: Annual Cost of Capital Recovery	1350	37%	3537	41%
AAC: Average Annual Cost	3745	100%	8607	100%
RFR	$24.87		$57.15	

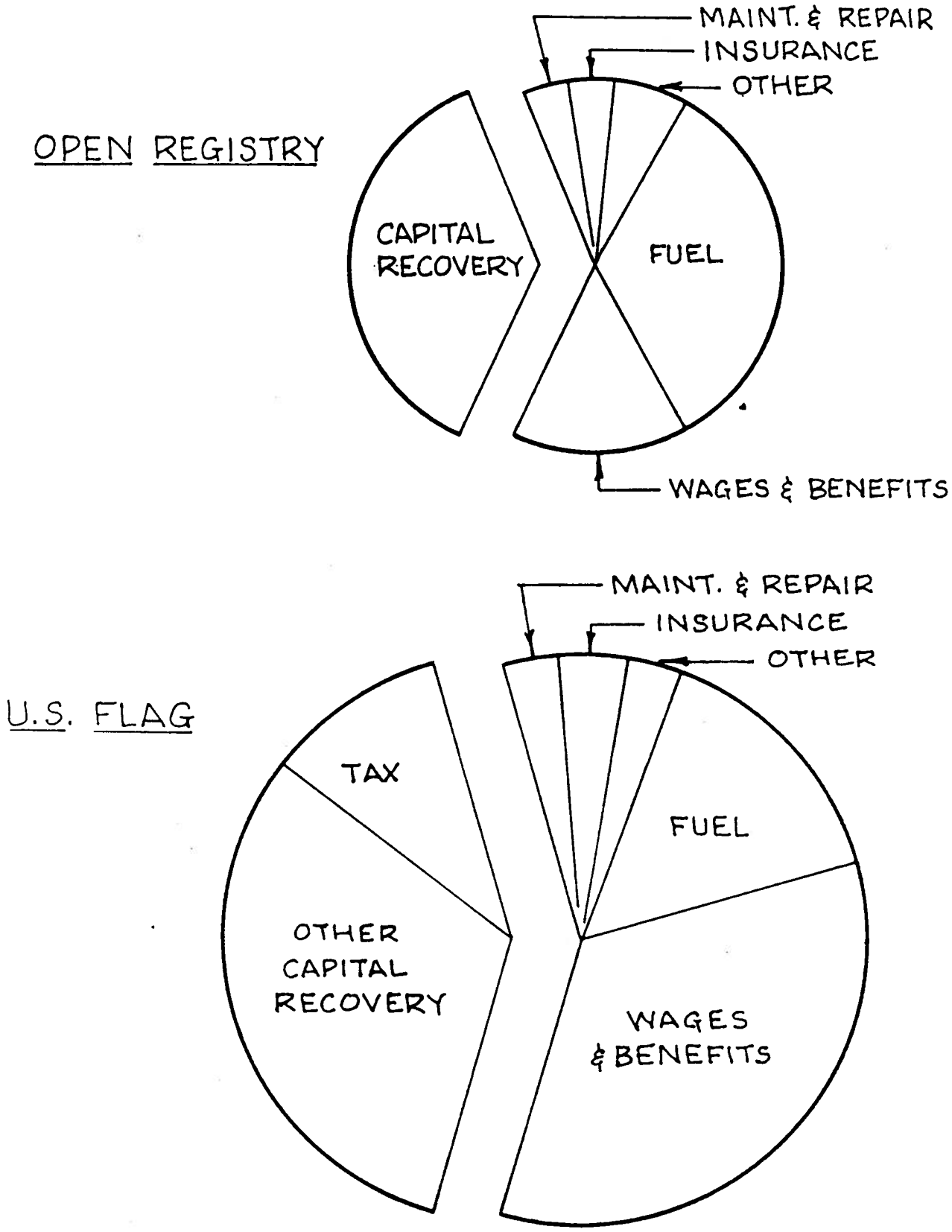

Figure 1: Relative size of major components of Average Annual Cost. Note: Areas of circles are in proportion to AAC and Required Freight Rate.

SHIPOWNERS' SURVEY

Last winter, thinking it would be of value to this conference, I asked 36 shipowners' representatives (or consultants) for their advice on setting priorities for change. Of these, 23 responded, giving a reasonable balance between fleets of various kinds of ships. The majority of respondents represented west European flag fleets, but there were also significant numbers of open registry flags and U.S. or Canadian flags as well. Table 18, in Appendix II, shows the number of responses in each combination of categories.

The questionnaire that I sent out was structured on the components of required freight rate. Respondents were asked to rank the relative importance of research and development aimed at improving each of 57 individual factors affecting RFR. They were also asked to rank 32 factors affecting safety, quality of life, vehicles for innovation, or education. Well aware that I had probably overlooked many worthy factors, I invited further suggestions from my respondents.

Ranking was done on a scale of one to ten, in which a ranking of ten was to correspond to a big factor, or one that was easy to improve, or both. At the other end of the scale, a ranking of one would correspond to a small factor, or one that was relatively hard to change, or both.

In short, what I wanted from my respondents was their collective judgement as to where we should place our bets in R&D.

OVERALL RESULTS

One could hardly expect to find much uniformity of opinion arising from as diverse a group as those responding to my questionnaire. There are, however, a few recommendations that receive exceptionally strong endorsement. Briefly put, our respondents see maximum gains arising from developments leading to smaller, better-qualified crews working with benefit of more reliable physical components. Moreover, they look for leadership in all this, not to traditional researchers, but to entrepreneurial pioneers.

