SESSION ON VALIDATION

Chairman: Mr. A. Hansen

Panel on Validation Procedures Memberships: W.C. Lin (Chairman) - G. van Oortmerssen (Secretary) - M.E. Davies - B. Della Loggia - O. Faltinsen - A. Haimov - P. Hocquet - K. Mori.

Discussion of the Report and the Draft Recommendations of the Validation Panel (Cf. Proceedings, Volume 1, pp.577-604).

I. DISCUSSIONS

V-1

Y. KODAMA
Ship Research Institute, Japan

COMMENTS ON THE REPORT

In the editorial policy of an ASME journal, it is stated that results of flow computations cannot be accepted as valid, unless they are obtained using more than one grid. This statement show that CFD (computational Fluid Dynamics) results can vary depending on the grid used. Dependence of computed results on grids comes from two sources. One is grid resolution. This factor has the primary importance, but its check is rather straightforward. One only has to double the number of grid points and re-compute. The other is grid quality, which is related with skewness, irregularity, smoothness, and so on. This factor is difficult to check, because one generally does not have a grid-generation system which is flexible enough to generate grids of various qualities. Still, this factor should be checked whenever possible, for the validation of CFD results.

V-2

M. SCHMIECHEN
VWS, Berlin Model Basin, Berlin, F.R. Germany

SYSTEMS IDENTIFICATION

In the opinion of the present discusser some of the fundamental work of the Panel needs to be continued on a general level. This applied in particular to the problems of uncertainty analysis arising in the context of systems identification problems encountered in performance, seakeeping, and manoeuvring problems to mention only a few.

Concerning the problem of the true values it should be kept in mind that our mathematical models are conventional in nature and the parameters we are determining are only coordinates in the space they are spanning.

In the experience of the present discusser the systhematic errors or biases and their isolation were found to be the dominant problem in general. In any particular case special strategies may have to be developed. Some general guidance by a permanent Panel would be most valuable if not necessary.

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Y. HIMENO
University of Osaka, Japan

UNCERTAINTY ANALYSIS AND CFD VALIDATION

I do appreciate the effort and the activities of the VP, and I would like to make two comments on UA and CFD Validation.

In the technical report of the Validation Panel, there is an example of the uncertainty analysis of the resistance test in p.592, in which the measured instantaneous resistance data are split into 7 subsections, and then a grand average of the average of the data in each subsection, in order to obtain the precision error of the resistance. This procedure corresponds to a kind of filtering of the raw data. My opinion is that this procedure could be right only if we know the necessary frequency range in the resistance test. At present time, we do not know much about the frequency response of the resistance test system. I think we must be careful if we adopt a filtering process in uncertainty analysis.

As for the CFD Validation process, I think the most important thing is to take such a procedure as listing up the possible error sources and estimating the errors one by one, just like the UA procedures. And only the comparisons with experiments and the sensitivity check by changing the internal parameters like grid size etc, would not be enough for the whole validation process.

In this sense, the analyses of the numerical errors, arising from the discretization process, and numerical solution process, would be most important. These errors include truncation errors, errors due to finite iteration number, round-off errors, etc. I think it would be necessary for each CFD developer to try to evaluate these numerical errors.

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A.J. MUSKER
Admiralty Research Establishment, Haslar, U.K.

WRITTEN DISCUSSION FOR VALIDATION PANEL REPORT

Validation featured prominently in all of the meetings of the Resistance and Flow Committee and I should like to take this opportunity of commending the Validation Panel for their efforts in the preparation of this report which is both helpful and timely. I have five points I wish to raise in the context of the CFD aspects of the Committee's presentation:

1. Whilst the broad guidelines proposed by the VP (Validation Panel) are to be welcomed, I believe our enthusiasm for validation must be tempered with an awareness of the cost of such ventures for CFD calculations. If a grid resolution is increased two-fold in the three component grid directions the cost of a single calculation will increase by a factor of between about 10 to 20. The CFD community should therefore be concentrating on determining general rules for cell distribution within a grid to capture the important features but at the same time minimising the effort required in grid sensitivity studies.

