SESSION ON HIGH-SPEED MARINE VEHICLE

Chairman: Prof. J.A. Alaez

High-Speed Marine Vehicle Committee Memberships: K.R. Suhrbier (Chairman) - K.O. Holden (Secretary) - J.P. Bertrand - C.S. Cieslowsky - A. Koops - K.V. Rozhdestvensky - O. Rutgersson - H. Tanaka.

Discussion of the Report and the Draft Recommendations of the High-Speed Marine Vehicle Committee (Cf. Proceedings, Volume 1., pp. 289-377).

I. DISCUSSIONS

HS-1

T. van TERWISGA
MARIN, Wageningen, The Netherlands

2. PROCEDURES AND INVESTIGATIONS FOR SURFACE EFFECT SHIPS

2.1 Test and scaling procedures
2.1.3 Scaling and
2.1.5 Tests in waves

I do not share the opinion of the Committee concerning the scaling of the resistance in waves. It is assumed in the Committee's report that the calm water viscous scale corrections can also be used in a seaway. However, experiments on an SES model have shown that the cushion pressure decreases significantly, due to the wave action. This causes the craft to sink in. This sinkage, together with the pressure reduction in the cushion plenum, causes a greater average wetted surface. The cushion pressure was not controlled actively during these tests. Both the fan and the fan-engine characteristics resembled their full scale counterparts. By assessing the change in wetted surface from the average change in rise, and using the 1957 ITTC flat plate friction line, an estimate could be made of the viscous scale effect in the added resistance due to waves. It is assumed that a quasi-steady approach in the determination of the frictional resistance in waves is valid. Applying this correction method, a decrease in full scale added resistance relative to the Froude scaled added resistance was obtained of 0–24%, the correction being a function of the frequency of encounter.

4. POWERING AND PROPULSOR RELATED PHENOMENA

4.2 Discussion on interaction effects

4.2.3 Waterjet/hull interaction

In addition to what is stated by the Committee, I would like to mention the following about the thrust deduction of a waterjet–hull system. A Joint Industry Project is currently conducted at MARIN, aimed at a better understanding of the interaction phenomena between the hull and the waterjet. This project is concentrated on a round bilge monohull equipped with two representative waterjets. From this study, and from several other self propulsion tests with waterjets, it is found that the thrust deduction fraction t may reach values of about 20% in the hump speed region.

For systematic tests with wedges, it is furthermore known that the total resistance in the hump speed region can be very sensitive to small changes in running trim. The precise character of this relationship is largely determined by the main hull form parameters. It is expected that a large part of the thrust deduction fraction in the hump speed region can be ascribed to the change in trim, relative to the trim found in the resistance test. This will be checked experimentally.

For a high L/B ratio round bilge monohull, more

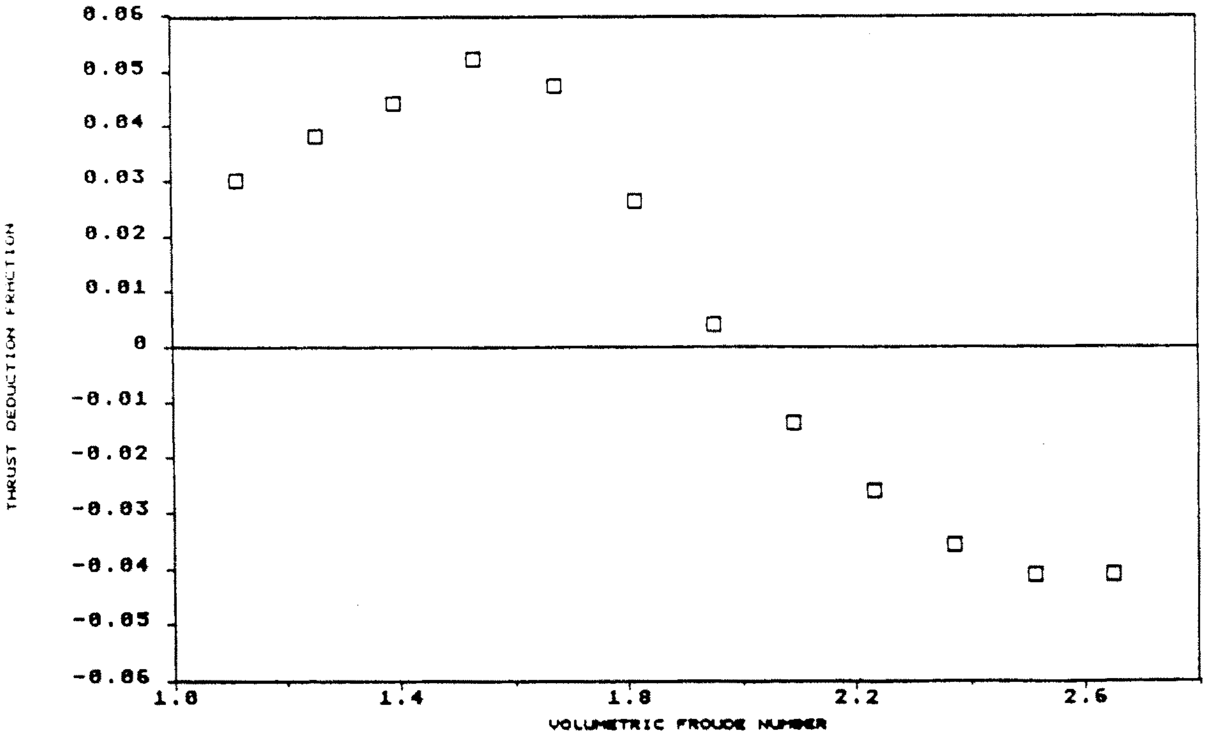


Fig. 1. Thrust Deduction Fraction as a Function of Froude number for a high L/B Ratio Round Bilge Monohull (L/B = 8)

moderate values for the thrust deduction fraction t were found. Values deduced from the measurements are given in Fig. 1. Negative values of the thrust deduction fraction appear to occur for the higher speeds.

All self propulsion tests referenced above are conducted along the guidelines given by the 18th ITTC. Definition of the thrust deduction fraction t is also according to these guidelines:

$$t = 1 - Rtm/Tg$$

where Rtm – Total resistance of the model with closed intake openings, having the same draft aft and forward as the self propelled model.

Tg – Gross thrust delivered by the waterjet system.