The number and diversity of original suggestions appended to the questionnaire are impressive. From them we may also fairly conclude that our shipowning friends not only see the need for change, but are capable of considerable creative thought on what ought to be changed and how to go about it. They certainly cannot be accused of complacency.

A PRELIMINARY INVITATION

I thought it wise to learn what problems were uppermost in shipowners' minds, and to try to elicit that information before influencing their thoughts with my detailed questions. I therefore made this preliminary request: "Before looking over the rest of this form, please answer this question: Of all the facets of ship design or operation, what is the one thing you would most like to see changed? (Please exclude political matters and labor problems.)"

The overall response to this invitation was somewhat surprising in that a full 30 percent of the respondents spoke along the lines of redesigning ships to allow smaller general purpose crews aided by

as-simple-as-possible automation, more reliable components, and a redistribution of management functions between ship and shore (resulting in more on-board decisions).

Two of the respondents wished to see larger locks in the Panama Canal.

One particularly stimulating response decried our industry's resistance to new ideas. That writer went on to suggest forming a prestigious agency to evaluate (and publish) the technical feasibility of new proposals as well as the probability of their economic success.

Another respondent suggested establishing a market to bring together shippers and shipowners to forecast the demand for tonnage and kinds of service. Could this be the way to eliminate, or at least attenuate, the sickening swings of our industry?

Appendix III paraphrases the remaining responses to my initial question. I think you will find much of value in those suggestions.

ANNUAL COSTS OF CAPITAL RECOVERY: CONCLUSIONS

Table 4 summarizes the respondents' views on capital recovery factor. None of the factor's three components is particularly susceptible to improvement through R&D. That fact is reflected in the uniformly moderate interest implied in the results. This table, and the ones that follow, show the various potential areas of improvement ranked according to the mean of the respondents' assigned numbers on the scale of one-to-ten. The first column shows the mean value of the

responses; the second shows the number of responses. (Where a respondent left a blank we interpreted that as meaning "no opinion" and ignored it in computing the mean.)

Two correspondents suggested the desirability of more favorable loan arrangements (extended grace period, etc.). Another pointed out that freight rates may be depressed over ten years but never over 25. Extending a ship's life to 25 years, then, might make the difference between a good and bad investment. That is a valid point as regards any given ship, but seems hardly appropriate within the framework of corporate investments in a continuing succession of ships.

Table 5 reflects the respondents' views on ways to reduce initial investments. Designing for easier production, and then producing standard ships in long series is, in their collective view, the winning combination. One shipowner, however, expressed a desire for procedures that would allow variations in standard design at little extra cost. Another saw a source of cost saving in developing easier ways to erect and join the various components of outfitting such as piping, wiring, ducting, and joiner work.

Another respondent laid some of the blame for high costs on overly-ambitious naval architects and the vanity of indulgent shipowners.

A final suggestion was to order ships when the market is depressed, a sagacious and happy thought sure to be applauded by every shipyard president in the world today.

Table 4 CAPITAL RECOVERY FACTOR	Responses Mean	 Number
Economic life	6.65	20
Interest rate (constant-value terms)	6.55	20
Effective tax rate	6.26	19

Table 5 INITIAL INVESTMENT	Responses Mean	 Number
Design for easier production	7.52	21
Multiple orders, standard designs	7.38	21
Better shipyard management	6.37	19
Better shipyard equipment	5.11	19
New ways of joining structural parts	4.25	20
New kinds of hull materials	3.80	20

Table 6 ANNUAL TRANSPORT CAPACITY	Responses Mean	 Number
Improved terminals	7.20	20
Faster port turnaround	7.15	20
Increased reliability and safety	7.04	21
Better fleet deployment	6.80	20
Greater versatility in service	6.74	19
Improved chartering arrangements	6.53	17
Better shipboard management	6.47	21
Fewer days out of service per year	5.90	21
Improved harbors and canals	5.75	20
Increased deadweight	5.74	19
Trade agreements (e.g. UNCTAD cargo-sharing arrangement)	5.18	17
Fewer weather delays	4.84	19
Better mooring systems	4.37	19
Improved aids to navigation	4.36	19
Lesser need for rain protection	4.07	15
Quicker-acting hatches, doors, etc.	3.47	15
Higher sea speed	3.11	18
Better ice transiting capabilities	2.49	16

ANNUAL TRANSPORT CAPACITY: CONCLUSIONS

Table 6 shows how the respondents rank the many factors entering into annual transport capacity. Improved terminals and faster port turnaround score high, as does increased reliability and safety. Under the Other category, several meritorious thoughts were volunteered as paraphrased below:

* Integrate complete door-to-door transport systems. The biggest gains today are in the inland segments.
* Develop ships that can more readily be switched to other services.
* Stretch out drydocking periods.
* Reduce time to secure containers (deck cargo).
* Develop better cooperation between shippers and operators (swapping slots to maximize transport efficiency) or even agreeing upon some equitable plan to scrap surplus tonnage.
* Provide better facilities for receiving slop or wash-water, particularly for OBO's converting from liquid to dry cargos.

More than one respondent spoke out against flag-related cargo allocation schemes such as those advanced by UNCTAD. This brings us to the task of drawing the line between political and technical developments. We may at first think that R&D has no role in solving political problems. That is wrong, however, in that economic research can show political decision makers the overall social cost of any given proposal.

REDUCING CREW COSTS: CONCLUSIONS

Table 7 reflects shipowners' views on both the importance of crew-related costs and how best to reduce them. Top priority goes to finding better trained crews, with reduced numbers a definite second. Indeed, of the entire 89 factors surveyed, better trained crews emerges as the single area where improvement is most worth going after. A little contemplation explains this. After all, well-trained (and, I might add, well-motivated) crews can lead to improvements in nearly every sector of operating costs, as well as many within the realm of annual transport capacity and, of course, safety and quality of life.

