STA-2 JIP proposal

Proposal to develop improved assessments of full-scale ship performance

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1 INTRODUCTION

1.1 Background

Within the Sea Trial Analysis Joint Industry Project (STA-JIP), MARIN in close co-operation with leading shipowners and major yards have set the industry standard for conducting and analysing speed trials. Lacking a single, accurate and transparent standard, the first STA-JIP was initiated in 2002, to develop a common methodology for speed/power trials for new ships coming into service.

Within the STA-JIP a review of existing trial procedures was conducted. New analysis methods were developed including correction methods for conditions deviating from the contract specification. In particular, correction methods for wind and waves were developed as it was found that existing methods were not reliable and could lead to substantial trial speed deviations.

After the research and development work of STA-JIP, the ITTC adapted the method in their guidelines and the ISO15016 was updated to the new method. The method was furthermore accepted for IMO EEDI by MEPC65. As well as delivering a new standard, software for the analysis of speed/power trials was developed within the JIP and made freely available to the industry (https://staimo.com/).

In recent years, both ITTC and ISO working groups have implemented incremental improvements on the original STA method. However, it is also recognised that there exists room for improvement in bringing the contract trial methods to a higher standard using the present-day knowledge. At the same time there is a strong desire to develop an in-service protocol which verifies the performance of ships in operation. For this reason, it is proposed to start with a follow-up joint industry project; STA-2 JIP.

1.2 Project objectives

The overall objective of STA-2 is:

STA-2 aims for more accurate and reliable determination of the actual, full-scale speed/power performance of ships, both from speed/power trials and in-service performance measurements.

Thereto, the project will aim at the following objectives:
- Determine uncertainty of the current standard for contract speed/power trials, and if beyond target uncertainty, reduce uncertainty by focusing on the items which contribute most to the uncertainty
- Evaluate state-of-the-art measurement techniques, including drafting guidelines and best-practices for electrical power measurements for cases where mechanical power measurement is not possible
- Develop accurate, reliable and easy to use correction methods for wind, waves and current
- Update and improve the contract speed/power trial protocol
- Develop an in-service performance test protocol
- Validate the above developments in measurement techniques, correction methods and test protocols by conducting dedicated high-fidelity test campaigns
- Deliver free software for the analysis of contract speed/power trials
- Actively promote and support adaptation of new protocols by ISO, IMO and ITTC

1.3 JIP participation

The project is of interest to many organisations in the maritime industry worldwide, like ship owners, ship operators, shipyards, research institutes and classification societies. The results are expected to be widely used for many years to come. The project is too large to be financed by one, or a small group of organisations. Hence, this proposal is set-up as a Joint Industry Project (JIP) with many participants.

The work is conducted as a Joint Industry Project (JIP), executed by MARIN. Results and costs are shared with participating organisations that have signed the JIP participation agreement. Twice a year JIP progress meetings are organised at the Vessel Operator Forum (www.vesseloperatorforum.com).

The participants will have access to the project results, software and other information through the confidential project website. The results will be confidential for three years after completion. Publication of any results will be communicated to all participants. Upon publication of any results, all participants will be mentioned.

A JIP enables a large-scale research project, while sharing experiences and expertise in co-operation for mutual understanding and adaptation of industry-wide standards. Typically, a JIP project bridges the gap between basic R&D activities and application in commercial projects. The activities are typically pre-competitive co-operation. Therefore, a part of the costs can be supported by subsidies from the Dutch government.

The advantages for all participants are to participate in large scale R&D with leverage on costs. All participants could be actively involved in the definition of the final scope of work and learn from the experiences of other participants. During the meetings, networking is encouraged to strengthen relations, connect with others and profile the companies.

2 SCOPE OF WORK

The project will work on both improving the method for contract speed/power trials and developing an in-service test protocol for evaluating the performance of ships operating with cargo on a schedule. Both approaches share correction methods that will be updated within the project as well, see Figure 1.