HS-2

M. HIRANO, Y. KUSAKA, and M. FUKUSHIMA
Akishima Laboratories (Mitsui Zosen) Inc., Japan

RIDE CONTROL ON AN ACV WITH AFT SIDEHULLS

Extensive model experiments were carried out in order to develop a new concept of a high-speed marine vehicle, namely and ACV with aft sidehulls (called ACVAS) as shown in Fig. 1, which has such features as: (1) lower resistance characteristics than that of an SES, (2) superior manoeuvrability to that of an ACV and so on. As an extension of an investigation on motion characteristics in waves, vertical motion reduction by means of control of cushion pressure, namely ride control, was examined from an experimental aspect with the use of a self-running model of 2.6 m long. Fig. 2 shows typical results of vertical motion characteristics of an ACVAS, where vertical acceleration at the centre of gravity in regular waves are presented for both cases of with and without the ride control (RCS ON and RCS OFF), with the ratio of wave length to cushion length as abscissa. By utilising the ride control technique, vertical

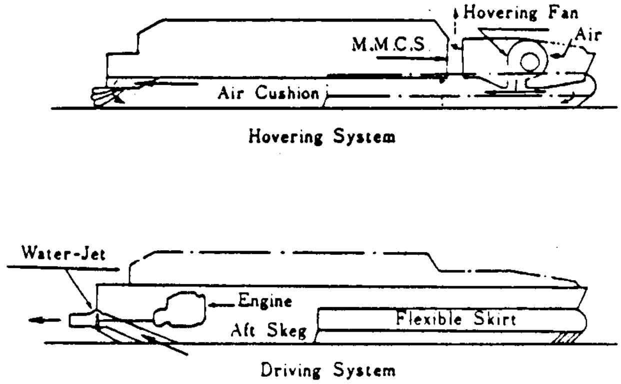


Fig. 1. Concept of ACVAS

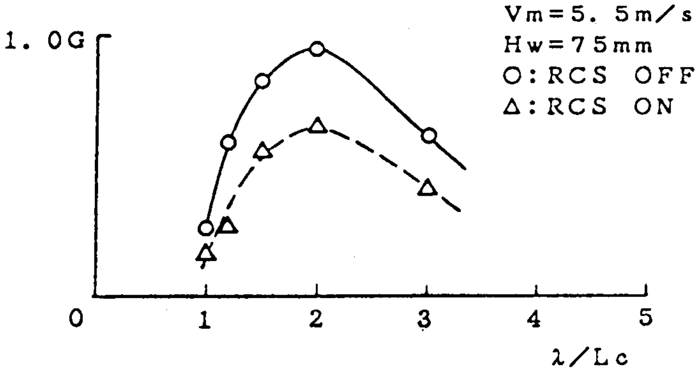


Fig. 2. Vertical Accelerations with and without Ride Control

acceleration can be reduced for two kinds of regions of heaving motions. One is the vertical acceleration in the higher frequency region due to the natural frequency of plenum chamber, and the other is that in the lower frequency region due to large heaving motions. The results shown in Fig. 2 are typical examples for the latter case.

HS–3

P. BROWN

Stevens Institute of Technology, Davidson Laboratory, U.S.A.

WETTED AREA OF PLANING BOAT HULLS

I would like to comment on conclusions number 1.6 on page 355.

In order to predict the full scale resistance of planing craft from model test, it is essential to know the wetted area. At the Davidson Laboratory the wetted area is routinely measured by underwater photography of the model. This technique has been found by us to be very reliable, and the photographic results correlate very well with the measured heave and trim. We find that overwater observations are very inferior.

In view of this experience it is hard to understand the Committee's conclusion, for which there does not seem to be much evidence.

We also find it is very important to measure the wetted area at intermediate speeds, contrary to the opinion expressed on page 260 of the Powering Performance Committee report. Particularly in the vicinity of hump speed where the wetted area changes abruptly, the neglect of variation in wetted area can produce very misleading results.

HS–4

Y. IKEDA

Technical University Berlin, F.R. Germany (Dept. of Naval Architecture Univ. of Osaka Pref.)

MEASUREMENT OF HYDRODYNAMIC FORCES ACTING ON A HIGH–SPEED CRAFT MODEL FIXED TO A THREE–COMPONENT LOAD–CELL ON A CARRIAGE

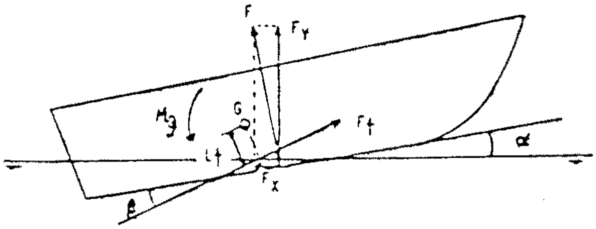
To make the power prediction of a high–speed semi–planing craft a conventional resistance test and a propulsion test are usually carried out. The attitude and the resistance of such a craft, however, are very sensitive to load condition, location of center of gravity (CG), shaft angle and appendages as well as the hull form as the report of the High–Speed Marine Vehicle Committee said. Therefore the result of the resistance test may be available for only one condition which is chosen in the experiment. If some changes are made in the design stage, the result would not be useful for the design anymore in the exact sense. Systematic tests are needed to respond to the wide requirements.

The purpose of the resistance test is to get the hydrodynamic forces which is difficult to predict. The steady hydrodynamic forces acting on a hull would be determined for a given speed if the sinkage and the trim in running condition are given. The effects of the location of CG and the shaft angle on the resistance are occurred as the results of the change of the attitude, and may be predicted by solving the balanced equations of the forces acting on the craft if the relationship between the three-component hydrodynamic forces (drag, lift and moment) and the attittude in running condition is given. The effect of an appendage would be also predicted using the relationship for the appendage if the hydrodynamic interference effect between the forces acting on the hull and the appendage can be ignored. By the conventional resistance test, however, only one component force can be obtained, and other two forces, that is the lift force and the moment, appear as the sinkage and the trim. So that on the basis of the results it is difficult to predict these effects.

The author carried out a measurement of the three-component hydrodynamic forces (drag, lift and moment) acting on a model fixed to a load-cell on a carriage of a towing tank, whose sinkage and trim are systematically changed, and did a simulation of the attitude and the speed for a given thrust force using the hydrodynamic forces obtained by the experiments [1].

A computer program to simulate the attitude and the speed of a high-speed craft using a database of the three-component hydrodynamic forces acting on a hull can be easily developed as follows [2].

In the steady condition, the hydrostatic forces, hydrodynamic forces and thrust forces should be balanced as follows [1].



Fx – hydrodynamic drag force
Fy – hydrodynamic lift force
M_G – hydrodynamic moment about centre of gravity
F_T – thrust force.

$Fx = Ft \cdot \cos(\alpha + \beta)$ (horizontal balance)
$Fy + Ft \cdot \sin(\alpha + \beta) + Fb = W$ (vertical balance)
$Mg + Ft \cdot Lt + Mb = 0$ (moment balance about CG)

where Fx, Fy and Mg are hydrodynamic forces and moment, Fb and Mb hydrostatic force and moment, α denotes the running trim angle, β the shaft angle, W the weight of the craft, Ft the thrust force and Lt the moment lever of the thrust force about CG. Interaction effect between the thrust and the hull resistance is ignored for simplification. The value A is defined as follows

$$A = \{(Fx - Ft\cos(\alpha+\beta)\}^2 + \{Fy + Ft\sin(\alpha+\beta) + \\ + Fb - W\}^2 + \{Mg + Ft \cdot Lt + Mb\}^2,$$

and the point where A is zero (or minimum value) for given speed Vs is searched by systematically changing the sinkage H and the trim angle α. The hydrostatic calculation program is used to get Fb and Mb, and the database of the hydrodynamic forces is used to get Fx Fy and Mg which are functions of V, H, and α.

Using the program a designer can make the sensitivity analysis of the location of the center of gravity, the shaft angle, the initial trim and the displacement to the resistance and attitude speed. In addition the effect of appendages can be predicted if the forces induced by them are considered in the equation.

It is noted that other hydrodynamic interference effects, for example between the propeller and the hull, on each force component can be measured by the same method. Then we may know the effect of the interference force on the change of the attitude, and on the induced resistance change.

The author thinks that a reasonable power prediction method for a craft may be deduced using the database of the hydrodynamic forces of its scale model.