Several individual comments are summarized below:

* Reorganize crew structure; use multi-purpose crews; allow more shipboard decisions--all of which sentiments were already expressed in the response to my initial question (see page 10).
* Maintain high levels of crew stability, crew health, and crew motivation.
* Reduce labor union tributes.
* Strengthen relationship between performance and pay.

REDUCING VICTUALING COSTS: CONCLUSIONS

Shipowners are naturally hesitant to trim victualing costs; good food, well served, is an accepted part of the maritime social contract. Table 8 reflects this reluctance. There were, however, some thoughtful proposals; two respondents suggested eliminating the catering department and letting each crew member prepare his or her own meals in his or her own kitchenette (or is <u>galleyette</u> a better term?). The money so saved would allow higher wages for the seafarer. The plan would also help overcome the boredom of shipboard life.

Table 7
CREW COSTS

	Responses Mean	Number
Better trained crew	8.96	23
Reduced crew numbers	8.31	23
Crew wages (per individual)	5.53	17
Crew benefits	4.76	17
Repatriation	3.86	14

Table 8
VICTUALS

	Responses Mean	Number
Cafeteria service	5.82	17
More shore preparation	4.65	17

Table 9
FUEL

	Responses Mean	Number
Smoother hulls	7.70	23
Better fuel rates in diesels	7.52	21
Cheaper oil	7.35	20
Better propellers	6.86	21
Better fuel rates in steam turbines	3.64	14
Copper-nickel hulls	2.47	15

Table 10
OTHER FUELS OR PRIME MOVERS

	Responses Mean	Number
Sail	3.88	16
Coal	3.60	15
Nuclear	2.62	13
Wood chips	1.50	14

The subject of victualing inevitably produced responses pertaining to quality of life and I have chosen to shift a number of them to that category.

REDUCING FUEL COSTS: CONCLUSIONS

Tables 9 and 10 show that today's operators are firmly wedded to diesel machinery and see little hope for alternative fuels or prime movers. With regard to diesels they stress the importance both of achieving better fuel rates and of burning cheaper (presumably lower quality fuel), which would seem to be moving in opposite directions. Nearly every respondent volunteered additional thoughts. Several replies stressed the importance of giving both deck and engine crews financial incentives to maximize fuel efficiency, and giving them the equipment and training necessary to the task. Others saw value in paying more attention to weather routing, scheduling, and speed/power strategies in heavy seas.

Other suggestions are paraphrased below;

* Either find sources of good-quality fuel or develop reliable onboard purifiers.
* Experiment with coal slurries.
* Develop better heat recovery systems.
* Integrate shaft and turbo generator systems.
* Make more frequent use of trained shore crews to tune plant and follow-up with close monitoring by officers and shore staff.
* Develop radical new hull forms.
* Redesign the entire engine room to aim for an integrated system of maximum overall economy.
* Engage in more sophisticated strategies for buying fuel.

REDUCING COSTS OF MAINTENANCE AND REPAIR: CONCLUSIONS

As implied by Table 11, the key to lower M&R costs would seem to be the availability of more reliable components. Better (or cheaper) protective coatings merit attention, as does easy removal of components for shore maintenance. Several respondents mentioned the desirability of machinery monitoring (based, for example, on vibration analysis) as part of a computer-assisted preventive maintenance system. In this, the on-board computer could give precise instructions on how to do any needed work.

One respondent complained that low degrees of reliability dictate investments in redundant components, which, in turn, add to the maintenance burden. Two correspondents recommended extending the overhaul period, perhaps to 30 months (which, as already noted, would enhance annual transport capacity). Other suggestions are to provide better training for on-board staff, and to make greater use of standard, interchangeable parts.

REDUCING OTHER OPERATING COSTS: CONCLUSIONS

As we look at Table 12 we see that our respondents seem rather concerned with overhead costs. This shows some admirable objectivity on their part because their salaries and benefits are, of course, all charged to overhead.

One correspondent would like to reduce pilotage and tug fees. There is surely potential for technological benefit in both of those areas.

Table 11
MAINTENANCE AND REPAIR

	Responses Mean	Number
More reliable components	8.82	22
Better protective coatings	7.91	22
Components more easily removed for shore maintenance	7.39	18
Preventive maintenance programs	7.00	20
Easier access to components	6.89	19
More work done by traveling maintenance & repair teams	5.15	20

Table 12
OTHER OPERATING COSTS

	Responses Mean	Number
Overhead	7.74	19
Port & canal fees	6.17	18
H&M insurance	5.76	17
P&I insurance	5.63	16
Lube oil	5.40	20
Stores and supplies	4.84	19

Table 13
SAFETY

	Responses Mean	Number
Better trained, safety-conscious crew	8.96	23
More reliable equipment	7.52	21
Better ways to reduce risk of collision or grounding	6.95	19
Traffic control in and around harbors	6.57	21
More rational interpretation of the rules	6.53	19
More rational safety rules	6.53	17
Better life-saving equipment	5.74	19
Better search & rescue systems	5.18	17
Better safety features (subdivision, redundancy, better closures, more freeboard, etc.)	4.59	17
Continual monitoring of ships' location by safety authorities	4.50	18
More sophistication on part of classification societies	3.84	19

INCREASING SAFETY: CONCLUSIONS

Table 13 underscores two points already made: the economic benefits of well-trained crews and reliable equipment receive bonus benefits in safety.

Some appended comments are as follows:

* Better lifeboats are needed (related to which one correspondent complained that better safety equipment is available but the U.S. Coast Guard is too slow to approve it).

