Minutes of Meeting

30 November 2023

Pitch and discussions on the project proposal

To	:	**Potential Tripping JIP participants**
From	:	**John Huisman**
CC	:	**MARIN**
Date	:	**2023-12-06**
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Project No.	:	**35082**
Subject	:	**Minutes of meeting, Thursday 30 November 2023, Busan, Korea**

Venue

Physical:
Korean Register
36, Myeongji ocean city 9-ro,
Gangseo-gu, Busan 46762
Republic of Korea

Online:
Teams meeting

Participant abbreviations

JH: John Huisman, MARIN
JJ: Johan de Jong, MARIN
ST: Scott Terry, DAMEN
JRN: Jens Ring Nielsen, MAN
RM: Remi Menard, CMA
MK: Kösterke, Maximilian, Thyssenkrupp
PH: Patrick Hooijmans, MARIN

JIP Participation status

There are no signed participants yet.
Registration is open until 1 March 2024.
For the project to start at least 15 participants are required.

JIP Chairman

The chairman will be nominated in the next meeting in Venice, April 2024.

Agenda

Thursday 30 November 2023

1	16:00 – 16:15 (UTC+9)	Pitch of the Tripping JIP during the VOF	John Huisman
2	16:15 – 16:30 (UTC+9)	Questions and answers	all

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Contents of this Minutes of Meeting

The current document contains:

- 1 and 2: Agenda items from the meeting on 30 November 2023
- 3: Questions asked during the days or via email

Documentation & Recording

The recording of the meeting, the presentation sheets and these minutes of meeting can be found on the website: Tripping | MARIN

These minutes were written afterwards using the TEAMS recording. Sometimes, unfortunately, the questions are not recorded. Therefore, please, if you want to clarify something that was not noted down or not interpreted correctly, let us know such that we can include this for the record.

The participant list is not included in this document. Nonetheless, this will be done for later official meetings of the Tripping JIP.

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1 PITCH OF THE TRIPPING JIP – JH

The objective of the Tripping JIP is to have better and more reliable predictions of the performance of propellers, either using model tests or full-scale RANS computations.

How to achieve this goal? There are two main items. The first approach is to trip the flow on the model scale propellers during the model tests such that the flow becomes turbulent, and then the flow resembles the full scale situation more accurately. As such, the experimental uncertainty is reduced because laminar flow effects are not present anymore. The second approach to address the problem is to consider the scale effect we still do have. Now it does not have laminar flow effects, but merely the viscosity effect of a turbulent flow. This needs correction as well. We want to determine this effect by using CFD computations. Having a turbulent flow on model scale in the model tests, we can also use turbulent CFD computations to compute this scale effect. Standard RANS computations, so without transition modelling, have lower uncertainty than CFD computations with transition modelling.

We want to trip the flow from a laminar flow towards a turbulent flow. The best way to do this is to use turbulators on the leading edge of the propeller blades. Turbulators are an obstacle in the flow, the flow trips, breaks down, and continues as turbulent flow. We mimic zig-zag trips using individual turbulators oriented such that the flow is always encountered in the most efficient way to trip the flow. We have made a template for that that is suitable to any propeller geometry. We plot (cut) the turbulator on a sticker for easy application on the propeller blade.

To give some perspective, what are we facing on model scale? Example with paint test showing the laminar flow. Yes, we can match that with RANS computations, but that requires significant tuning which comes with its own uncertainty, and we are unable to match KT, KQ and eta at the same time.

However, if we have boundary layer control, if we trip the flow, then we can use standard CFD, coming with lower uncertainty, and KT, KQ and eta are much better matched. The paint test shows that the turbulators indeed do trip the flow towards a fully turbulent flow. Also at 400 RPM, the typical rotation rate used during propulsion test.

The preliminary CFD computations give confidence that we should apply turbulators. And that we should develop new scale corrections using RANS computations with turbulent flow.

So we will test and compute a large set of propellers. This dataset shall be used for four items. First one is to provide benchmarking for CFD computations. The second one is that we want to develop generic scale corrections, suitable for a range of varying propeller geometries. The third one is that, since there is a mismatch between the tests and computations, - a RANS computation does not capture all the physics – we can deduce correlation allowances to correct CFD results towards reality. The final one is to provide input to develop full scale polynomials of the Wageningen propeller series.

We have four work packages. The first one is the model tests. We want to build up knowledge over a range of different propeller designs. We want a selection of the F-series, FC-series and C-series, but in addition to that, we also want to revisit the B-series. The B-series are renown, they are also simple in design, thereby being valuable in studying scale effects. The scope is 101 model tests at four different Reynolds numbers. We have the models of the F-, FC- and C-series, we need to manufacture additional propeller models. Part of these models would come from the participants, propellers that faced problems in the past, or for other reasons.