References

[1] Ikeda, Y. et al.: "Hydrodynamic Force Acting on a High-Speed Craft Moving in Calm Water and Head Waves", Jour. of the Kansai Society of Naval Architects, Japan, No. 210, September 1988 (in Japanese).
(English version of a part of the paper is available in RESEARCH MEMORANDUM TUB-1 by Y. Ikeda, 14. 08. 1990).

[2] Ikeda, Y.: "Simulation Program for Running Attitude and Speed of a Semi-Planing Craft using Database of Hydrodynamic Forces of a Fixed Model". Research Memorandum TUB-4, Sept., 1990.

HS-5

A.F. MOLLAND
Southampton University, Southampton, U.K.

I should like to comment briefly on form factors for high speed craft, say $F_n < 1.5$. The Powering Performance Committee suggested that the use of a form factor is not recommended, but it was not clear to me whether this was because it is thought to give the correct answer, or simply because of a lack of appropriate data. The HSMV Committee Report suggests (Section 4.1.3.1) that "k = 0 unless determined by special investigations".

Results from the Japanese tanks, in Appendix 1 of the report, indicate that k = 0. Recent work at Southampton, using a total resistance minus wave pattern resistance approach, reaches a similar conclusion.

I would suggest that, with current automated facilities for wave cut analysis, the total minus wave pattern resistance approach for high speed craft is a plausible method which does not seem to have been mentioned by either committee.

It is apparent from the report and I would thus concur with the recommendations of the Committee, that work should continue on procedures for speed/power predictions.

HS-6

C. KRUPPA

Technical University Berlin, Berlin, F.R. Germany

With reference to Section 4.3 (partially submerged propellers) of the Report of the High-Speed Marine Vehicle Committee I would like to endorse the need to use inclined shaft tests results for performance predictions related to surface piercing propellers. Fig. 1 was recently presented at the 2nd Conference on High-Speed Marine Craft in Kristiansand, Norway (September 3-6, 1990). It shows optimum diameters and efficiencies deduced from the model test results of a small series of 4-bladed propellers with 88% blade area ratio and pitch-diameter ratios varying from 0.9 to 1.6. The series was tested in the free-surface variable-pressure tunnel of Technical University Berlin, on behalf of Rolla SP Propellers SA, Switzerland. Shaft inclination and immersion ratio are matched, in accordance with common articulated shaft geometries.

In contrast to standard axial uniform flow propeller performance Fig. 1 show that for a shaft inclination of 12 degrees and 58% immersion ratio the achievable propeller efficiency does not monotonously increase with diminishing design loading coefficient (K_Q/J^5). The reason for this phenomenon must be sought in the effect of the upward component of the propeller normal force which tends to reduce the propeller thrust.

Its effect on propeller thrust increases with diminishing propeller loading, as in non-cavitating propellers.

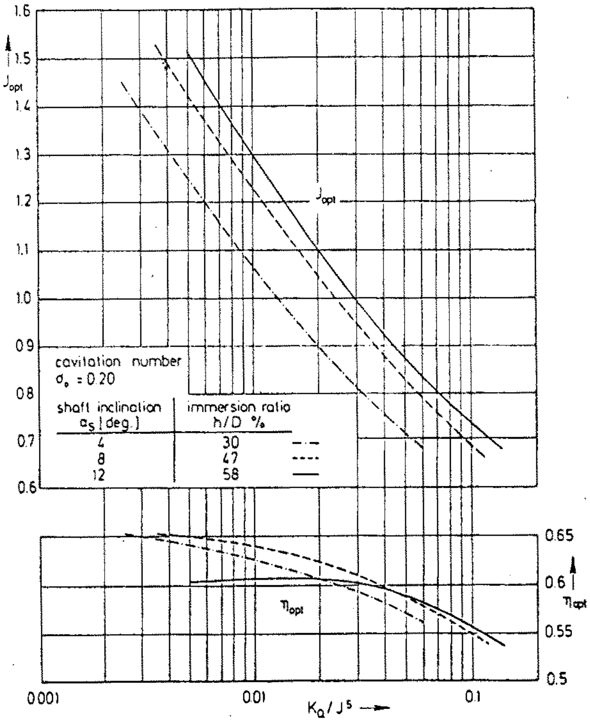


Fig. 1. Optimum Diameters for Surface Piercing Propellers

HS-7

M. NAKATO

Hiroshima University, Hiroshima, Japan

ON THE SCALE EFFECTS OF SPRAY

In the last part of the Committee report, Appendix A1 page 362, it is stated that "Hiroshima University found also that spray is influenced by such effects (scale effect) and are thought to contribute to scale effects on the trim moment".