* Two respondents think that fleet managers need to take a more responsible attitude toward safety.

* Better ways should be found to reduce the incidence of oil spills, whether operational or accidental.

IMPROVING QUALITY OF LIFE: CONCLUSIONS

With all the previously recorded stress on attracting better qualified crews, we might have expected a good deal of interest in finding ways to improve the quality of life aboard ship. Yet, as may be inferred from Table 14, our respondents' collective wisdom is that a carefully selected crew is the royal (and only) road to that particular destination.

Some respondents reminded us that questions of this nature become more important as crew numbers are reduced. This is reflected in various comments pertaining to food service. One continuing debate (related to lowering onboard social barriers) concerns the issue of installing a common restaurant in place of separate messes. This is recommended by some respondents. Also related to food service, are suggestions that the need exists for better managing of the catering department.

Table 14 QUALITY OF LIFE	Responses Mean	 Number
Greater care in crew selection	8.00	21
Reduced noise in accommodations and working areas	6.35	20
Reduced social barriers between officers and ratings (e.g., common dining rooms)	6.32	22
Eye appeal, interior decoration	5.84	19
Reduced vibration in accommodations and working areas	5.47	19
Better habitability standards	5.35	20
Better food services	5.28	18
Decentralized decision-making	5.19	21
Better recreational facilities	5.16	19
Permission (and accommodations) to allow wives and children on occasional voyages	5.09	22
Eye appeal, exterior	4.53	19
More time ashore, with pay	3.83	18

Table 15 VEHICLES OF INNOVATION	Responses Mean	 Number
Entrepreneurial pioneers	8.62	21
R&D support: by groups of like-minded companies	6.68	22
R&D support: internal by private industry	6.36	22
R&D self-financed in university labs	4.91	22
R&D support: by government	4.41	22

Table 16 EDUCATION AND TRAINING	Responses Mean	 Number
Education of business managers	8.00	17
Education of ship officers	7.38	21
Training of ratings	7.38	21
Education of engineers	7.30	20

This quality-of-life section elicited two intriguing responses:

* One tanker operator thinks "tankers should be as appealing to the public as clipper ships. Today's tankers are like garbage trucks: necessary, but . . .!" This, I suppose, reflects the view that handsome ships help attract good new blood to the industry and generally enhance public relations.

* One American correspondent gave Better Habitability Standards a negative ten rating, adding the comment that we need to go the other way because rooms are already too big and over-furnished. This is not necessarily a curmudgeon's black opinion. Some seafarers have been known to complain that their over-size cabins fail to give the proper sense of privacy and snug security.

VEHICLES FOR INNOVATION: CONCLUSIONS

The need for change is one thing; how best to do it is another. Our respondents, by a wide margin, look to entrepreneurial pioneers for leadership in this. Solidly in last place, in their collective expectation, is government-financed R&D; while self-financed research in university laboratories comes out nearly as low. See Table 15.

In giving such overwhelming credit to entrepreneurs, I suspect our respondents were overly-influenced by the high visibility of successful innovations, without giving thought to the theoretical research that laid the necessary groundwork. In my own view, continuing progress requires a healthy degree of cooperation by theoreticians, practical engineers, business managers, and related government employees. (Pray forgive this gratuitous personal comment.)

One respondent notes that cargo owners have a role in technological progress, but he knows of none who recognizes it.

IMPROVING EDUCATION AND TRAINING: CONCLUSIONS

Table 16 relects the owners' views on education and training. Overall, they see the greatest need for increased emphasis on the education of business managers. After all of their earlier statements about the need for well-trained crews, I find this rather surprising, but there it is.

Unfortunately, the category of Education of Engineers was interpreted by some as referring to shipboard engineers, whereas what I meant was design engineers. My apologies for this ambiguity.

Two respondents would like to use intensive short courses. One suggestion was for one- or two-day refresher courses for senior executives, covering current developments in commercial and technical matters. The other was for continuing the education of design engineers as well as ships' officers.

Other related suggestions are:

* Apply pressure to ratings to move up and become officers.
* Provide better training for catering personnel.
* Re-orient maritime schools to get away from strictly technical training. Train cadets to be "managers with a strong technical background."

SOME FINAL SUGGESTIONS

At the conclusion of my questionnaire, I issued this invitation: "If you think we have left out any important areas for improvement anywhere down the line, please specify." Some responses are paraphrased below.

* Place greatest emphasis on increasing annual transport capacity and achievement.

* Encourage shippers to engage in more realistic forecasting. They seem to resist doing this and the shipowners suffer from the resulting radical misalignments in supply and demand.

* Find out why good ideas for technical improvements lie around for years, or decades, before application.

There are other suggestions specifically centering on American problems. Because this text is already too long, I am relegating them to Appendix IV.

RESULTS BROKEN OUT ACCORDING TO FLAG OR TYPE OF SHIP

Table 21 (Appendix V) summarizes the rankings disaggregated by flag of registry. Table 22 (Appendix VI) summarizes the rankings disaggregated by type of ship. In both cases, the sequence of entries is exactly the same as that derived from the overall mean values, as shown in Tables 4 - 16. This allows easy perception of those factors in which major divergences of opinion are evident. One may draw one's own conclusions.

CLOSURE

In the foregoing I have tried to give some idea of the relative importance of the several components of transport economic efficiency. I have also summarized the opinions of nearly two dozen shipping experts on how best to improve each of those components. My emphasis in this is to help us make wise decisions on how we invest our managerial talent and financial capital in attempting change in

maritime transport. What we have here, then, is an extensive compendium of targets for change in our ships and their methods of operation. We may hope that these proposals will encourage new research and new developments leading to more efficient maritime transport and renewed prosperity for all concerned.