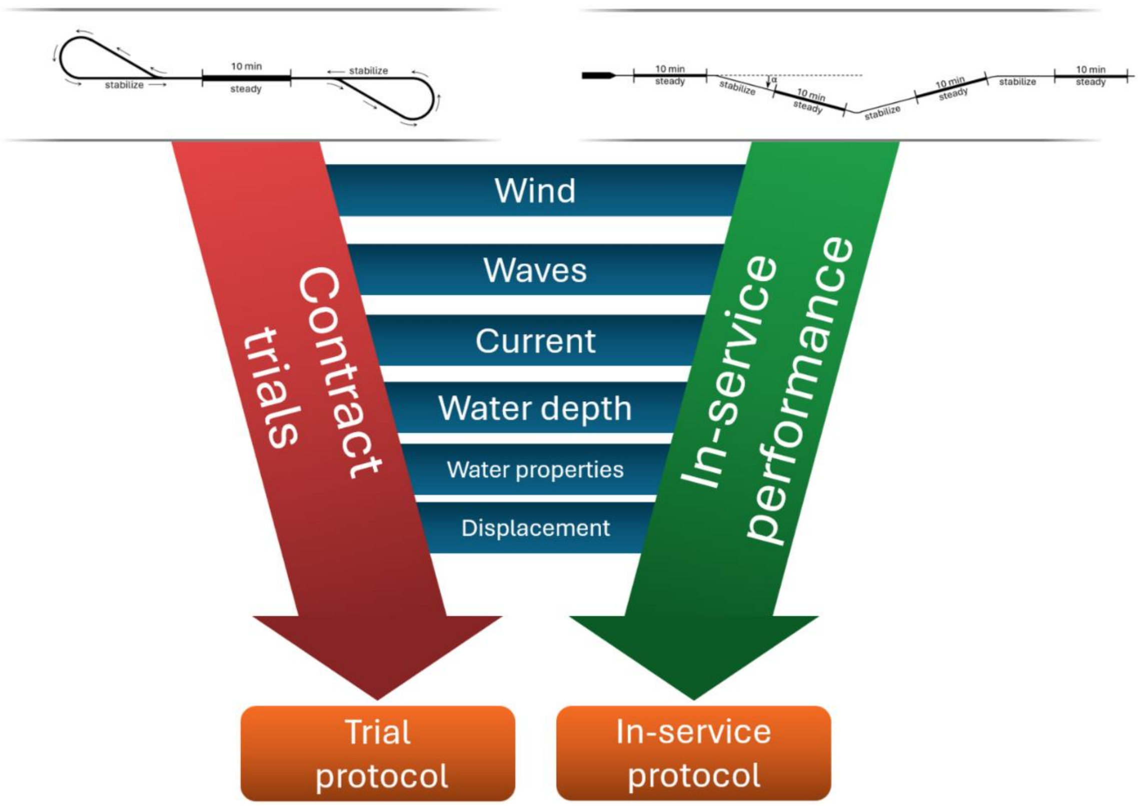

Figure 1: Project scope for both contract and in-service protocol and their shared correction methods, leading to two test protocols.

The project will be divided into the following five work packages:

WP1	Aspects of uncertainty
WP2	Measurement techniques and test protocols
WP3	Correction methods
WP4	Validation trial campaigns
WP5	Procedures, implementation & dissemination

The following sections discuss each work package.

2.1 WP1: Aspects of uncertainty

Within this work package the components contributing to the uncertainty in speed/power trials and in-service performance test results will be identified. All aspects will be considered including test protocol, measurement techniques and correction methods. One of the important aspects that will be addressed is the contribution of each of the aspects to the total uncertainty. The uncertainty analysis will be done following the JCGM 2008 guidelines[1] or similar. From there, priority can be given to the aspects that contribute most to the uncertainty. For this reason, this work package will be started at the beginning of the project in order to give input for the other work packages.