The second work package is to do the RANS computations on all these propeller for a number of Reynolds number and a range of full scale roughness. Surface roughness is an important parameter

is important for the performance on full scale. We want to quantify this simultaneously with the main project.

How to do the RANS? MARIN has pretty good idea about this. But we also want to invite participants to collaborate, to achieve a common consensus, confident that MARIN is doing the correct things. We can learn, we can set the basis for the RANS computations together. This will be organized in Q3 in Wageningen.

The scope of the CFD computations is similar to the scope of the model test, but in addition we will compute more on the B-series.

Then the third work package is to combine the results from work package 1 and 2, into the development of these scale corrections that we want to use for the extrapolation of model tests. And the CFD correlation allowances. These will be a function of propeller geometry, but in addition to that a function of Reynolds number and the full scale roughness of the full scale propeller.

The fourth work package is to use the dataset to develop full scale polynomials for the Wageningen propeller series. This polynomial will not only be a function of blade number, pitch, blade area and J-value, but now also including the Reynolds effect and the full scale roughness. The polynomial will be included in a preliminary design tool with which you can easily check optimum diameter or rotation rate in early design phases.

The estimated costs are as presented on slide, 1.3 million euros in total. For that we need about 21 participants with an annual fee of 15 kE; the project will run for three years.

In terms of planning it is a three year project, the first project meeting will be in Venice; The Blue Forum. After that we will start up with setting up the RANS computations and organizing the RANS workshop. After that the main bulk of the work will be carried out.

The Tripping JIP is organized MARIN, the work is carried out by MARIN for the largest part. The project is hosted within the Vessel Operator Forum. Participants are expected to actively participate and wherever steering is required or comments need to be processed, MARIN will be open to that. Two meetings will be arranged each year.

You are encouraged to sign in between right now and 1 March, coming year. The contract, including the JIP agreement and the project proposal, is more elaborated as can be told in 10 minutes, is on the website of MARIN Tripping | MARIN. After April, after Venice, participation is regarded as late.

What did we do to promote the project? The have the website Tripping | MARIN with a promotion video, the complete project proposal and the leaflet. Also active on LinkedIn to share ideas on this JIP, to present the proposal and that kind of things, in addition to address frequently asked questions.

There will be two papers in SMP24 in which the work that was done prior to the Tripping JIP is reported. Also the MARIN report 138 magazine.marin.nl will have promotion of the Tripping JIP.

2 QUESTIONS AND ANSWERS DURING THE MEETING– ALL

***JJ**: There was a sentence about a reward for the RANS workshop?*
JH: Yes, if you are going to compute the reference propellers that will be used during the workshop with your own tools and your own methodology, you can cover these costs up to 6 kE. This will help the Tripping JIP defining the correct way in doing the CFD computations. **JD**: That means also not only doing the computations, but also sharing the results.

JJ: *Are there any plans or vision for later involvement of the ITTC?*
JH: The ultimate goal is to convince the ITTC that they should encourage the model basins to apply turbulators in all propeller related tests, both open water tests and in-behind tests. Also to use the scale corrections to be developed in this JIP. That is the ultimate goal, with a time line most probably about 10 years.

ST: *Beginning of the F-series we spoke about manufacturing tolerances and the accuracy of the existing B-series model. Are we using the old models or are we manufacturing new B-series models?*
JH: New B-series propellers will be manufactured based on the numerical B-series – an interpretation of the geometry of the B-series. So we will manufacture in total 10 B-series models, and 4 geo-sim models, like 16 cm for very small models for seakeeping tests, up to a very large size, to check whether the corrections that the Tripping JIP develops, are still relevant and suitable for different model sizes. Because that is the goal and this is a good way to prove that.

JRN: *I think it is a very relevant JIP you are proposing here. We have the ITTC scale corrections which we believe is simply too simple and leads to lots of discussions all the time. How to do it? Does the ITTC cover all the different flow regimes there is on a propeller? Simple answer to that is: NO.*
JH*:* Thank you for this comment. Indeed, the currently using ITTC scale corrections in the propeller extrapolation are not OK; they lack the required physical background.

JRN: *When we introduced the F-series, we discussed that they are to substitute the B-series… Our suggestion is, what if we take out the B-series here and cut the budget by the same?*
JH: Good question from a F-series participant to leave out the B-series. We have extensively thought about this, and we have decided to not do this. We want to have this project open to participants open outside the F-series. The F-series results will not be shared with non F-series participants; the B-series are included not only to give value to other participants, but also to add reference.