2. How do we deal with the somewhat nebulous concept of a 'true value'? The true value is obviously our goal but is never attainable. Wave resistance predicted using potential flow methods, for example, bears little resemblance to the 'wave-resistance' deduced even from wave cuts in tank-tests since in this there is a viscous interaction effect and in any case the presence of the side wall (for the wave-cut experiment) is a source of interference which cannot easily be treated.

3. Does 'uncertainly analysis' include the uncertainty of the method used (p.579)? I believe that it is important that our terminology should be right from the outset. Does the committee agree that 'validation' embraces both verification and uncertainty analysis and that it is not a separate entity? The R and F Committee concluded that verification included both code and geometry (grid insensitivity) verification.

4. The fact that an establishment may label a facility a 'Numerical Towing Tank' does not imply that its role is to in any way replace a conventional facility. The label merely stresses that the towing tank is not wet but numerical.

5. My final point concerns the problem that the point in 3D space at which primitive variables are calculated in a CFD procedure can never coincide with the measuring point unless the experiment is performed after the calculations. This arises from the unpredictable way the grid points are generated -often

from a solution of a set of Poisson equations. Therefore, comparisons between CFD and experimental velocity field data will probably involve interpolation procedures which themselves will have erros which may be difficult to determine.

II. REPLIES BY THE PANEL ON VALIDATION PROCEDURES

Reply to Dr. KODAMA

The Panel agrees completely with Dr. Kodama's comment. There may be still more factors which affect the final results such as boundary conditions, computing domain and so on. Procedures of the CFD Validation may depend on the computation method and there may be no universal procedure. The panel, therefore, wishes for each technical committee to establish validation procedures for their specified problems. We are not at the position to discuss in depth for individual problems.

Reply to Prof. SCHMIECHEN

The Panel thanks Prof. Schmiechen for his contribution to this subject. His observations provide an interesting background to the philosophy of modelling and predicting useful estimates of the real world without requiring detailed knowledge and understanding of the physical processes involved.

The continuation of the validation work within the Technical Committee is still regarded as the first priority in an attempt to bring practical examples to the ITTC community.

Reply to Prof. HIMENO

Prof. Himeno rightly points at the possible error involved in taking averages of the data collected during resistance tests. The examples given in the Panel Report are meant as a demonstration of the approach and steps needed in uncertainty analysis. There are by no means complete and should therefore not be regarded as a definitive recipe. What is needed first of all for validation of both experiments and CFD is an increased awareness of all the possible sources of errors and inaccuracies. Examples and procedures can never be complete and should not be followed dogmatically without critical scrutiny. The Panel is

grateful to Prof. Himeno for his support and constructive comments.

Reply to Dr. MUSKER

The Panel should like to thank Dr. Musker for his elaborate discussion of the report. In the following the five points raised by Dr. Musker will be addressed successively.

1. The Panel agrees with Dr. Musker that grid sensitivity analysis may be an expensive exercise, but nevertheless it is of utmost importance to have insight into the effect of changes in grid resolution on the calculated values. Such sensitivity studies are needed also for setting up guidelines for grid generation in routine application of CFD codes.

2. Indeed, the concept of the 'true value' is bound to remain somewhat nebulous and philosophical. Nevertheless, the notion that we can never reach our goal is crucial for our attempts to approach reality as closely as possible, however paradoxical this may seem.

3. The Panel fully endorses the importance of clear terminology. In accordance with the definitions proposed in section 3.3.1. validation indeed embraces both verification and uncertainty analysis.

4. The Panel agrees that the notion of a "Numerical Towing Tank" may be misleading in the sense of suggesting that it replaces the physical towing tank.

5. In his last point Dr. Musker addresses the practical problems in comparing detailed CFD results with experimental values. It is clear that the development of CFD requires parallel developments in experimental techniques as well as in methods for analyzing and comparing large amounts of data.