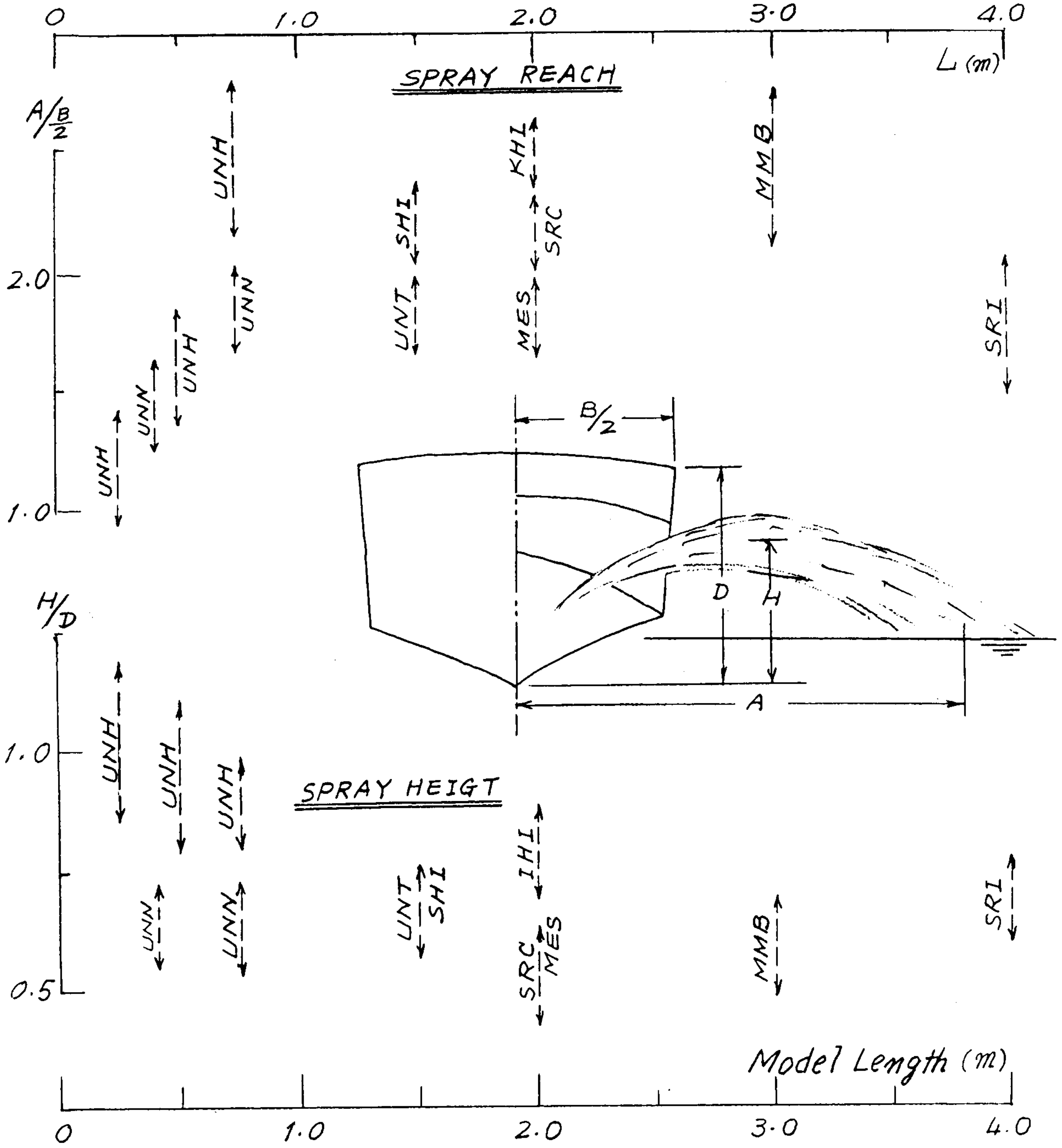


Fig. 1. Scale Effects on Spray

I would like to show the scale effects of spray by figures. The abscissa indicates model size and the ordinate, the spray size. In spite of the scatter of the data, the scale effects of spray can be observed in the smaller size models.

The figures are for Froude number 1.0, however, it is about the same for other speeds.

These data were obtained from photographic records submitted by the towing tanks involved in the cooperative study. Unfortunately, the camera positions and angles were different for the photographs used to evaluate the wetted surface areas.

It was found from the photographs that the spray characteristics are quite different between the smaller models and the larger ones, as stated before by Dr Gadd and several other researchers. The smaller models display feather shape weakened spray; on the other hand, the larger ones splash fine water particles as full scale craft.

Finally, it is stated in the report that the scale effects of spray contribute to the scale effects on the trim moment. However, it is difficult to say which is the cause and which is the result (a kind of 'chicken and egg' problem), because spray and trim are not only functions of Reynolds and Froude number but also of the Weber number and there may also be complex interactions between spray and trim.

HS-8

M. ABE
Akishima Laboratory, Mitsui, Japan

This is a general point of view to the Committee report:

As pointed out by the Committee, high speed marine vehicles are currently carrying various demands and missions in commercial service. In these circumstances, considerations regarding the aspects both of design and operation of HSMVs have to be preferred as well as the scientific approaches relating the hydrodynamic performances of them. The Committee will be expected to make an effort to pile up the topics of the new-built and new-era's HSMVs so as to know and assess the operational criteria, and to exercise the aims of design, namely, sustainable speed and load, sea-worthiness and safety.

The available tool for this purpose is the high-speed cinematic film by Video, which will hopefully be presented by the HSMV's operator and the builder.

It should be noted that this matter will deeply relate the direction of the future work of the Committee.

HS-9

T. FUWA, H. TAKESHI and J. HASEGAWA
Ship Performance Division, Ship Research Institute, Tokyo, Japan.

AVAILABILITY OF FLOW CALCULATION PROGRAM FOR HSMVs

There can be seen some characteristic flow phenomena around HSMVs. They are planing, wave breaking, spraying, cavitation, air-drawing, etc.. Theoretical modelling or reasonable understanding has not yet been established for some of these phenomena. Therefore there are quite a few tools of theoretical investigations available for HSMVs. In future a great deal of effort should be put into this field as well as experimental investigations in order to build up concrete methodology for the rational HSMV design and to have better understanding of the flow phenomena.

In contrast with HSMVs, there are some theoretical tools for conventional ships running at relatively slow speed. Numerical models, which have been developed for conventional ships but lose their theoretical foundation at high Froude numbers, will bring some useful information on the flow structure around HSMVs as long as aspects of flow phenomena are correctly modelled.

Comparison between experimental and theoretical results will show the availability and limitations of the theoretical tools for practical purposes. And the numerical results offer information for the modelling of flow phenomena or the extension of the program. It is therefore strongly recommended that every possible flow calculation should be performed for HSMVs.

A study on flow measurements and calculations for a submerged body of revolution with struts, which can be considered as a component of some kinds of HSMVs, are carried out in SRI [1]. As an example a flow calculation for the submerged body towing at F_n= 0.89 is shown here. It is an application of Neumann–Kelvin's wave calculation scheme developed for lower Froude number regions [2.3]. Fig. 1 shows the panels for the calculations, and Fig. 2 shows the calculated velocity vectors on the body surface, which are stretched in Z–direction. Experiments are performed for the corresponding model (l = 4 m) in a towing tank (400 m x 18 m x 8 m). Total resistance, trailing waves, flow velocities (by 5–holes Pitot tube and/or LDV) were measured. Flow patterns were observed by means of tufts and a water proof video camera. A composite photo of the video pictures is shown in Photo 1. Though the connection of the prints are not satisfactory, the flow pattern is easily understood. The shape of free water surface and flow directions in the spray of the struts above the water surface are also observed. Measured and calculated flow patterns resemble each other. The result shows that the numerical models, which have insufficient theoretical background for HSMVs, can be applied for practical purposes.

References

[1] Hasegawa, J., Takeshi, H., Fuwa, T.: "Calculation of a Flow Field around High–Speed Submerged Body with Struts". 56th Meeting of SRI, 1990 (to be published).

[2] Adachi, H. and Takeshi, H.: "Neumann–Kelvin Problem Solved by the Iterative Procedure Using Hess & Smith Solver Problem". 2nd Workshop on Ship Wave Resistance Computation, 1983.

[3] Tanaka, H., Takahashi, K., Ishizaka, J., Takeshi, H., Hinatsu, M.: "Evaluation of Characteristics of a Submerged Slender Body by Analysis of Flow around the Hull Surface" Symposium on Fluid Dynamic Drag, 1985.