ACKNOWLEDGEMENTS

Credit for any value in this paper must go to my 23 correspondents who were good-hearted enough to take the time to give us the benefit of their wisdom and experience. In alphabetical order, here they are:

David Aicken, Goodwin-Hamilton & Adamson Ltd., Wirral, Merseyside, England.

John W. Boylston, Seaworthy Systems, Inc., Solomons, Maryland, USA.

Albert Calvarin, Esso S.A.F., Paris, France.

Charles Cushing, New York City, N.Y., USA.

U. Döhmel, Deutsche Shell Tanker-Gesellschaft, MBH, Hamburg, West Germany.

Sten Ekholm, Brostrom Shipping Ltd., Goteborg, Sweden.

Alf Eriksson, Monitor Shipping AB, Stockholm, Sweden.

John Eyre, Richford, Vermont, USA.

Per Fagerlund, Rederiaktiebolaget Transatlantic, Goteborg, Sweden.

William O. Gray, Exxon Corporation, New York City, N.Y., USA.

Arthur J. Haskell, Matson Navigation Co., San Francisco, California, USA.

Hans Peter Hoeft, Hapag-Lloyd, Hamburg, West Germany.

F. J. Joyce, New York City, N.Y., USA.

Rolf W. Karlemo, Finncarriers, Helsinki, Finland.

William J. Linehan, Esso Singapore Private Ltd., Singapore.

Arthur McKenzie, New York City, N.Y., USA.

Antonio Miraglia, Italian Line, Genoa, Italy.

S. E. Peters, Esso SAPA, Buenos Aires, Argentina.

J. Frederic Pitre, Canada Steamship Lines, Inc., Montreal, Quebec, Canada.

Richard T. Soper, Sea-Land Service, Inc., Iselin, N.J., USA.

Jukka Suominen, EFFOA, Helsinki, Finland.

Vladimir Vlašić, Jugolinija, Rijeka, Yugoslavia.

Guilio Zito, Almare di Navigaxione Sp.A., Genoa, Italy.

* * *

Within our own walls I wish to acknowledge the good work of Scott Bogard (who analyzed the shipowners' responses and prepared the resulting tables), and Maria Merola (whose nimble fingers produced these neatly typed pages).

Appendix I

Table 17

ASSUMPTIONS USED IN ESTIMATING REQUIRED FREIGHT RATE UNDER OPEN REGISTRY, TAX-FREE CONDITIONS (Table 1)

* Gearless dry bulk carrier, 18,000 dwt
* Trans-pacific voyage, one-way cargo
* Diesel single screw machinery
* Fuel cost: $135 per long ton
* Crew complement: 24
* Average sea speed: 14 knots
* Corporate income tax: none
* Economic life: 20 years
* Return on investment: 10 percent
* Time frame: 1986
* Shipyard: European

Appendix II

Table 18

DISTRIBUTION OF RESPONSES BY FLAG AND TYPE OF SHIP

Type of Ship	Flag				
	W. Europe	U.S. and Canada	Open Registry	Other	Total
Tankers	3	0	3	1	7
Dry Bulk Carriers	3	1	2	0	6
Container Ships	6	3	0	1	10
RO/RO Ships	4	1	0	0	5
Passenger Ships	3	0	0	0	3
Totals	19	5	5	2	31*

* Grand total exceeds 23 because some owners operate more than one type of ship.

Appendix III

Table 19

ADDITIONAL RESPONSES TO INITIAL QUERY AS TO THE ONE CHANGE MOST NEEDED.

(See page 10 of text for preamble)

* Reduce costs.
* Scrap more ships.
* Improve safety.
* Lower operating costs.
* Induce designers and builders to consider total life of ship, not just guarantee period.
* Standardize documents.
* Temper overreaction on part of IMCO, U.S. Coast Guard, et al.
* Eliminate useless tradition.
* Penalize dishonest ship operators.
* Build all tankers stronger, with double hulls.
* Induce charterers, underwriters, and classification societies to give greater weight to quality of management.
* Develop take-apart ships to allow propulsion plant to be independent of cargo hold.
* Encourage better understanding between economists, operators, and technical people within the office staff.
* Improve crew quality.
* Standardize harbor equipment, shipboard equipment, and some types of ships.
* Make shipowners realize that they must offer competitive rates and service.

Appendix IV

Table 20

FINAL SUGGESTIONS PERTAINING TO THE U.S. MERCHANT MARINE

These are responses to the open-ended question that terminated the questionnaire. Being specific to just U.S. problems, I have tucked them away in this appendix.

* Our problems have most of their roots in federal maritime policies. The subsidy system has done more harm than good. The sooner it is completely eliminated, the better.

* We need to establish a forum representing industry, government, academia and labor in recognition of our commonality of interest. Such a forum should undertake to: (1) separate problems of, and solutions for, U.S. shipowners and U.S. shipbuilders; (2) eliminate infighting among U.S. shipowners; and (3) effect major improvements in federal maritime regulations--both commercial and technical.