RM: *You want to correlate the full scale CFD results to the model tests with turbulators. The model tests with turbulators act then as reference. How can you ensure that this validates full scale real life?*
JH: How can we validate full scale CFD results with experimental model scale results. Currently, how we do this, is either using fully laminar flow; this comes quite close to the model test result. Or doing the validation using a transition model. This gives a bit of confidence in the CFD. However, going towards full scale we are going to use a turbulence model; hence different from a laminar flow computation. In the Tripping JIP we will use the same turbulence model for full scale and model scale. If we can validate the computational setup at model scale, would that not give confidence in the full scale situation as well? That is our reasoning. We believe that this would give confidence. It does give confidence to MARIN.

MK: *Is it also planned to use these turbulators in cavitation tests to check the influence of cavitation behavior.*
JH: We need to use sand-roughness in our cavitation tests to stimulate cavitation inception. Interpretation of the question by JH: Could we possibly use turbulators there as well? The short answer

is: yes! But we need a bit different layout of the turbulators. For turbulence stimulation we use as few turbulators as possible, but for cavitation tests we need a bit denser distribution of the turbulators. But yes, that works really well.

Later added when writing these minutes: no, the turbulators will not change the cavitation behavior and the corresponding pressure distributions; on the contrary! Instead they can be used to achieve the correct behavior of the cavitation on model scale. Currently, this is part of ongoing internal investigations at MARIN. Sand-roughness distorts the leading edge, while turbulators keep the very leading edge untouched. For the Tripping JIP, cavitation tests are not part of the scope, however.

PH: Y*ou mentioned two things. First is, you mention that for 45 kE you get a research package worth 1.3 million Euro, right?* **JH:** Yes. ***PH****: Two, what if you do not have 21 participants on March 1?* **JH:** if we do have 15, we will continue. Otherwise, we will wait.

[Question not recorded] **JH:** If I interpret the question correctly: do we not change the geometry to much by adding turbulators? The good thing about turbulators is that we leave the leading edge untouched. The leading edge stays intact; after the leading edge there is a small trip, only very thin, only just enough for the boundary layer to trip. So the main flow will be correct, even more correct without turbulators. Locally the thickness of the propeller is a bit increased, only very locally, and after the turbulators the flow is more representative. We believe that this effect, although indeed present, does not counteract the benefits from the tripping itself.

[Question not recorded] **JH**: The example that I presented was for 400 RPM, question is can we not achieve the same thing (tripping with higher Reynolds instead of tripping with turbulators) by going to higher rotation rates. Short answer is: no! First of all, during propulsion tests, this is not feasible. And second, even at very high model scale Reynolds numbers, the flow is at least partially laminar, with flow transition. Especially for the smaller blade area ratio propellers. For the large blades, yes I think it is possible, but for the lower BAR propellers that we currently see in the Maritime Industry, laminar flow really is a problem. That is why we are so keen on doing this.

JH: If there are any questions left, I am here, please drop by. I am happy to have a TEAMS meeting anytime that fits.

3 OTHER QUESTIONS AND ANSWERS

JH: We got several good questions during the acquisition phase of the Tripping JIP. This document tries to capture them, although there is some overlap. I have tried to order them per topic.

Question: *we welcome an initiative aiming at establishing new and improved methods for scaling of model test results. The proposal raises several important topics on how to do this such that the results may be used to obtain a generalized method for scaling open water tests and to obtain improvements in propulsion optimization. We refer in this context also to your presentation of June 7th for the F-series.*
JH: Indeed, on 7th June the first ideas for the Tripping JIP were presented.

3.1 B-series vs F, FC and C-series

Question: *The outcomes of the Tripping JIP will be incorporated into the B series and made accessible to everyone irrespective of their attendance at Tripping JIP. However, the updated results related to the application of Tripping JIP for the F series and FC series will only be disclosed to parties that additionally participate in the Tripping JIP among the existing participants of the F & FC series. This approach aims to enhance the overall completeness of the results for the F & FC series, providing a benefit to organizations participating in the Tripping JIP.*
JH: This is correct. In addition, this also holds for the C-series and their participants.

Question: *Subsequent to the development of a generic scale correction method based on model tests and RANS computations the scope is to develop a full scale B-series polynomial. We are more interested in in having scaling methods for the C-series, D-series and the F-series. Is the reason for selecting the B-series that you expect that scaling effects are marginal for these series?*
JH: As member of the C-series and F-series, you will get the full-scale polynomial of the C-series and F-series. The B-series are revisited as well for reference, are the scale corrections for the B-series similar? This knowledge will be required in developing a generic scale rule.