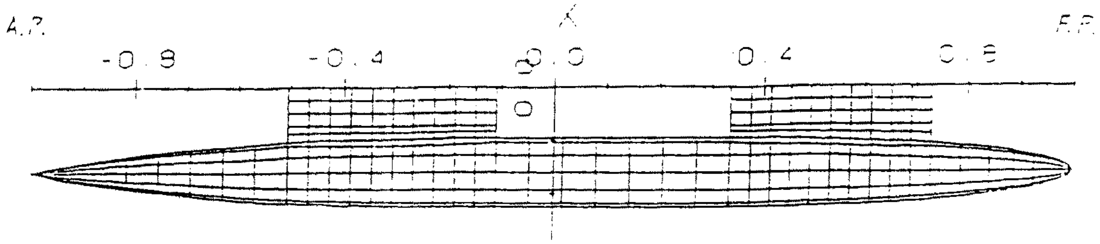


Fig. 1. Panels for Calculation

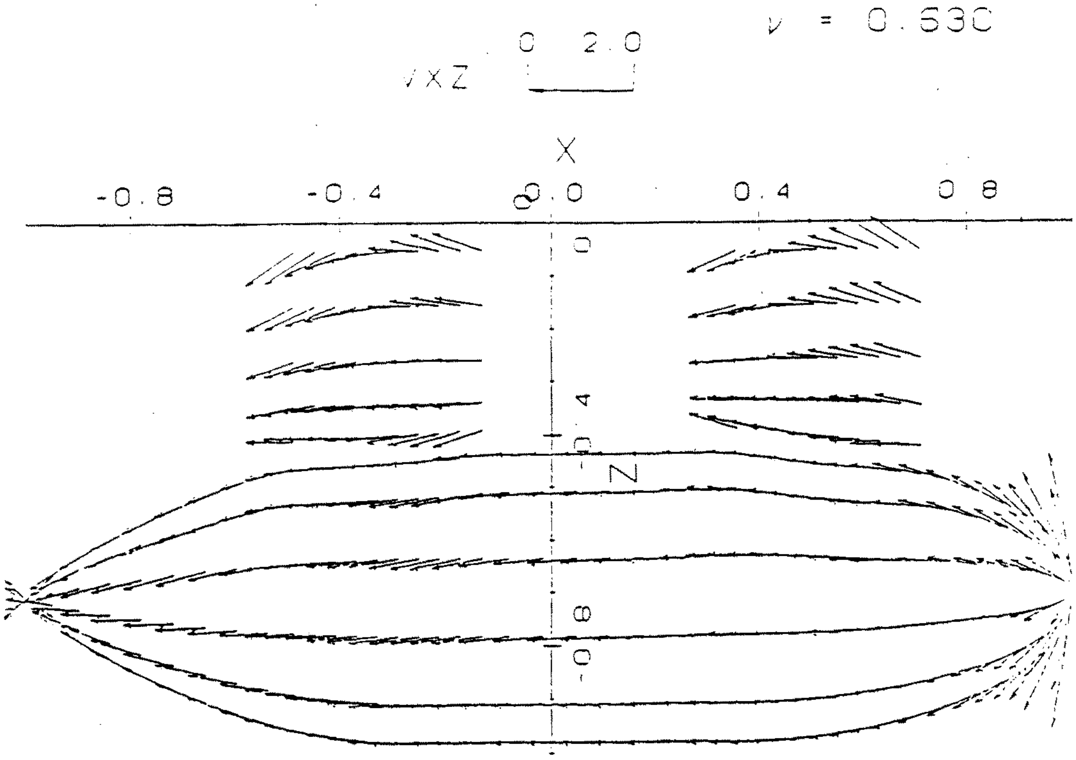


Fig. 2. Calculated Velocity Vectors ($F_n = 0.89$)

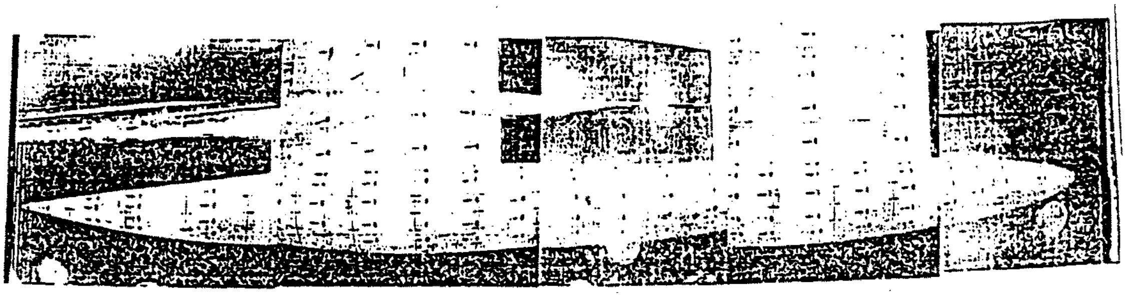


Photo 1. Observed Flow Pattern ($F_n = 0.89$)

HS-10

R.C. McGREGOR
Glasgow University, Glasgow, U.K.

I find this report very interesting and informative, but I would like to make a few points.

In the survey of craft built or on order HSMVs are categorized 5 types. Fig. 1 states that USSR craft are not included in the totals of hydrofoils and SES. This is unfortunate when trying to appreciate totals but is it not also true that all vessels from Eastern Europe and China are omitted. For example, members of the HSMV Committee were taken for a ride on a Chinese SES at the time of the meeting in Shanghai in 1988.

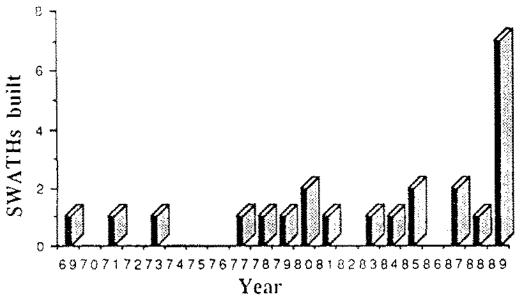


Fig. 1. SWATH Build Profile

In the case of SWATH, Fig. 1.5, while the total number of craft is still small, if the data is viewed by the date of launch it may be seen that while the rate of build was by discrete drops in the 1970s, it increased to a trickle during the 80s, and has risen very steeply in the last two years (Fig. 1). It would be interesting to see the way in which the relative share of the "High Speed Marine Vehicles" has been changing over recent years.

One small correction relating to p.333 (4 lines from bottom on column 1) it should not be 'negative wave resistance' but 'negative added resistance in waves'.

In the section on side loads, it is stated that the most severe wave loads for catamarans and SWATHS are experienced in beam seas. While this may be the case for the overall loads, it is not necessarily the case for the local loading when the longitudinal distribution is considered. The statement is also in a sense a function of the way in which tank tests are conducted with data normally being collected in head, beam and quartering seas. Computed results (Fig. 2, Ref. 1) for heading angles of 82,5 degrees and 97,5 degrees shows that for SWATHS at least, locally high loads are observed skewed forward and aft respectively. The integrated load for these off beam angles are very similar to the beam sea values.

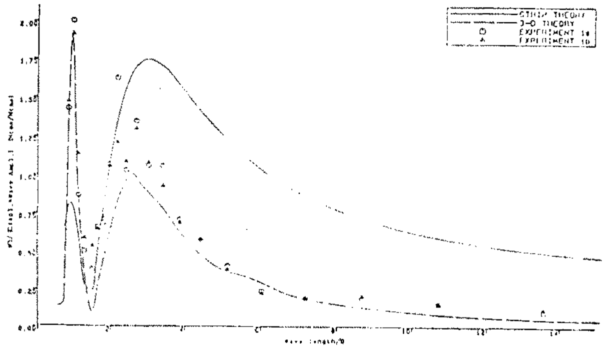
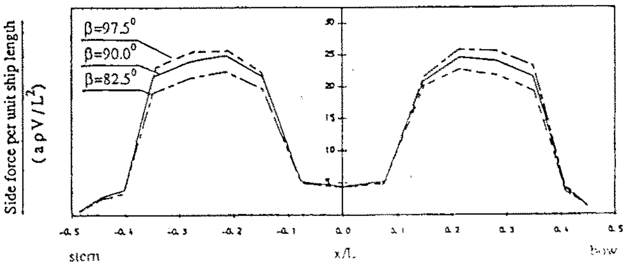


Fig. 2. Bending Moments at Mid-Point of Cross Structure SWATH1 Model in Regular Quartering Seas

Other results (Ref. 2 & 3) show that in quartering seas the sharp peak in loads near a wavelength to beam ratio of 2 (Fig 3) can exceed the peak at $\lambda/B \approx 4$ and that this peak can also be significant in beam seas. This effect is usually associated with the trapping of waves between the hulls.