Appendix V

Table 21
RESULTS FOR DIFFERENT FLAGS

CAPITAL RECOVERY FACTOR	Open Registry Responses Mean	Number	US/Canadian Responses Mean	Number	W. European Responses Mean	Number
Economic life	6.50	4	7.25	4	6.00	10
Interest rate (constant-value terms)	5.50	4	5.5	4	7.60	10
Effective tax rate	7.67	4	6.5	4	5.56	9
INITIAL INVESTMENT						
Design for easier production	8.00	4	8.25	4	7.10	10
Multiple orders, standard designs	8.25	4	8.50	4	6.36	11
Better shipyard management	7.75	4	3.50	4	6.80	10
Better shipyard equipment	5.75	4	3.50	4	5.30	10
New ways of joining structural parts	5.25	4	5.75	4	2.80	10
New kinds of hull materials	4.50	4	4.75	4	2.40	10
ANNUAL TRANSPORT CAPACITY						
Improved terminals	6.25	4	7.50	4	7.20	10
Faster port turnaround	7.00	4	8.25	4	6.70	10
Increased reliability and safety	8.60	5	6.00	4	6.10	10
Better fleet deployment	7.25	4	5.67	3	6.82	11
Greater versatility in service	7.25	4	6.50	4	6.13	8
Improved chartering arrangements	7.00	4	2.75	4	8.26	8
Better shipboard management	6.25	4	5.75	4	6.20	10
Fewer days out of service per year	6.00	5	6.50	4	5.33	9
Improved harbors and canals	6.25	4	4.75	4	5.50	10
Increased deadweight	7.00	3	6.25	4	4.50	10
Trade agreements (e.g. UNCTAD cargo-sharing arrangement)	4.25	4	5.67	3	5.37	8
Fewer weather delays	4.25	4	6.00	4	4.60	10
Better mooring systems	5.25	4	2.25	4	4.78	9
Improved aids to navigation	5.50	4	5.75	4	3.67	9
Lesser need for rain protection	5.00	3	4.75	4	3.00	7
Quicker-acting hatches, doors, etc.	5.00	3	3.00	4	3.29	7
Higher sea speed	3.50	4	5.00	4	1.89	9
Better ice transiting capabilities	3.67	3	2.75	4	2.00	8

Table 21 (cont.)

CREW COSTS	Open Registry Responses Mean	Number	US/Canadian Responses Mean	Number	W. European Responses Mean	Number
Better Trained Crew	9.20	5	9.25	4	8.73	11
Reduced crew numbers	8.40	5	8.25	4	8.64	11
Crew wages (per individual)	7.25	4	7.00	4	4.50	8
Crew benefits	6.00	4	7.25	4	3.38	8
Repatriation	5.50	2	3.50	4	3.29	7
VICTUALS						
Cafeteria service	7.67	3	6.75	4	5.33	9
More shore preparation	7.33	3	2.75	4	4.25	8
FUEL						
Smoother hulls	8.40	5	8.00	4	7.65	11
Better fuel rates in diesels	7.25	4	8.75	4	6.40	10
Cheaper oil	5.25	4	8.25	4	7.33	9
Better propellers	8.20	5	7.25	4	6.40	10
Better fuel rates in steam turbines	5.67	3	4.75	4	2.60	5
Copper-nickel hulls	4.00	1	3.25	4	2.11	9
OTHER FUELS OR PRIME MOVERS						
Sail	8.33	3	1.50	4	4.00	7
Coal	4.00	3	4.25	4	3.67	6
Nuclear	3.00	2	4.75	4	1.33	6
Wood chips	3.00	2	1.25	4	1.17	6

Table 21 (cont.)

	Open Registry Responses		US/Canadian Responses		W. European Responses	
MAINTENANCE AND REPAIR	Mean	Number	Mean	Number	Mean	Number
More reliable components	8.80	5	8.50	4	8.90	10
Better protective coatings	7.75	4	9.00	4	7.18	11
Components more easily removed for shore maintenance	6.75	4	8.25	4	7.00	9
Preventive maintenance programs	7.50	4	7.50	4	5.89	9
Easier access to components	7.50	4	7.50	4	6.10	10
More work done by traveling maintenance & repair teams	5.75	4	6.25	4	5.00	10
OTHER OPERATING COSTS						
Overhead	7.25	4	8.00	4	7.00	8
Port & canal fees	5.00	3	5.50	4	6.00	9
H&M insurance	5.00	4	7.75	4	4.88	8
P&I insurance	5.00	4	8.75	4	3.86	7
Lube oil	5.00	4	4.50	4	5.33	9
Stores and supplies	4.50	4	5.00	4	4.22	9
SAFETY						
Better trained, safety-conscious crew	8.40	5	8.75	4	9.00	11
More reliable equipment	8.20	5	6.75	4	7.40	10
Better ways to reduce risk of collision or grounding	7.00	3	7.75	4	4.67	9
Traffic control in and around harbors	4.00	4	8.00	4	6.50	10
More rational interpretation of the rules	8.33	3	7.25	4	6.20	10
More rational safety rules	8.00	3	7.25	4	5.67	9
Better life-saving equipment	7.50	4	5.50	4	4.67	9
Better search & rescue systems	7.00	3	4.25	4	4.50	8
Better safety features (subdivision, redundancy, better closures, more freeboard, etc.)	5.00	4	5.75	4	4.13	8
Continual monitoring of ships' location by safety authorities	4.00	4	3.50	4	4.56	9
More sophistication on part of classification societies	5.40	5	4.50	4	2.89	9

Table 21 (cont.)