According to ISO, the target total uncertainty of a contract speed trial is 2% on shaft power and 0.1 kn on ship speed. From this work package it will become clear if this target is within reach with the present procedures and, if not, what is needed to reach this target. For in-service performance evaluations a somewhat higher uncertainty is accepted; within this work package typical levels will be identified.

In addition, a feasibility study will be performed to include (standardised) uncertainty analysis in the contract and in-service protocols.

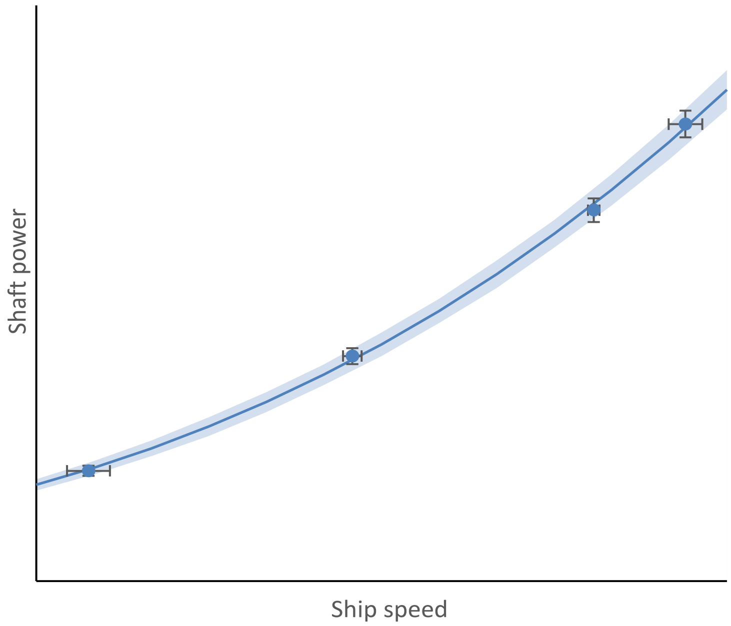

Figure 2: Example of uncertainty in a speed-power trial result

[1] Joint committee for guides in metrology, *"Evaluation of measurement data – Guide to the expression of uncertainty in measurement"* JCGM100:2008 BIPM, Sep 2008 France

2.2 WP2: Measurement techniques and test protocols

Test protocols

Besides measuring the correct things at high precision and correcting results to ideal conditions as best we can, the way we conduct any tests contributes greatly to the accuracy and usefulness of the results. Sometimes, trials that were not conducted correctly provided unusable results. For instance; above weather limits, no proper steady-states were achieved before staring a measurement run, high current fluctuations, local effects within the runs, etc.

For contract trials, it is important to have a practical protocol that is both easy to carry out correctly and well-described so as to not contain ambiguities.

For in-service performance determination, the need for practicality is at a higher level. The absence of a dedicated trial team during the tests puts more requirement on practicality and good description of the protocol. Finally, the tests themselves need to fit within operational constraints.

Contract trials protocol

With the above goals and restrictions, the protocol for conducting 'speed runs' on contract trials will be further developed. Clearer descriptions will be drafted on how to carry out these runs. Where possible, definitions will be developed on matters such as:

- when the vessel achieves steady state,
- guidance on lengths of approach runs,
- how to measure and calculate the ship's loading condition,
- which heading to choose for the runs (wind, wave).

Furthermore, we expect to investigate the requirement to return to track in a reciprocal run, and if possible, arrive at a set of requirements under which one can sail in opposite heading without returning to track (Figure 3).