(a) SWATH 1 (Tandem strut)



(b) Single strut SWATH

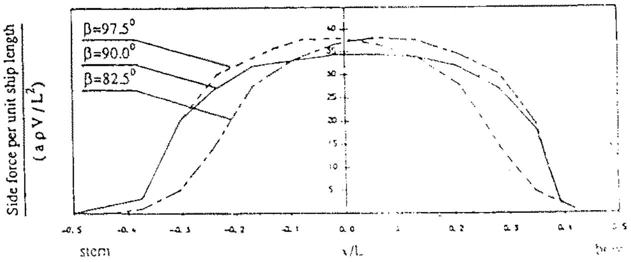


Fig. 3. Side Force Distributions along the Hull of the SWATH in Longitudinal Axis at the Frequency Where the Maximum Side Force and Bending Moment on Cross Deck Occur ($\omega_c = 6.0$)

Finally, while appreciating that this Committee will not consider SWATHS in the future, it is rather disappointing that its considerations of SWATHS in this report has not lead to conclusions specifically relating to SWATHS.

Thank you for a most interesting report.

References

[1] Zheng, X.: "Prediction of Motion and Waveload of Mono & Twin Hull Ships in Waves", Ph.D. Thesis, University of Glasgow, 1988.

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[3] McGregor, R.C., Arthur, E.K., Djatmiko, E.B., Drysdale, L.H. and Zheng, X.: "Comparative Seakeeping Studes of SWATH Ships", High Performance Vehicles Conference, Shanghai, 1988.

HS-11

K.S. MIN
Hyundai Maritime Research Institute, Ulsan, Korea

SOME COMMENTS ON THE REPORT OF THE HSMV COMMITTEE

First of all, congratulations on the marvellous summarisation of the state of the art regarding the HSMV model test and Performance Prediction technique. The committee members should be highly admired.

Even if I am very satisfied and happy with the report of the Committee, I would like to make personal comments on the following three minor items:

1. Propulsion System

Most of the discussions on propulsion systems has been assigned to propeller propulsion. However, you should be aware that most of HSMV nowadays have waterjets as a propulsion system. Recently we have reached the conclusion that waterjet is the future propulsion system for HSMVs. I believe that conventional propeller propulsion systems will disappear in the near future.

2. Test Method

As well known, a weak point of the traditional resistance and propulsion test method is the fact that flow conditions for model and ship are not completeley identical, that is, not all of the non-dimensional quantities related to the flow around the ship are satisfied. In case of HSMV tests with appendages or other devices, this problem becomes more complicated and significant.

Let's talk about a hydrofoil catamaran as an example. If the foil is fitted to the hull and tested together, the test results will suffer from a severe scale effect. If foil and main hull are tested separately, then no detail flow information including interaction effect could be obtained.

This situation has been well discussed in the report of the Committee, and once more I admire their effort.

It is desirable to carry out some kind of cooperative resarch work for the preparation of generally applicable test procedures or correlation in the near future.

3. Seakeeping

Up to now most of the commercial HSMV are operated for short range or short time, say 1/2 hour to 2 hours. Still they suffer from severe motions, particularly at the bow.

These poor motion characteristics may be intrinsic in the case of small high speed vessels, particularly for short craft. However, it is true that the comfortability for passengers and crew is severely affected.

Apart from passenger comfortability, another problem is the effect of wave load on structure. We have investigated several high speed passenger catamarans under operation in Europe and South-East Asia and noticed that some of them already had fatal cracks in decks and superstructure.

Considering the above, it is obvious that prediction techniques alone are not sufficient. How to improve the quality is equally or more important. In my view, the seakeeping quality for most of HSMV should be improved even if speed is a little bit sacrificed.

This is the end of my comments. Thank you for your attention.

HS-12

B. MULLER-GRAF
Berlin Model Basin, Berlin, F.R. Germany

MODEL TEST TECHNIQUES

The report of the High-Speed Marine Vehicle Committee gives an excellent review of all aspects associated with model testing and full scale extrapolation of high speed craft.

1. I like to underline, that despite increasing costs and expenditure the aerodynamic drag models should be determined routinely at high model speeds. The increase of the model resistance due to aerodynamic drag, which is already large at monohulls, becomes

larger in the case of catamarans due to the additional aerodynamic drag of the wet deck and the special bridge construction which connects the demihulls. In general it can be assumed that all published catamaran resistance data are more or less affected by aerodynamic drag and by other aerodynamic effects. For the correction of resistance, effective power and of the friction deduction of the propulsion tests, the aerodynamic drag of catamaran models is determined at VWS routinely by towing the catamaran models of model speeds higher than 5.5 m/s additionally behind a wind screen.

2. An important problem of high speed planing catamarans which is not solved satisfactorily at present, has not been considered in the report of the HSMV Committee. This concerns a reliable prediction of the frictional resistance of the spray wetted tunnel area of symmetrical planing catamarans.

The wet deck or tunnel root and the inner sides of the demihulls are wetted increasingly at speeds above the hump speed by the tunnel main spray. This spray formation is caused as seen by the Figure 1 , by the collision of both bow sprays of the demihulls at the centreline of the tunnel. The united sprays are reflected by the water surface vertically on to the wet deck.

The frictional resistance of the spray cannot be calculated because:

- the spray wetted area cannot be determined correctly;
- the wetted hull sides are hidden by the main spray;
- the flow velocity of the spray at the wet deck and hulls is unknown;
- the specific frictional resistance cannot be calculated.

The frictional above water resistance of the model can be determined by measuring the resistance additionally without the wet deck.

Up to the time when better extrapolation procedures will be available, a first approach in estimating the full scale resistance component is given by an extrapolation of the measured resistance difference by Froude's law.

With regard to the above mentioned resistance problem, more attention should be drawn by the next committee to the specific hydrodynamics of high speed planing catamarans.

3. As shown by these two contributions more and more special and supplementary tests are required to improve the power predictions of high speed marine vehicles. At the same time we are more and more faced by the requirements of the small shipyards which are the main builders of high speed marine vehicles, to reduce the cost of tests. Due to limited funds they are not interested in extensive test series. With a minimum of tests and calculations a realiable power prediction should be achieved. It would be very helpful, if the next committee could establish guidelines for monohulls and catamarans depending on speed and type of propulsor, what kind of tests are indispensable and what can be done to simplify the test procedures and what would be the most effective and economical test sequence without reducing the reliability of the power predictions. Resistance tests

without appendages after the propulsion test as suggested by the HSMV Committee would not be accepted by a shipyard which plans further propulsion tests with an altered hull form.

To my regret the draft of the ITTC Standard Symbol List for special craft, which was prepared by the HSMV Committee of the 17th ITTC and which was published as SSPA-Report No. 101, has not been taken into account by the Committee.