	Open Registry Responses		US/Canadian Responses		W. European Responses	
QUALITY OF LIFE	Mean	Number	Mean	Number	Mean	Number
Greater care in crew selection	8.25	4	8.33	3	7.27	11
Reduced noise in accommodations and working areas	6.25	4	6.75	4	6.00	10
Reduced social barriers between officers and ratings (e.g., common dining rooms)	4.60	5	7.00	4	7.80	10
Eye appeal, interior decoration	5.80	5	5.75	4	5.38	8
Reduced vibration in accommodations and working areas	3.50	4	5.25	4	5.90	10
Better habitability standards	5.80	5	4.00	4	4.88	8
Better food services	5.75	4	6.25	4	4.33	9
Decentralized decision-making	4.00	4	5.50	4	4.00	10
Better recreational facilities	5.00	4	5.75	4	4.56	9
Permission (and accommodations) to allow wives and children on occasional voyages	5.00	5	4.00	4	6.00	10
Eye appeal, exterior	4.00	5	3.75	4	4.50	8
More time ashore, with pay	5.00	4	1.75	4	3.75	8
VEHICLES OF INNOVATION						
Entrepreneurial pioneers	9.20	5	6.75	4	8.67	9
R&D support: by groups of like-minded companies	4.75	4	7.25	4	6.82	11
R&D support: internal by private industry	5.75	4	5.75	4	6.91	11
R&D self-financed in university labs	6.00	4	6.00	4	4.18	11
R&D support: by government	4.00	5	6.75	4	3.30	10
EDUCATION AND TRAINING						
Education of business managers	7.00	4	8.00	4	8.25	8
Education of ship officers	7.80	5	6.50	4	7.10	10
Training of ratings	6.80	5	7.50	4	7.10	10
Education of engineers	4.75	4	8.00	4	8.10	10

Table 22
RESULTS FOR DIFFERENT TYPES OF SHIPS

CAPITAL RECOVERY FACTOR	Tanker Responses Mean	Number	RO/RO Responses Mean	Number	Container Responses Mean	Number	D. Bulk Carriers Responses Mean	Number	Pass./Auto Ferry Responses Mean	Number
Economic life	7.00	6	2.50	3	6.36	11	6.00	6	6.50	2
Interest rate (constant-value terms)	6.80	5	7.00	4	7.09	11	4.83	6	6.00	3
Effective tax rate	8.33	6	4.00	2	5.80	10	2.75	4	5.00	1
INITIAL INVESTMENT										
Design for easier production	7.86	7	4.67	3	7.45	11	5.83	6	7.50	2
Multiple orders, standard designs	8.50	6	8.00	4	7.18	11	5.83	6	7.00	3
Better shipyard management	6.80	5	6.33	3	6.55	11	4.00	6	4.50	2
Better shipyard equipment	5.20	5	5.33	3	5.45	11	3.50	6	4.50	2
New ways of joining structural parts	3.83	6	1.67	3	4.18	11	4.17	6	3.50	2
New kinds of hull materials	4.67	6	1.67	3	3.18	11	3.67	6	1.00	2
ANNUAL TRANSPORT CAPACITY										
Improved terminals	5.33	6	9.33	3	8.27	11	7.83	6	7.50	2
Faster port turnaround	5.80	5	7.50	4	7.18	11	8.33	6	5.67	3
Increased reliability and safety	8.57	7	6.33	3	6.55	11	6.83	6	6.56	2
Better fleet deployment	7.67	6	7.25	4	6.30	10	6.33	6	7.33	3
Greater versatility in service	8.50	6	6.67	3	5.60	10	7.67	6	5.00	1
Improved chartering arrangements	6.33	6	7.67	3	5.70	10	7.67	6	10.00	1
Better shipboard management	6.43	7	6.33	3	6.36	11	6.33	6	6.50	2
Fewer days out of service per year	7.17	6	2.33	3	5.64	11	6.83	6	3.00	2
Improved harbors and canals	3.33	6	7.33	3	7.00	11	5.83	6	7.50	2
Increased deadweight	5.60	5	4.33	3	6.27	11	4.67	6	5.00	2
Trade agreements (e.g. UNCTAD cargo-sharing arrangement)	3.00	4	5.33	3	7.40	10	3.50	6	9.00	2
Fewer weather delays	2.40	5	6.67	3	5.64	11	5.83	6	8.00	2
Better mooring systems	6.00	6	4.67	3	3.00	10	6.83	6	10.00	1
Improved aids to navigation	3.00	5	4.67	3	5.00	10	4.67	6	3.00	1
Lesser need for rain protection	2.00	2	2.67	3	3.40	10	5.33	6	5.00	1
Quicker-acting hatches, doors, etc.	5.00	2	2.33	3	2.60	10	4.83	6	3.00	1
Higher sea speed	2.00	4	2.00	3	3.09	11	3.67	6	1.50	2
Better ice transiting capabilities	1.00	2	2.00	3	2.18	11	3.33	6	3.00	2
CREW COSTS										
Better Trained Crew	9.25	8	8.25	4	8.64	11	9.17	6	10.00	3
Reduced crew numbers	8.75	8	8.25	4	7.36	11	8.83	6	10.00	3
Crew wages (per individual)	7.25	4	4.00	3	4.10	10	7.67	6	2.00	1
Crew benefits	5.00	4	4.33	3	4.18	11	6.00	5	4.50	2
Repatriation	3.00	3	5.00	2	2.78	9	5.50	6	5.00	1
VICTUALS										
Cafeteria service	6.67	3	4.33	3	5.73	11	6.00	6	10.00	2
More shore preparation	5.67	3	2.67	3	4.00	11	5.83	6	5.50	6

Table 22 (cont.)

