Response from 27th ITTC Resistance Committee to discussers

1.

Arthur M. Reed
David Taylor Model Basin (NSWCCD, USA)

In the Resistance Committee's discussion of optimization in the section on 'Simulation Based Design', only the refinement of the lines of the vessel was discussed. However, the optimization of the principal dimensions of the vessel (L, B, T and C_B or C_P, given C_M) can have a significant positive impact on the resistance and consequently the powering of the vessel. It is not inconceivable that a 25% or more reduction of the resistance of a vessel over an unoptimized hull form could be realized over a small range of speeds.

Thus, I would recommend that a two stage optimization process should be recommended and incorporated---first an optimization of the principal dimensions of a vessel, followed by an optimization of the detailed hull form (as described in the Committee's report). For the first stage principal dimension optimization, a cost metric should be determined that takes into account the construction costs *and* the lifetime operating costs for the proposed vessel. Then the principal dimensions of the vessel should be optimized against this cost metric, stretching a generic hull form to fit the principal dimensions to define the initial hull form. Then when the optimal principal dimensions the detailed hull lines can be optimized.

The success of this proposed scheme requires that *all* of the constraints on the design be determined and quantified before the start of the process. Many a successful optimization has been derailed by the design violating a constraint that has been identified *after* the optimization has been completed.

Response:

The committee would like to thank Dr. Reed for his insightful comments and suggestions. Even though the committee report has focused on the optimisation of the hull form from the point of view of hydrodynamic performance and detailed geometry modifications, the committee strongly agrees that in general the hull form optimisation should be seen from a wider perspective taking into account among others the economic and manufacturing factors as well as the optimal choice of the main dimensions. During the review of the relevant literature the committee came across several papers, where the first step of Dr. Reed's proposal has been performed. An example of this is presented in the paper by Hart and Vlahopoulos (2010), which is cited under Sec. 8.2 - Analysis tools of the committee report.

2.

David Murdey
National Research Council Canada

I will confine my remarks the "World Wide Campaign"

This must surely be one of the most comprehensive studies of ever carried out by the ITTC. The work of planning the tests, overcoming logistical problems transferring models around the world and analyzing the results should not be underestimated nor go without recognition.

It is disappointing to read in their report that the work of the Committee has been limited not by their own time, expertise or enthusiasm, but by the inability of many participants to submit the data required in the form requested, to check their results for errors or even to submit their results at all. For the large model out of 21 organization who participated, the results from only 11 could be included.

As noted by the Committee another limitation on what can be learned from the Campaign stems from the decision to use the “double blind” approach. This has prevented any study to explain the differences in results from different facilities. In their conclusions the Committee recommend that an open approach should be used in future. The problem with this is that that it may be many years before a study like this can be repeated. I think it is too early to give up on collecting the information necessary to enable the ITTC to get the full benefit from the effort expended so far. The participants are known, and I do not think it would be too difficult to match results with participant. One way would be to ask participants to resubmit their data directly to the committee. The committee could give organizations who submitted incorrect or incomplete information the opportunity to resubmit. Those who participated by carrying out the tests but never submitted the results could be contacted to find out if the data could be made available or not. Once the most complete set of data have been obtained the analysis could be continued and extended in scope. This will be yet more work for the committee, but this should be compared to the big investments made by participants.

Response

The Committee is in complete agreement with David Murdey and the spirit of his comments and suggestions. The dataset should be an invaluable resource to the ITTC community for many years to come. It is worth noting that despite the requests of the committee during both the terms of the 26th and 27th committee no more data was forthcoming. The worth of the data that was submitted should not be detracted from as there is sufficient for both the small and large models to draw some interesting conclusions as the last few series of ITTC committees has indeed attempted to do. It is not obvious that these conclusions would change significantly with a larger dataset although for all the tanks concerned it would very much improve their understanding of their own towing tank’s process and performance relative to the wide community. It is in this spirit that the 27th ITTC RC generated the analysis spreadsheets alongside the complete datasets that it would encourage the whole community to investigate.

3.

Jinbao Wang
Marine Design & Research Institute of China (MARIC)

First I should say this is a very good report which we do not have to wait until the last report which reads “the last, the best.

Two questions are for the committee:

1. 3-D printing is an interesting and attractive technology, smoothness and expense are of great concern. I wonder if the committee has got some successful example for 3-D ship model printing?

2. There exist some mistakes in table I (Vol. 1, p. 16) because form factor reaches about 0.4 which is too large for bulk and oil tank. Also, where has roughness allowance gone? I would like to have an explanation.

We are grateful for the questions posed. Indeed at the time of writing the report the committee was not aware of any complete models constructed using 3-D printing. However, the area of technology of which 3-D printing is one part is developing very rapidly so it would not be a surprise if such models do start to be made during the period of the 28th ITTC. As always with the introduction of new processes it requires the development of best practice and clever use of the tools available. For instance building models using computer controlled laser cut transverse sections of plywood and hot wire cut foam sections already provides a cost effective method. Returning to the specifics of surface finish – this does depend on the characteristics of the specific device/material used. One method of generating a smooth surface is to use surface treatment that 'melts' the surface locally.