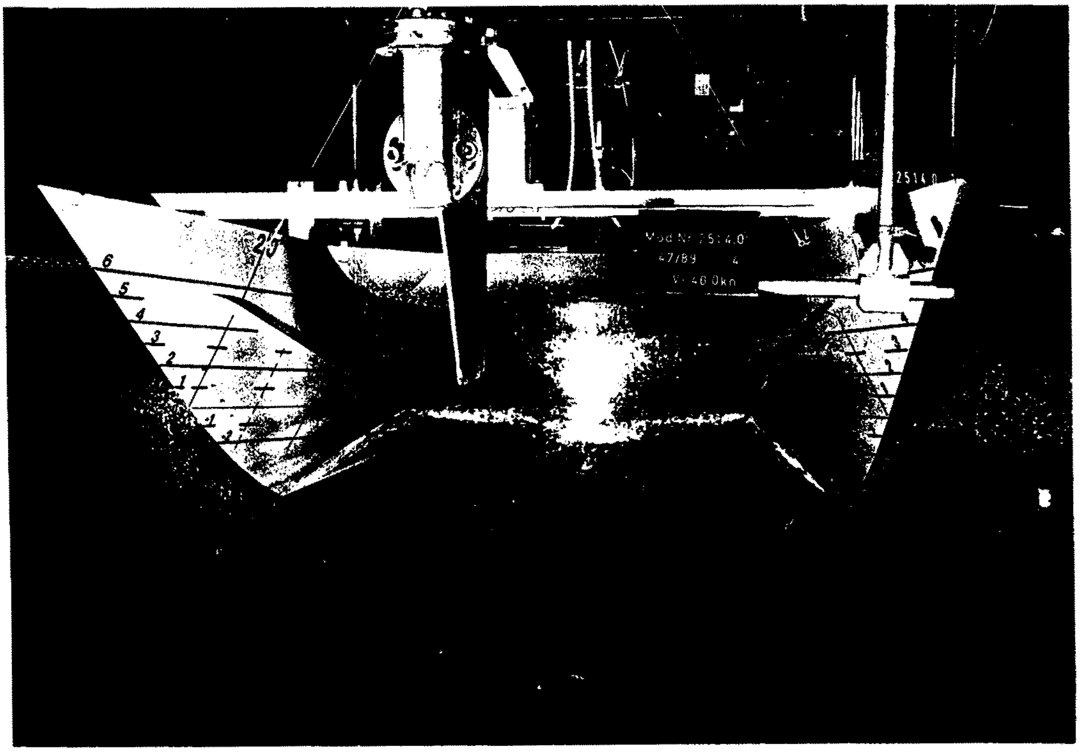

Fig. 1 Formation of spray in the tunnel of a catamaran with symmetric demi-hulls

HS-13

J. MARCHAL
Naval Architecture Department, LHCN Towing Tanks, University of Liège, Belgium

HIGH-SPEED STABILITY OF MONOHULLS IN CALM WATER

I have highly appreciated the Committee's report and I have been particularly interested in Chapter 6.3. relating to the high-speed stability of monohulls in calm water.

On the one hand, the Committee has pointed out some important remarks about experimental problems due to:

- limitations by using model tests which are restrained in yaw and sway;
- influence of the propulsor on the model trim which can be significant at very high Froude numbers;
- difficulty to simulate the conditions for cavitation and ventilation in model tests;
- interactive effects of trim, sway, roll and yaw motions, etc..

On the other hand, the Committee has described several features which influence the dynamic stability:

- metacentric height value
- trim
- hull forms
- LCG position
- propeller forces/moments
- deadrise angle; etc..

Taking into account all these factors, the impossibility to handle the problem theoretically and the remaining difficulty to handle experimentally the problem of the dynamic stability of high-speed monohulls at high Froude number, I propose to the Committee to insist, in their first recommendations for future work, firstly to pursue researches in calm water conditions through model and full scale tests with small high-speed boats with a special attention on the correlation problems.

My other comment is related to a special full scale test with a high speed pleasure boat with a modern hard chine hull. Of course, just before to reach this Congress, I received an expert report related to an accident with this boat; it was moving in calm water with a high speed which was difficult to evaluate by observer: "the boat was moving with a high-speed when it turned suddently on starboard and sunk", they said.

Taking into account the installed engine power and the rpm observed by the pilot, our computations evaluated a Froude number of 1.4, and we verified the phenomena observed in Figs. 6.10 and 6.11 of the Committee's report and the driver comments which said: "I had progressively steering difficulties and suddenly a violent yawing motion occurred".

This non-projected full scale test shows, as it has been pointed out by the Committee's report, that even with modern hard chine hulls, problems can arise at high Froude number, even with exceptional high metacentric height values!. Special efforts must be done in the future to define carefully dynamic stability criteria.

II. REPLIES BY THE HIGH-SPEED MARINE VEHICLE COMMITTEE

The Committee would like to thank all discussers for the interest shown and their valuable contributions made.

Mr. VAN TERWISGA (HS-1) raises a point regarding the wetted surface and scaling of viscous resistance of surface effect ships in waves. We think we would probably all agree that, whatever method is used, the value for the wetted area will always be approximate since it varies with time or motions. As pointed out by the discusser, with constant fan rpm cushion pressure decreases in waves due to air leakage and thus the draught changes. It is however, also customary to control (increase) the fan rpm in order to keep the air pressure the same as in calm water. The proposal made in the report refers to this condition; this should, of course, have been made clear. We note with interest the correction method used by the contributor and the noticeable effects found for the added resistance.

The comments on the subject of thrust deduction of waterjet–hull system are much appreciated. The study carried out at MARIN and the data obtained are welcome additions on this subject and we thank the discusser for making the information available. The data given in his graph (Fig. 1) seems to be in line with results obtained from some other sources (see also the 18th ITTC HSMV report) and confirms clearly that negative thrust deduction values can be obtained, presumable largely due to trim changes. The extreme values found for hump speed are also noted with interest. We are certainly looking forward to further results and conclusions from the investigations in hand in The Netherlands.

Drs. HIRANO, KUSAKA and FUKUSHIMA (HS-2) describe a new concept of ACV and its ride control. This hybrid design is interesting and we certainly wish every success.

Ride control systems have for many years been a fascinating subject for those involved in this field. The main problems with today's SESs are still the high frequency vibrations due to excitation of the natural frequencies of the cushions and bags. It is hoped that this problem will be solved in the near future with advanced sensors, electronics and control systems. The results shown appear to be promising –in spite of the fact that acceleration levels are high compared with the comfort criteria of 0.1 ... 0.15 g.

Mr. BROWN's **(HS–3)** point regarding the wetted surface is taken. Our conclusion 1.6 was based on comparative resistance tests discussed in Section 5.1; the wetted areas and lengths had (only) been obtained by above water photography and visual observations. We therefore regret very much the omission of the word 'above water' since we only meant to say that this particular kind of photography was found to be inferior to visual observation. (Reference may also be made to the 17th ITTC HSMV Committee Report 'Estimates of Wetted Area of High–Speed Marine Vehicle', pp.350–354).

We certainly agree with the statement made by the discusser regarding the need for additional measurements of the wetted surface at intermediate speeds.

Dr. IKEDA (HS–4) discusses the procedures and the advantages of systematic 3–component model measurements in order to prepare a suitable data base for analysis and prediction purposes. We agree, of course, that such approach is principally superior, particularly for tests of model series (see also our discussion on p.302), and we welcome this contribution to the report. The method does however require a great deal of extended testing in particular if a number of hull form variations or modifications are to be investigated. It is mainly for this reason that for routine work the simpler test procedure, i.e. tow along the shaft line, is normally adopted and its consequences are accepted.

Dr. MOLLAND (HS–5) refers to the subject of form factors for high–speed craft. It is stated in our report that these are usually ignored; the Powering Performance Committee, on the other hand, recommended not to use the form factor approach. We submit that the reasons for these statements are not that approaches with k = 0 are thought to produce more accurate results. They are made (as also implied by the discusser), because the k values are rather difficult to determine, and/or because of lack of data. It is usually assumed that the form factor effects are relatively small. The information obtained in Japan (see Appendix A.1) and at Southhampton may indeed stimulate further thought and insight into the possible prediction errors involved.