	Tanker Responses		RO/RO Responses		Container Responses		D. Bulk Carriers Responses		Pass./Auto Ferry Responses	
FUEL	Mean	Number	Mean	Number	Mean	Number	Mean	Number	Mean	Number
Smoother hulls	9.38	8	6.75	4	6.34	11	7.38	6	8.33	3
Better fuel rates in diesels	8.00	6	5.75	4	7.45	11	7.50	6	6.67	3
Cheaper oil	7.17	6	8.00	3	8.00	11	6.83	6	7.50	2
Better propellers	8.00	6	6.00	4	6.00	11	7.17	6	6.67	3
Better fuel rates in steam turbines	4.00	3	1.00	2	3.10	10	4.75	4	0.00	0
Copper-nickel hulls	3.67	3	1.00	2	1.70	10	3.67	3	1.00	1
OTHER FUELS OR PRIME MOVERS										
Sail	4.60	5	7.00	2	3.22	9	3.67	3	0.00	0
Coal	2.00	5	6.00	2	4.67	9	1.50	4	0.00	0
Nuclear	1.67	3	1.00	2	3.63	8	1.00	3	0.00	0
Wood chips	1.00	3	1.50	2	1.89	9	0.67	3	0.00	0
MAINTENANCE AND REPAIR										
More reliable components	9.50	8	8.67	3	8.73	11	8.67	6	10.00	2
Better protective coatings	7.43	7	7.50	4	7.91	11	8.33	6	10.00	3
Components more easily removed for shore maintenance	5.67	3	7.75	4	7.18	11	7.33	6	9.33	3
Preventive maintenance programs	7.43	7	5.00	2	6.30	10	9.00	5	1.00	1
Easier access to components	5.80	5	6.75	4	7.30	10	7.50	6	7.50	2
More work done by traveling maintenance & repair teams	3.40	5	4.75	4	5.27	11	6.17	6	5.67	3
OTHER OPERATING COSTS										
Overhead	9.14	7	4.33	3	7.11	9	6.33	6	3.00	1
Port & canal fees	7.25	4	6.67	3	6.00	11	5.67	6	7.50	2
H&M insurance	6.25	4	3.33	3	6.00	10	5.17	6	3.00	1
P&I insurance	6.00	3	3.33	3	5.90	10	4.83	6	3.00	1
Lube oil	6.29	7	4.33	3	4.80	10	6.17	6	8.00	1
Stores and supplies	6.00	6	3.00	3	4.10	10	5.00	6	5.00	1
SAFETY										
Better trained, safety-conscious crew	10.00	8	9.00	4	8.73	11	8.33	6	9.33	3
More reliable equipment	8.86	7	6.00	3	6.82	11	8.33	6	8.50	2
Better ways to reduce risk of collision or grounding	6.40	5	5.33	3	7.36	11	5.17	6	6.50	2
Traffic control in and around harbors	5.14	7	5.75	4	7.30	10	6.00	6	5.00	2
More rational interpretation of the rules	4.00	6	3.00	3	6.82	11	8.00	6	7.50	2
More rational safety rules	5.00	3	8.33	3	6.55	11	7.83	6	5.50	2
Better life-saving equipment	7.20	5	4.67	3	5.27	11	5.33	6	6.50	2
Better search & rescue systems	5.25	4	7.50	2	4.90	10	5.83	6	3.50	2
Better safety features (subdivision, redundancy, better clasures, more freeboard, etc.)	5.67	3	3.00	3	4.27	11	5.33	6	2.00	2
Continual monitoring of ships' location by safety authorities	2.50	4	3.00	3	4.91	11	4.83	6	2.00	2
More sophistication on part of classification societies	4.80	5	2.67	3	3.91	11	2.17	6	3.00	2

Table 22 (cont.)

	Tanker Responses		RO/RO Responses		Container Responses		D. Bulk Carriers Responses		Pass./Auto Ferry Responses	
QUALITY OF LIFE	Mean	Number	Mean	Number	Mean	Number	Mean	Number	Mean	Number
Greater care in crew selecton	9.14	7	6.25	4	7.70	10	7.33	10	5.67	3
Reduced noise in accommodations and working areas	6.50	6	6.00	3	6.36	11	6.00	11	6.50	2
Reduced social barriers between officers and ratings (e.g., common dining rooms)	6.14	7	5.25	4	5.82	11	7.00	6	6.33	3
Eye appeal, interior decorations	5.83	6	4.67	3	6.40	10	4.67	6	5.00	1
Reduced vibrations in accommodations and working areas	5.00	5	6.00	3	5.55	11	6.00	6	6.50	2
Better habitability standards	5.57	7	2.00	2	5.10	10	5.83	6	3.50	2
Better food services	4.25	4	2.33	3	5.55	11	4.83	6	3.50	2
Decentralized decision-making	6.29	7	5.50	4	4.70	10	3.67	6	7.50	2
Better recreational facilities	4.60	5	2.67	3	5.00	11	5.00	6	3.50	2
Permission (and accommadations) to allow wives and childern on occasional voyages	4.13	8	5.67	3	5.18	11	6.17	6	6.50	2
Eye appeal, exterior	4.33	6	3.33	3	4.80	10	3.50	6	5.00	1
More time ashore, with pay	4.00	4	3.33	3	3.91	11	3.40	5	3.00	2
VEHICLES OF INNOVATION										
Entrepreneurial pioneers	9.63	8	7.67	3	7.30	10	8.83	6	7.50	2
R&D support: by groups of like-minded companies	4.43	7	9.00	4	7.36	11	6.00	6	9.33	3
R&D support: internal by private industry	7.14	7	6.50	4	5.09	11	7.33	6	7.33	3
R&D self-financed in university labs	5.14	7	4.50	4	4.64	11	5.17	6	6.00	3
R&D support: by government	3.38	8	4.25	4	5.60	10	3.83	6	3.50	2
EDUCATION AND TRAINING										
Education of business managers	8.75	4	6.67	3	7.70	10	8.17	6	10.00	1
Education of ship officers	6.50	6	6.25	4	7.36	11	7.50	6	8.33	3
Training of ratings	8.17	6	7.00	4	7.36	11	6.67	6	8.33	3
Education of engineers	7.60	5	5.50	4	7.09	11	7.50	6	6.67	3