Question: *While the F series results are generally quite satisfactory, there is a specific concern regarding the diameter. As you know, the optimal diameter determined by the F series tends to be much larger than the optimal diameter established by the existing B series. The substantial margin by which it exceeds the optimal diameter of the B Series is considered to be intrinsic significance. However, in behind tests while checking this did not show significant benefits of the large diameter.*
JH: The diameter difference is one of the clearest general feedback that reaches us from the results of the F-series. We are concerningly aware of this difference and the corresponding implications. This is one of the reasons why we want to incorporate the B-series as well as the F-series in the scope of work of the Tripping JIP. For both series we will make new polynomials based on turbulent flow. As such, any low Reynolds effects from laminar flow are ruled out. The hypothesis is that the full-scale optimum diameter will be closer together, providing a sound basis to the optimum diameter in reality full scale situation.
One of the research questions on the sideline of the Tripping JIP will be: Is the observed difference in optimum diameter between the B-series and F-series a consequence of model scale artefacts, or is the difference to be explained due to the difference in geometry?
In this sense we are also waiting with interest for the final results of the FC-series how that optimum diameter is going to behave. Short answer to your question is that we highly believe that the results

from the Tripping JIP to the F series (and B series) will mitigate the difference in optimal diameter compared to the B series.

Question: *If we don't have 21 participants from the start please consider if the B-series should be a part of the JIP from the start.*
JH: I will take this into account in considering whether the 15 participants are hard numbers... This strongly depends on the added value for other signed participant at that time and will be for further discussion, if necessary.

3.2 In behind tests and ITTC

Question: *Because of low Reynolds effects, there might be a necessity to devise a new model test method or analysis approach, and I think the Tripping JIP may represents an effort within this framework. We would like to know whether applying the results from the Tripping JIP to the F series is expected to mitigate the difference in optimal diameter compared to the B series.*
JH: We agree on your notion of self-propulsion tests and the corresponding low Reynolds. This is why we believe that future self-propulsion tests should be done with turbulators as well. Although we realize that this is an important change on the experimental side, we believe it is a necessary step in improving model test accuracy. On the analysis side, we then inherently need the new scale corrections to be developed in the Tripping JIP. Doing so, we believe that we will have much more accurate mutual comparisons between different propeller designs, despite the low Reynolds number. The Tripping JIP will indeed be aimed at devising new extrapolation methods; ultimately convincing ITTC for adoption into the guidelines. Please also refer to section 2.3, page 34 of the agreement (download from Tripping | MARIN) in which this is also discussed.

Question: *If the OW tests will be done with turbulators, does the self-propulsion test also have to be done with turbulators? This might have an influence on the propulsive coefficients and new methods for scaling method might have to be investigated. If this is to be included, a self-propulsion test with a low and high CTH propeller (single and twin screw) have to be included as a minimum in the proposal.*
JH: I refer to the question above. In addition, we also do realize that the basic scope of the Tripping JIP again only considers open water. Also other potential participants already suggest including propulsion tests in the Tripping JIP scope. If there will be enough participants (>21), we will likely prioritize that indeed. We believe that we should be able to get more than 21 participants for the Tripping JIP, such that we can dedicate a working package to the study of self-propulsion tests and the corresponding interaction effects. I agree that we should both investigate single and twin crew cases. We have had this discussion MARIN internally as well, a few months ago, and there we were thinking about using some public reference ships, like the DTMB and KCS, but other suggestions are more than welcome.
By adopting the new procedure by analysing each ship speed with an open water on the correct Reynolds number (using a small polynomial function of both J and n), we already have seen that the interaction coefficients are more consistent. Trends that were previously present likely are related to Reynolds effects. We do however see a quite large etaR, which still needs further investigation and thoughts.
At MARIN we have done 4 propulsion tests with turbulators as of now. Next year, we focus on the Tripping JIP. Hopefully, later, the Tripping JIP we also be the platform to indeed do further investigations regarding the matter of in behind performance.

Question: *Have you discussed the proposed turbulence stimulator at the ITTC?*
JH: No. Instead we are going to propose these turbulators to them. We are fully confident that the ones we have developed are the most convenient, both in terms of performance and easiness of usage.
We will have the ITTC looking over our shoulders, as it is stated in tor-revised-after-conference.pdf (ittc.info). Although the ITTC is not yet ready to accept that the long-term-used clean propellers method is to be replaced, we strongly believe that we will be able to convince them, in particular if the Tripping JIP gains support from a large number of participants.

6. Conduct a benchmark study focusing on the effect of Re at model scale and scaling methods for full scale prediction. CFD calculations would be run at a range of Re at model scale and full scale, along with open-water model tests at a range of Re. The study could use two propellers that were provided for the previous benchmark study run by the 28th ITTC.
7. Investigate the issue of laminar effects in self-propulsion test of propeller with low blade area.