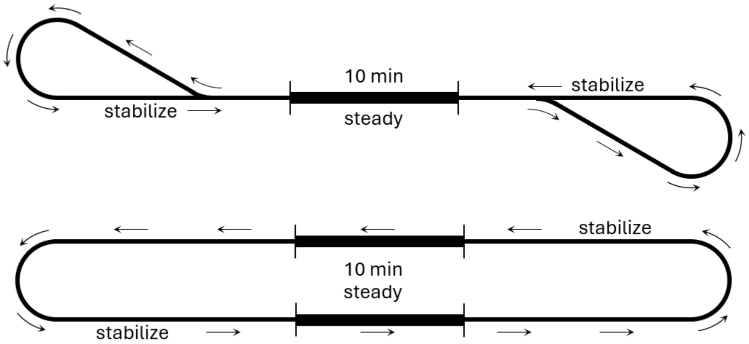

Figure 3: Reciprocal runs: using Williamson turns (upper) or simple 'paperclip' track (lower)

In-service performance protocol

To be able to derive a good baseline performance from an in-service measurement, care needs to be taken to limit uncertainties on the results arising from both weather conditions and measurement accuracy. While taking into account that the ship's schedule is not affected by performing dedicated tests.

Besides influences from weather, we can identify the ship's speed through water (STW) as one of the dominant contributors to the uncertainty. Although Doppler or electromagnetic speed logs are fitted for this purpose, it has been observed they are too unreliable for the purpose of evaluating a vessel's speed/power performance[2].

To overcome this shortcoming in available measurement techniques, a test protocol will be developed from which the vessel's STW can be derived in a similar fashion as by reciprocal runs, but without the need to hamper the schedule by performing a return run. The proposed protocol uses steady runs at heading deviations much smaller than 180°, resulting in a zig-zag patterned track (Figure 4) from which the current vector, and consequently STW, can be derived by vector calculus. The expectation for this protocol is that it will only yield usable results in very favourable weather conditions, thus needing more restrictive requirements on limiting wind speed and wave height. Within this WP, supported by WP4's validation campaigns, the conditions and limits for application will be developed. The final deliverable for this task will be a written protocol with which ship operators can instruct their crews to incorporate these tests in their transits to allow regular testing of their ship's in-service performance.

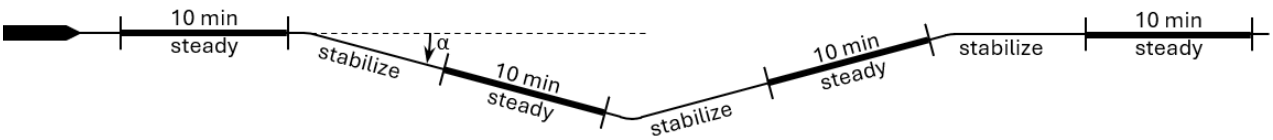

Figure 4: Proposed in-service protocol using a zig-zag pattern

Measurement techniques
Where possible and deemed promising, tasks on evaluating the effectiveness and accuracy of measurement techniques will be carried out. Comparisons of new technology to old, or high-fidelity to low-fidelity approaches can be made by incorporating multiple measurement techniques in the validation campaigns of WP4.

Electrical power measurements
It is expected that future propulsion arrangements will incorporate more 'integrated propulsion systems' such as thrusters and pods where access to a driving shaft for mechanical power measurement by strain gauge system is limited or impossible/impractical. For such cases, one needs to rely on other means of obtaining the propulsion power, such as electrical power measurements. Experience has shown however that this often does not align well with the actual mechanical power output to the propeller. This issue needs addressing to make the protocol future proof.

It is foreseen that this task will deliver guidelines/best-practices on where and how to measure electrical power to a propulsor.

[2] Hasselaar, 2012, "*Water speed log research - STW measurement validation based on performance data MV Belgian Express*", SPA-JIP report 23200-12-TM

2.3 WP3: Correction methods

In this work package, the correction methods will be evaluated and improved, depending on the priorities coming from WP1.

Wind

Together with waves, the effect of wind is typically one of the bigger corrections to arrive at contract conditions (usually stated as no wind, no waves, deep water without current). Given that the relative (apparent) wind speed and direction are properly measured (WP2), the correction for wind consists of:

- Wind averaging
- Correction for the position of the anemometer
- Calculation of wind added resistance using wind coefficients

For each of the three steps, there is potential for improvement. Wind averaging between the double runs assumes constant wind speed between the runs and is a method to correct for the effects of disturbances due to the presence of the ship (superstructure, see Figure 5). If the anemometer is located in undisturbed wind (to be confirmed by e.g. a CFD pre-scan) the averaging procedure is not needed. This is connected to the second point for corrections for the position of the anemometer. This can be split into two items; disturbance due to the ship (superstructure) and height correction due to the wind profile.