The values of form factor in Table 1 as discussed in the original reference are taken as indicative of the increase in friction related (eg shear stress) resistance compared to an equivalent flat plate. As such they can be seen as including roughness allowance. The key perspective on this is that looking for approaches that reduce full scale ship resistance requires an appreciation of the relative balance of resistance components and also the potential for reduction. For instance the air drag at 2 – 4% looks a small amount but crucially for many ship designs it has not been optimised so there is considerable scope to apply appropriate flow control devices and reduce the bluff form drag by 50% or more

4.

Joel T. Park, Ph. D., FASME
Naval Surface Warfare Center Carderock Division

The Resistance Committee has provided an excellent report to the 27th ITTC on Monday, 01 September 2014. The following are three comments on the report.

1. Percentages. Several times early in the presentation, information was provided as percentages. However, the specific definition of the percentage was not provided. This issue is present in many engineering reports. As an example, instrument manufacturers state the accuracy of an instrument as percentage of the full-scale range

of the instrument. In physical units, the value is constant over the range of the instrument.

2. Error (uncertainty) Bars. On page 28 and 29 of Volume I, graphs of the World Wide Campaign are shown as Figures 11-13, which were also presented at the Conference as PowerPoint. The figures should have included the uncertainty estimates for each laboratory as error bars.

3. Outliers. The correct method for assessment of outliers in Figure 11, page 28 and 29 is described in ITTC Procedure 7.5-02-01-01, Section 12, p. 11. The differences from the average should have been computed and normalized with the standard deviation. From Table 6, the difference for laboratory #4 is 0.298 and the standard deviation is 0.11, or the standardized residual is 2.7, which is clearly an outlier per Chauvenet's criteria. With the outlier removed, the difference and standard deviation are respectively, 0,331 and 0,038 or a standardized residual of 8.5.

Response:

The committee very much appreciates the questions and the expertise and knowledge behind them.

In considering 1, for each measurement (data point) of resistance, the percentage for its uncertainty is referred to the relative uncertainty of measurement, i.e., the uncertainty divided by the specific measurement value, which complies with the expression of ISO-GUM. With regard to the percentage for uncertainty of an instrument, e.g., dynamometer, as shown in Figure 5, it refers to the component of measurement uncertainty resulted from instrument calibration but not the uncertainty of instrument calibration itself. In reality such a component of uncertainty results from the propagation of uncertainty of instrument calibration (with the value being 0.0087*kgf* constantly for all measurements). For the Froude number of 0.28, the relative uncertainty component from dynamometer calibration is 0.19%, while for a Froude number of 0.1, this component is 1.59%.

For question 2 we agree completely with this opinion. However, those uncertainties provided by each laboratory are estimated by AIAA method rather than ISO-GUM and consist of bias and precision components. Furthermore, no detailed analysis information on these uncertainties is provided so that use of these uncertainty estimates for each laboratory may be misleading. Therefore, only the uncertainty of repeat tests for each laboratory is included for inter-laboratory comparison

Finally for question 2 we again are in agreement with the questioner. Strictly, the outlier should be judged by those existing methods, such the Chauvenet's criteria. However, for routine tests, the number of repeat tests is not large enough to perform such a strict test for outliers. In this report, an approximate and simple method is recommended for use in routine tests and may be intuitive to technicians of towing tanks, which will be of benefit in promoting uncertainty analysis in routine tests of towing tanks. As known to some extent, many technicians tend to use double-sigma or triple-sigma to judge the doubtable outliers, especially when the sigma may be adopted from in-lab database instead of repeat tests.

5.

Luis Perez-Rojas
Technical University of Madrid

I have two questions for the committee:

1. Your opinion about the appendages extrapolation??? .

2. I am wary about the new technologies in the 3-D models. In the conventional method, you know the uncertainty of the CAD model and the uncertainty of the milling machine. But in these cases you do not know the behaviour of the machine, for instance under the temperature effect. I would like to know the committee's feelings.

Response:

The committee did not explicitly examine appendage extrapolation but there is a significant section in the resistance committee report of the 26th ITTC which supported the application of turbulent stimulation in the model construction procedure. In overview the process of extrapolation of an appendage will depend on the flow similarity between model and full scale. If at model scale the appendage is too small such that the local Reynolds number does not allow fully turbulent flow due allowance needs to be made for this lack of flow similarity.

In discussing 3-D model production we refer back to our response to Professor Wang but would also add that there are trade-offs for specific 3-d printing machines as regards their dimensional fidelity. These depend on the size of the component and often the direction in which it is aligned within the machine. As in conventional casting techniques some of these possible distortion issues can be overcome through use of appropriate allowances applied to the original 3D CAD geometry.

6.

Sakir Bal
Istanbul Technical University

As it is a well-known truth, the form factor (1+k) depends on Reynolds number. Does the committee suggest investigating this dependency significantly? If yes, how? Is it possible to derive an equation for this dependency?

Response:

Dr Bal's question is definitely worthy of consideration and indeed an advantage of well validated computational methods for predicting viscous flow around hulls should allow deeper understanding of how 1+k varies between model and full or indeed across a ship's operational Froude Number. The challenge as always is in being able to unpick the relative changes in viscous and wave components and crucially their interaction. Is it likely that a single equation will be applicable to all ship hull forms? Our opinion would be that this is perhaps not the best way forward but rather better knowledge of the likely magnitudes/relative importance of changes should be sought using results from CFD and better knowledge of operational performance of ships in service.