A) Conduct a survey how ITTC members tackle this issue, and which scaling method they use for low blade area propellers.
B) Investigate the sufficiency of conduction two open water tests at different Reynolds numbers for full scale extrapolation.
C) Review literature on the subject.
D) Suggest modification to recommended procedures.

12. Investigate the use of CFD methods in scaling of model test results for a more precise speed-power prediction. The issues with high priority are:

A) propeller open water scaling
B) difference in Reynolds number at self-propulsion and open water test, laminar effect in self-propulsion test
C) effective wake scaling
D) scaling of immersed transoms
E) energy saving devices

3. Address issues related to hull and propeller surface roughness such as:

A) Definition of roughness properties
B) Components of roughness
C) Measurement of roughness
D) Effects of roughness on in-service performance including filtering and analysis methods for evaluating hull and propeller performance separately
E) Roughness usage in performance prediction and cross effects with correlation

Question: *Do you consider it possible that the proposed turbulence stimulator will be adapted as a standard by ITTC?*
JH: Highly possible. Standard zigzag trips are too difficult to apply neatly and give more drag. Yet, further explanations and evidence might be required before adoption.
We see Tripping JIP results as the major stepping stone to convince the ITTC about the proposed approach for future model tests involving propellers.

3.3 Turbulators

Question: *Is your proposal to use turbulators on the propellers used in propulsion tests?*
JH: Yes, otherwise the scale correction we are going to develop would be not applicable. The scale corrections would only be valid for propellers with turbulent flow on model scale. We have decided to pursue the project like this, because of two main reasons. One reason the high experimental uncertainty due to laminar flow effects, and two the high numerical uncertainty when applying transition modelling. We believe that the widely application of turbulators would be the way forward.

Question: *Concerning the full scale power predictions. Will each test set-up require open water tests with turbulators with three Reynold's numbers, unless you use a stock propeller?*
JH: Yes, using QSO method this should not take too much additional effort. In the extrapolation, you then can determine the propulsive coefficients using the open water performance at the same Reynolds as in-behind. This is the most accurate way to do. The stock propeller also needs to be tested at these three rotation rates, but that would then probably already have been done.

Question: *Have you considered alternative methods for turbulence stimulation near the LE of the blades that may give less drag?*
JH: We have studied several types of turbulators, including the 'good-old' sand-roughness. We obtained best results with the 'wishbone' turbulators, in the sense that they trip the boundary layer most effectively.
It is impossible to directly measure the effect of the turbulators themselves, because they alter the flow which has more effect than their direct drag. We have made some CD quick estimates, but this would need further refinement, being one of the tasks within the new JIP.

Question: *No details are given for the geometry or size of the proposed turbulence stimulators.*
JH: Good question. We have varied shape, thickness (height), size, position, distribution, orientation, density etc. We have found a good and robust recipe. Reporting is currently being done, to be published on the SMP 24, in Egypt.

Question: *We wonder if the drag induced by the turbulence stimulators may be a challenge.*
JH: So far, we have not corrected for the drag of the turbulators. The drag is very small and the effect of the turbulator is much more important. Nonetheless, in the Tripping JIP we will correct for the effect based on a simple drag-coefficient based method. We do not expect challenges here.

Question: *Is it possible to find a turbulence stimulator that will not give additional drag?*
JH: No, but we believe it is possible to really minimize the effect of the turbulator, as shown in the figures below.

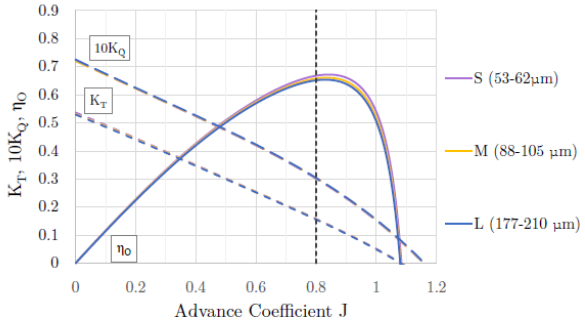

Figure 11: Open water diagram of Propeller-B performed with a rotation rate of 800 rpm for various leading edge sand roughness heights

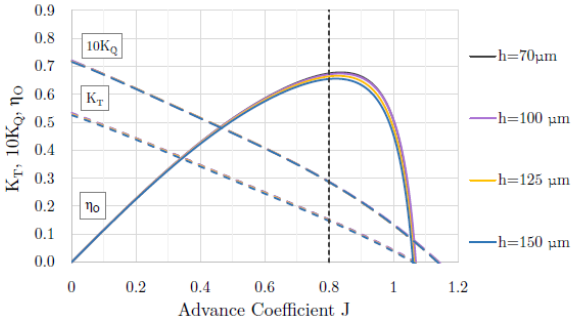

Figure 13: Open water diagram of Propeller-B performed with a rotation rate of 800 rpm for various turbulator heights