Regarding the latter, in the current standard (ISO15016:2025) a 1/9th profile is used. However, recent research from both on board and stationary wind profile measurements over sea suggests much steeper profiles. In this discussion it is also worthwhile to consider the wind profile used in the determination of the wind coefficients.

Once relative wind speed and direction at the reference height are known, the calculation of the wind added resistance is straightforward and mostly influenced by the selection of the wind coefficients. At the moment four methods are allowed: wind tunnel tests, CFD, the 'ISO dataset' with common ship types, and the Fujiwara regression formula.

The right-hand plot in Figure 5 shows an example of the variation in wind coefficients for a twin island container vessel. It shows a large variation, indicating the need for better protocols for wind tunnel tests and CFD predictions and a re-evaluation of the datasets for common ship types.

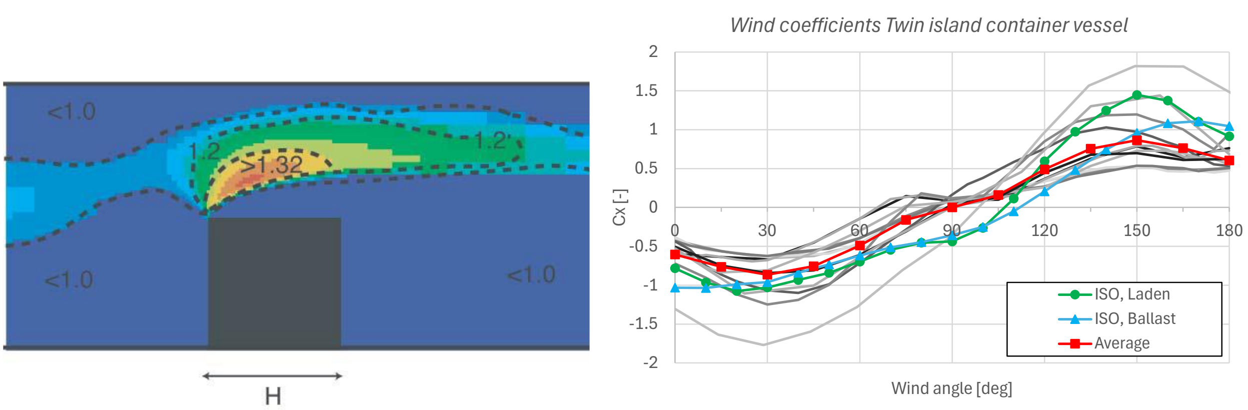

Figure 5: Example overspeed Moat 2003 (left figure) and example variation C_X for a twin island container vessel (right figure)

Waves

Besides the wind correction, the wave correction is often one of the dominant corrections. Within ISO15016:2025 the following three correction methods are allowed: transfer functions from model tests, SNNM and STAWAVE-1. From several studies it is shown that all three methods have their own pros and cons. The starting point within this task is to evaluate the presently available approaches for a wide range of ship types and identify shortcomings and areas for improvement.

In trial conditions, the wavelength is typically short when compared to the ship length. It is therefore important to have an accurate prediction in these conditions. It has already been identified that some of the methods do not perform well in the short-wave region. The left plot in Figure 6 shows an example for the KVLCC2, a 320 m tanker. In 2023 MARIN performed model tests for the ITTC benchmark study (results to be published) in which four test setups were evaluated (grey lines in left-hand plot). When compared to three empirical methods it is shown that results vary considerably. The right-hand plot shows the empirical methods in ballast condition (no test results available).