Wave cut analysis could, as suggested, be a plausible approach, except maybe for routine work, and we agree that work should continue in this area.

We very much welcome the information on surface piercing propellers provided by **Prof. KRUPPA (HS–6)**. His diagram should also serve as useful guidance for initial selection and performance assessment of this rather special type, of propeller. We are of course looking forward to further results from his laboratory, in particular, also on the propeller normal forces because of their influence on efficiency and attitude of high speed craft.

We thank **Prof. NAKATO (HS-7)**, one of the coordinators of the Japanese resistance test programme (Section 5.2 and Appendix A.1), for his comments and additional information.

We are aware that he contributed a great deal on matters concerning the smaller models and we note with interest his analysis and graphic presentation on scale effect of/on spray. As suggested, spray characteristics seem to affect trim and vice versa. Reference should perhaps also be made to the influence of the Reynolds number dependent skin friction on differences in trimming moments, discussed by Crago [3.7], as well as the comments and findings by Michelson [3.4] and Hadler and Moore [3.6] (briefly referred to on p.303 of our report).

We agree with **Mr. ABE (HS-8)** that the subjects of operational criteria, seaworthiness and safety on high-speed craft have to be addressed. The Committee has identified these topics as highly relevant. We were however unable to deal with them at any depth in our report. They are therefore proposed in our Recommendations for Future Work for the next Committee.

We also concur that video recordings are a useful tool for assessments of craft characteristics, but they should be considered as additional. They can provide a great deal of information and thus complement the measurements essential for evaluations (acceleration, motions, etc.).

Drs. FUWA, TAKESHI and HASEGAWA (HS-9) draw attention to the lack of theoretical tools for dealing with high-speed flow phenomena.

We agree that calculations should be performed wherever possible and that suitable numerical methods should be developed. The example of a flow calculation for a SWATH type body and the experimental information given are noted with interest. Further work is obviously required to extend such theoretical approaches to HSMV problems. In the meantime, we will have to be content with experimental investigations.

We agree with **Dr. McGREGOR (HS-10)** that it is somewhat unfortunate that the survey of craft does not include more information, particularly data on craft built in the USSR, Eastern Europe and China. We believe that the presentations are, nevertheless, useful and of benefit to those involved in this field. For various reasons we had to rely on data (generously) made availabe to the Committee (financed by the Norwegian High-Speed Research Program). Maybe, the next Committee will be able to extend and update this survey. We thank for the additional data supplied.

As regards the critical side loads on multi-hull vessels, we note with interest the data presented. Local loads are most important and we agree their maxima may well be somewhat off the beam sea conditions.

Tests recently carried out in Norway on a seagoing model of a 'foilcat' (with strain-gauged struts and foils), showed, for instance, that the most critical loads occurred at high speeds in beam/quartering seas. It is hoped that these results will be available for the next committee report.

As regards SWATHs, the Committee did not intend to draw any final conclusions since we were until recently not aware that this subject should in the future be dealt with by other committees.

We thank **Dr. MIN (HS-11)** for his complementary remarks.

With regard to future HSMV propulsors, we have to say, however, that we do not quite share his views. Waterjet systems undoubtedly have their place, but so have other types of propulsors. The relative merits depend, in our opinion, on operational conditions, efficiencies, design considerations, etc. Propellers may cause vibrations or erode, but waterjet systems may in certain applications, for instance, suffer from cavitation and/or air ingression problems.

The comments made on problems of test methods and scale effects are certainly relevant. The hydrofoil catamaran case referred to is a good example. Obviously, scale effects have to be minimized, component testing may be necessary, theoretical and experimental investigations need to be made and good correlation data are most desirable, but not always easily available. The suggestion for cooperative research should obviously be followed up whenever possible.

We would agree with Dr. Min's observations as far as the present status of HSMV seakeeping and structural matters is concerned. We feel also that operational conditions and criteria need to be specified, the vehicles should be designed and manufactured for specific operational limits which have to be adhered to by the operator(s) for reasons of safety or economy – as in the case of aircraft operation and manufacture.

We also thank **Dr. MÜLLER-GRAF (HS-12)** for his kind words. We agree aerodynamic effects on models with large superstructures, such as catamarans, SESs, etc., deserve special attention. The Committee recommended a test procedure with a streamlined rig in front of the carriage and it is felt that tests behind windscreens as suggested can cause other effects (possibly disturbing the water surface, etc.); rather special care would be necessary to avoid secondary influences.

We did not, as originally intented, discuss the special problems of catamarans. We therefore welcome the discussion (and slides shown) as well as the proposals made on spray and wetted areas in the tunnel and the related scaling problems as well as the proposals made. We also agree the difficulties should be realized and more attention should be paid to establish suitable extrapolation procedures.

Regarding your third point, the matter of how many additional experiments should be carried out and at what cost must, in our opinion, depend on the case and the degree of reliability required, bearing in mind that the discussions in the report were meant to deal (or also deal) with very high Froude number or rather unconventional cases. We fully realise the practical implications. Resistance tests after propulsion experiments are most inconvenient and may well not be necessary for the majority of model tests, but they would perhaps be if, for instance, the appendage drag was found to be negative. Furthermore, Method B of Section 4 is frequently considered as an alternative thus avoiding or by-passing the resistance test(s) altogether; its application would, of course, very much depend on the confidence that can be placed on the scale effect corrections.

We hope we may be forgiven for not using the list of symbols referred to; it was published in a draft report (not generally available) and not in the ITTC proceedings, except the one for this conference.

Prof. MARCHAL's (HS-13) contribution on high-speed stability, discussed in Section 6.3 of the report, is much appreciated. Problems in this particular area are certainly much more frequent than generally admitted. As also stated by the discusser, there are various difficulties in dealing with this subject, theoretically or experimentally. We therefore agree that this topic should be subject to further research which, to an extent, is reflected in our recommendations. We suggest that the subject is pursued by the Member Organisations and also the next Committee, though it was felt that for future work particular emphasis had to be placed on stability of high-speed craft in waves.

The unstable behaviour of a high-speed pleasure boat described by Prof. Marchal follows patterns very similar to those observed on other craft, i.e. steering difficulties followed by violent yawing motions, although in most cases it has fortunately been possible to avoid such accidents by reducing speed in time, i.e. immediately after inception of heel and yaw. The case reported certainly highlights the seriousness of the phenomena involved. Modern high-speed hulls can indeed suffer greater stability losses than generally expected. More traditional forms may be less affected, particularly because of greater stability forces generated in the forward chine area. It is, of course, difficult to speculate on the causes in this particular case without detailed knowledge of the craft. Reduced trim at high Froude numbers could have played a role and might have triggered dangerous instabilities, as also referred to in our report.

III. COMMITTEE REPORT - ERRATA

We offer our apologies for the lengthy list of errata enclosed as a flysheet in Volume 1 of the Proceedings. Additional corrections should be made as follows:

p.333, left column 5th/4th line from the bottom: *read* 'negative added resistance in waves' *instead of* 'negative wave resistance';

p.365, Fig. A1.9, Condition FA (-o-) at F_n = 1.0: *change* value of 1+k plotted as 1.4 *to* 1.32.