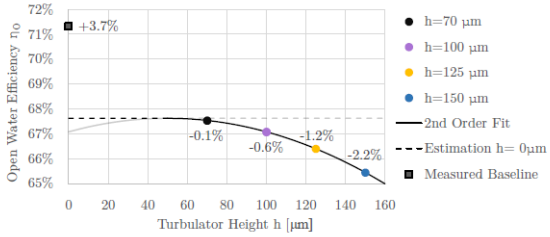

Figure 15: Estimation of isolated turbulator penalty on the efficiency for Propeller-B for $J = 0.8$ at a rotation rate of 800 rpm ($Re = 7.5 \cdot 10^5$)

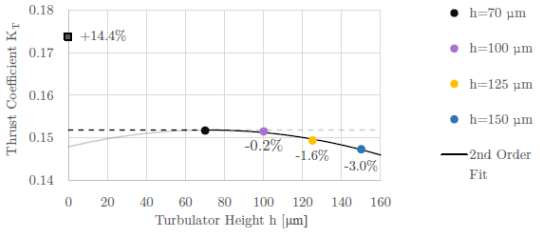

Figure 16: Estimation of isolated turbulator penalty on the thrust for Propeller-B for $J = 0.8$ at a rotation rate of 800 rpm ($Re = 7.5 \cdot 10^5$)

These figures originate from the draft of one of the SMP24 papers, I was referring to earlier. Turbulators smaller than 70 um do not work anymore, they are below the critical height to trip, submerged too deeply in the boundary layer. The turbulators are only in the order of 70um high and approximately at 70% of the boundary layer thickness at that location. In conclusion, the additional drag of the turbulators of 70um is only very small.

Question: *Do you have comparisons between the drag created with different turbulators?*
JH: Yes, we have. Also sand-roughness was included for a good comparison. We found that the proposed wish-bone type of turbulator gives the best properties. This will also be part of the topic of the SMP24 paper.

3.4 CFD usage

Question: *I'm not sure to fully understand how the boundary layer tripping will be applicable to future model tests done with propeller makers for industrial projects, nor why results with these turbulators are considered as more reliable. CFD at model scale and full scale should be used to understand the gap and introduce corrections.*
JH: The Tripping JIP has quite some consequence on the full extrapolation method, as it will involve significantly different scale corrections.
The turbulators will trip the flow towards a turbulent flow. This makes the flow characteristics similar to the full-scale situation. As such, the uncertainties due to laminar flow and transition effects are resolved. This makes model tests with turbulators more reliable. Only the viscosity effect needs to be corrected, instead of a correction for a mixture of laminar flow effects, transition effects, increased separation effects and the viscosity effect itself.
I totally agree that CFD at model scale and full scale should be used. This is also the idea in the Tripping JIP. The CFD computation involving turbulent flow only require less tuning and have been well established, providing reliable scale effects. Would CFD computations be used to correct tests without turbulators, transition modelling would be required in CFD, which has large uncertainties and involves severe tuning.
Already several makers have shown very serious interest in the Tripping JIP. Finally their CFD starts to match our measurements…

Question: *In the JIP CD-Series we spent a large sum of money on CFD calculations to assess scale effects, but the study was non-conclusive. Have you made new assessments using CFD which implies that you may obtain a method for scaling that is dependent on the propeller main parameters?*
JH: We have confidence that we can develop such method for three reasons:

1. CFD is more mature and more robust in the meantime.
2. For the proposed work we will not rely on difficult incomprehensive transition modelling
3. We avoid the highly unpredictable laminar effects in the model tests by applying turbulators. This would give a more consistent data set. We would also test at different Re, in order to avoid the Re effect over the series, which may disturb the assessment of the scale effects.

With the turbulators we have gained confidence in the 'simple' CFD, just using turbulent boundary layer, because the results match the turbulated model test, for all the cases we have evaluated so far. In the CD JIP it was very difficult to obtain a benchmark due to transition effects.

We think it is now time to take up the work that was done so far and lift this towards a reliable assessment of scale effects, in the end proposing updated procedures for dKT and dKQ.