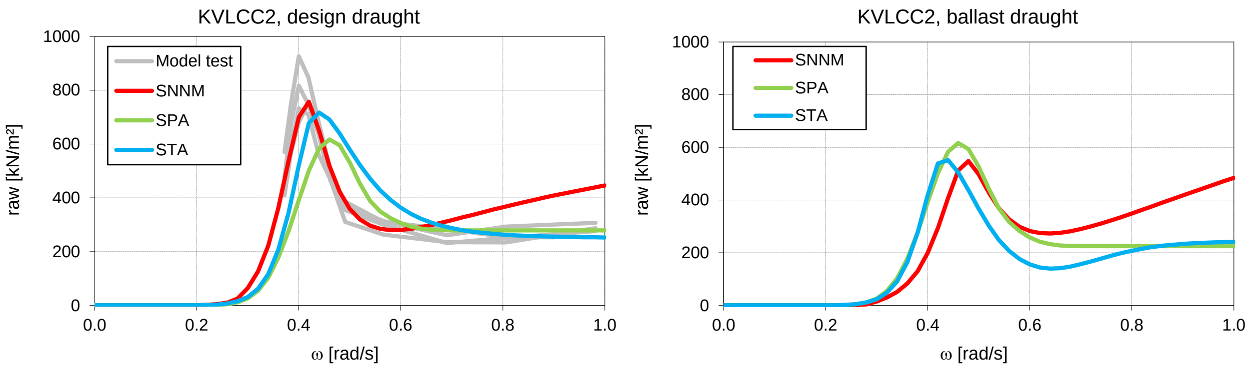

Figure 6: Transfer function of wave added resistance for the KVLCC2 at design draught in head waves (left plot) and KVLCC2 at ballast draft (right plot)

Within this task, a new (semi-)empirical method will be developed that gives a good prediction in both long and short waves, for all wave directions, and for all displacement type hull shapes. The method should be robust, easy to implement and use, and require as few as possible and readily available input parameters. This task can be a joint effort with interested participants.

The method will be validated with available datasets within MARIN and with limited seakeeping model tests, focusing on short waves and for conditions and ship types in which the dataset is not conclusive. Within the basic scope there is probably sufficient budget to perform tests for two ship types. Furthermore, universities and other institutes will be invited to validate the method with their own dataset, in order to avoid bias and ensure industry wide acceptance.

In the current standard (ISO15016:2025) numerical approaches like CFD are not allowed for wave correction in the ISO procedure, contrary to for instance the wind correction. A feasibility study will be performed if it is possible include this option in future protocols. This includes recommendations for verification and validation of these methods and a blind benchmark.

Current
To arrive at the needed speed through water (STW) from the measured speed over ground by GNSS instruments, the speed trial method uses the double run protocol to obtain the current component in the ship's heading direction. To derive the current component in the ship's direction from this, either the mean of means (MoM) method using sets of four runs per propeller setting or the iterative method can be used. The latter was introduced to enable users to use fewer runs while getting an acceptable result.

In the present standard, the method for iterative current correction can be used with fewer datapoints than strictly necessary, resulting in an underdetermined system of equations. This has raised concerns about the soundness of the method, and will be investigated. If needed, an improved method will be developed.

For obtaining the STW for in-service performance evaluation, the zig-zag run protocol will be developed as described in WP2.

Water depth
No updates are foreseen for the present correction method for water depth (Raven shallow water method[3]). If further validation data becomes available, it might be evaluated within the project.

Water properties
No updates are foreseen for the present correction methods for water temperature and water density.

Displacement
No updates are foreseen for the present correction ISO methods for small displacement corrections. However, depending on the outcomes of WP1, some work is foreseen in the loading condition translation in cases where the trial cannot be executed at the contract draught (for instance on varying correlation coefficient between ballast and design draught).

[3] Raven, H.C., 2022, *A correction method for shallow-water effects on ship speed trials*, MARIN report available at: https://www.marin.nl/en/publications/a-correction-method-for-shallow-water-effects-on-ship-speed-trials

2.4 WP4: Validation trial campaigns

This work package aims to support the above WP2 and WP3 by carrying out dedicated measurement campaigns on a number of vessels in different scenarios.