Question: *What is plan B if different CFD solvers with the same grid setup gives contradictory results?*
JH: We do believe that most of the participants are on the right track with their CFD, and in line with REFRESCO, also based on feedback we get during running projects.
The Tripping JIP will be based on the most basic CFD computations, with the standard turbulence model which is very well settled. We do not expect to see the big surprises here that we did see for transition modelling in past workshops. There might be outliers however.
That is the reason we regard the dataset as a validation case. We believe our REFRESCO solver is quite close to the industry solvers, but we want to achieve common confidence in this particular solver to avoid discussions afterwards.
If there are inexplicable results, plan B is to gather a small committee of CFD experts to make the decision on the intended approach for the Tripping JIP.

Question: *Hence in CFD WP, there will be both model scale CFD calculation with turbulators (to validate compared to model tests), AND full scale CFD with turbulent model (without turbulators) if I understand correctly ?*
JH: We will do the CFD at model scale without the turbulators as well, as will be done by the industry. Nonetheless, you touch a very interesting point which I need to think about and discuss first before giving a sound answer.
Thanks for your answer. As "industry" representative here, I can tell you our CFD calculation are always in full scale. And I agree we do not want to complexify the simulation with turbulators in industrial projects, but there is no need in full scale. Hence indeed I would suggest considering the CFD model scale with turbulators for clear validation of model scale results between model tests and CFD at model scale

Question: *Point 4 of the Agreement says "The Project will be carried out by MARIN… computational checks or testing of the software are to be carried by the participants at their own costs". Does this mean that if participants want to use ReFRESCO software (granted by MARIN) for testing the projects propellers, will be at their own costs?*
JH: a. The usage of ReFRESCO software is not part of the scope of this project. b. If participants wish to do benchmarking with their own tools (which could be one of the reasons to participate), the JIP will not bear these (company) internal costs.

3.5 Generic scaling method

Question: *In the JIP CD-Series an attempt to use CFD to generate a scaling method was attempted, but at that time with no conclusive results.*
JH: The Tripping JIP is intended to continue this work. CFD has matured and the application of turbulators will get rid of laminar effects in the model tests and uncertainties regarding transition modelling in the CFD.
Question: *It is unclear to us whether the basic idea is to use CFD to calculate the full scale propeller performance, or if full scale CFD are to be used to calculate the relevant full scale performance with drag corrections for model propellers with turbulators.*
JH: The basic idea is the latter. Note that the lift correction is also significantly present. If we match the model scale results with standard turbulence modelling, we also have confidence that the full scale results are realistic to extract the scale corrections for KT and KQ.

Question: *Is the idea here that the CFD tool ReFresco shall be used to determine the possible additional drag of the turbulence stimulators compared to a full scale propeller with a given surface roughness ?*
JH: No, this is not the idea.
Some computations have been done to determine the drag coefficient of the turbulator. This will be used in the Tripping JIP to have a small correction.
Note that the effect of the turbulators in tripping of the flow is much more important on the total performance of the propeller.
The application of full scale roughness is a separate topic, which is not related directly to the turbulators. We will compute different roughnesses in CFD for each propeller.

Question: *The intention is to run computations for a large number of propellers, each over a large range of Reynold's numbers up to full scale, with varying surface roughness. Do you have benchmark analyses with comparisons between different CFD calculations that can be used to establish an uncertainty range for the CFD calculations ?*
JH: Uncertainty analysis has already been extensively done, especially for model scale computations. For model scale computations we have found a recipe that works well.
For full scale computations we need to do this more extensively by studying different grid setups. Also related to the next question, we will do this within the Tripping JIP.
In the Tripping JIP a RANS workshop will be organized to compare the results of different parties and to mutually agree on the approach for the CFD computations. In the April meeting of 2024 we will select a few propellers as benchmark cases, which are to be tested with turbulators and then computed by a number of participants and MARIN. For these propellers MARIN will do numerical uncertainty analysis. In September 2024 a workshop will be organized to compare all results.

Question: *Is the uncertainty range in the CFD calculations the same for a wide range of propeller geometries as a function of blade number, pitch, blade area ratio, J-value, Reynolds number (both at model scale and full scale) and full scale surface roughness, or can the uncertainty range be a problem for the development of a robust generic scaling method?*
JH: We do not have a closed answer to this good question. We need to investigate this in the Tripping JIP, as there will always be exceptions. The uncertainty is dependent on the turbulence model, grid resolution and quality and CFD solver. We propose to investigate numerical uncertainty for a number of extreme propellers as well, assuming that the propeller in between then have similar or less uncertainty.

3.6 Roughness

Question: *How well does CFD modelling of roughness fair for propellers??? Any validation against measurements if there is any.*
JH: We will use the standard roughness model in CFD (equivalent sand roughness). Nowadays, validation studies are focused to link the real roughness (either from new build, coating or fouling) to CFD roughness. This remains a challenge and an area of uncertainty. At MARIN extensive R&D studies are being done on this matter. Also a new project within the CRS (Cooperative Research Ships) is focused on this. Nonetheless, taking the CFD roughness into account during the Tripping JIP will enhance the dataset such that the effects of fouling can be easily determined in the future.

Question: *Discussion on the roughness height to be considered for new build propellers (against recommended ITTC 30um). I believe MARIN has some knowledge base here from the JoRes project* Jores.
JH: Thank you for this good suggestion. When deciding on the exact scope of computations, I propose to have this discussion within the group. I am gathering info from the JoRes project, but I still need to discuss further. This remains an open action item. But indeed, within JoRes there have been extensive measurements. The data I saw where even smoother that 30um (which already is already almost smooth as far as the flow is concerned (hydrodynamically smooth)). Whether there are also measurements on fouled propellers or recently cleaned propellers, I need to investigate further. We propose to have a clean (no roughness, 5um), 30 um and two more fouled roughnesses to be included in the Tripping JIP.

3.7 General questions

Question: *We think the TRIPPING JIP is very significant. We are very interested in using model tests and RANS computations to study the scale effect of propeller and develop a generic scale correction method, and also the additional scope of work for retests at other basins for benchmarking and correlation. For the TRIPPING-JIP, if we participant in, we wish three colleagues could participate in practical way, which means that three of them could be allowed to participate the model tests on site or carry out RANS computations and so on for TRIPPING JIP-at MARIN. In this way, they will be able to participate some discussions and meetings in MARIN within this project. Additionally, I believe three of my colleagues can help or attend some work for other tests or calculations with their knowledge on propellers.*
JH: Of course, you are warmly welcome at MARIN to review the propellers, see the turbulators plotted and applied. However, if the model tests are running, we will not be able to be on the carriage due to automatic testing to have full control of the environment and waiting times. We will investigate whether it would be possible to organize one of the JIP meetings at MARIN such that we can combine the witnessing of model tests and further discussions on the project.
Concerning the CFD. As written in the project plan, the main part of the work will be carried out by MARIN. However, for the CFD workshop, we would appreciate it very much indeed if you could actively participate with doing own CFD computations and be active in the discussions. Note that such participation in the CFD workshop will be rewarded with 6kE as well (to be invoiced separately).
We appreciate your offer about extra benchmarking tests. This could be indeed part of the additional scope of work, for which we need enough participants, and which needs to be agreed upon by the steering committee (the JIP members) when the JIP is running. So in advance we cannot make promises on this, but we will definitely keep this in mind when considering the additional scope of work.

Question*: It is not clear what is the merit for owners/operators to join in this project? The study is focused on the propeller performance and it seems to be difficult to contribute modification/upgrade of total vessel performance.*
JH: Indeed, this project has a clear focus on the propeller only. Nonetheless, in our vision, ship owners and operators could merit from this project in three aspects:

1. Better estimate of the actual performance of the propeller in terms of efficiency, especially during lower speed operation. The current model tests suffer from too low rotation rates, such that the predictions at lower speed become somewhat unreliable.
2. Quantify the effect of blade surface roughness (cleaning intervals) or quantify the benefits of propeller coating (to have smoother blade surface).

3. Indirectly, we expect that better propeller designs (better choice of blade area ratio, diameter and pitch) and better powering predictions (more accurate prediction of required power) will be made, such that the overall performance of the fleet would increase.

We acknowledge that the direct benefits from this project for ship owners might be limited, however, we believe that this project could be very valuable for ship owners and operators, also to achieve a common understanding with propeller designers and manufacturers.

Question: *Will any participant be able to conduct towing tank tests or CFD computations? Point 2.1 of the Agreement Tripping JIP says "The open water tests will be conducted at MARIN…".*
JH: The bulk of the open water tests will be carried out by MARIN. There may be benchmark tests awarded, see section 2.5, to be discussed if there are enough participants. The bulk of the RANS will be carried out by MARIN as well. Note however, that during the CFD workshop, participants are encouraged to present their own work. This will be awarded by 6kE.

Question: *Point 2.1 table says test will be carried with "5 propellers from participants". As mentioned in the previous question, it will be easier if the same participant could do such tests.*
JH: The 5 propellers are propellers that participants may bring in. For instance propellers that have shown large differences between model tests and CFD. We will manufacture them and test them at MARIN.

Question*: PLANNING of the Agreement says "the Project will be carried out by MARIN. Participants are expected to actively contribute to the Project meetings". Will participants be assigned with any work package within point 2 WORK PACKAGES?*
JH: Participants will not be assigned with a work package. But they can steer the scope of work (especially the additional scope of work). More importantly, participants get at least 1.3 million worth of research that could be indispensable for R&D, the confidence in CFD on propellers and the impact on future model tests.