Ship owners and operators within the project are encouraged to facilitate measurement campaigns on their vessels within this work package.

Validation campaigns are aimed to employ high-fidelity approaches: e.g. using state-of-the-art equipment such as wind LiDAR, wave radar and wave buoys (as well as visual wave observations), anemometers, etc. This way, the resulting data will be of high fidelity as well as offer a verification of lower-fidelity approaches and equipment. Specific to STW validation (in-service protocol, revised iterative method), in-situ high-fidelity current measurements by stationary current measurements are foreseen.

The above-described approach deliberately exceeds the practicality constraints of the target protocols, such that the aimed pragmatic approach of the protocols can be tested. Stated differently: “Will the simple zig-zag protocol deliver STW to sufficient accuracy?” can only be answered when a high-fidelity ground-truth is available for STW or current.

The number of campaigns and vessels in this work package will depend on the sizing and budget of the project (i.e. the number of participants).

2.5 WP5: Procedures, implementation & dissemination

Procedures

For the contract trials, an updated trial protocol will be written to incorporate all the project’s findings. The goal is to arrive at a clearly written, pragmatic procedure.

For the in-service protocol, the new approach will be written to be fit for implementation with on board crew.

Update trial software (STAIMO)

The current STAIMO software for the analysis of speed/power trials will be modernized and brought into line with the updated trial standard.

Dissemination & adaptation (ITTC, IMO, ISO)

Publications of our progress and findings will be made where deemed effective to inform industry and regulators and facilitate the adaptation of the project’s recommendations.

Furthermore, liaison with ITTC, IMO and ISO will be pro-actively undertaken to ensure the project’s work is known and reviewed within these bodies, and considered within their future updates of recommendations, procedures, and standards.

3 DELIVERABLES

The following will be the deliverables of the JIP:

- An updated contract speed/power trials protocol
- A new in-service performance test protocol
- New software for the analysis of speed/power trials
- Full results of model tests in short waves
- Summary results of validation trials (ship owners/operators of the subject ships will receive the full results)
- Working group reports per task

4 FINANCE

4.1 Budget

The estimated costs of the described scope of work are specified in the table below:

	Description	Costs (k€)
WP1	Aspects of uncertainty	75
WP2	Measurement techniques and test protocols	285
WP3	Correction methods	100
WP4	Validation trial campaigns	300
WP5	Procedures, implementation & dissemination	195
	Management	140
	Contingency	155
	Total	**1250**

4.2 Funding

The funding of the described scope of work is specified based on 20 participants:

	Description	Funding (k€)
	MARIN contribution	45
	Subsidy Dutch government (TKI ~25%)	305
	Participant contribution (20 participants x 3 yr x 15 k€)	900
	Total	**1250**

The early-bird participant fee is set as 45 k€ (15 k€ per year, for three years). For participants signing up after the fall meeting 2025, the fee is 56.25 k€.

MARIN pays a ticket as well and additionally arranges Dutch government funding, expected at about 25%.

If the total funding becomes higher than the above budget due to the participation of more than 20 participants, additional work will be agreed with the participants in an expansion of the scope of work.

The project will be carried out by MARIN, unless specified otherwise. Attendance at the meetings, computational checks or testing of the software, are to be carried by the participants at their own cost.

5 PLANNING

The project will be carried out by MARIN. Participants are expected to actively contribute to the project meetings. Two meetings will be arranged each year. The project is defined as a 3-year project.

On 22 November 2024 at the VOF in Wageningen, the first version of the proposal was pitched.

The VOF is the Vessel Operator Forum under which the STA-2 JIP is hosted:

https://www.vesseloperatorforum.com/

The following table provides the intended timeline for each work package.

		2025				2026				2027			
WP		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	Start-up phase												
WP1	Aspects of uncertainty												
WP2	Measurement techniques and test protocols												
WP3	Correction methods												
WP4	Validation trial campaigns												
WP5	Procedures, implementation & dissemination												
	Management												