From METEOR 1988 to ANONYMA 2013: Future Ship Powering Trials and Monitoring Now!

Principles of rational conventions further clarified, consistently applied in a particularly delicate case and lessons (to be) learned

Michael Schmiechen

A letter to my colleagues and my students
and to whom it may or must concern, published on the occasion
of the 25th anniversary of my propulsion tests with the research vessel METEOR in the Greenland Sea in November 1988,
of the 15th anniversary of a proposed rational alternative standard for the assessment of the powering performance of ships submitted to the Japan Marine Standards Association in April 1998,
and, last but not least, in view of the long overdue recent revision of the not only error prone standard ISO 15016: 2002-06.

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in memoriam
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Future Ship Powering Trials and Monitoring Now!

Michael Schmiechen, Berlin

retired apl. Prof. for Hydro-Mechanical Systems at ISM/TUB
and Deputy Director for R&D at VWS, the Berlin Model Basin

www.m-schmiechen.de
m.schm@t-online.de

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Motivations

The 25th anniversary of my propulsion tests with the research vessel METEOR in the Green-land Sea between Spits Bergen and Greenland during her voyage from Hamburg to Bergen from October 27 to November 22 1988,

the 15th anniversary of a proposed rational alternative standard for the assessment of the powering performance of ships based on traditional trials submitted to the Japan Marine Standards Association on April 15, 1998 triggered by the Committee Draft of ISO 15016,

Motivations, cont'd

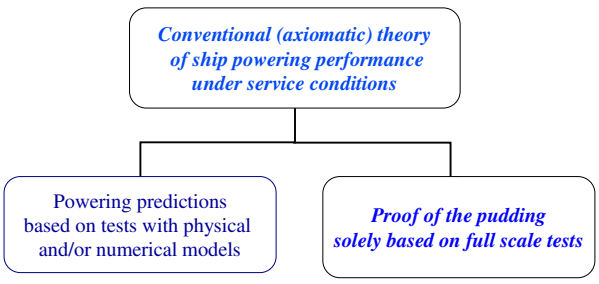
and, last but not least,

the long overdue revision of the not only error prone, but hopelessly old-fashioned standard ISO 15016: 2002-06 and

the 'ITTC 2012 Guideline', based on the incredibly naïve STA procedure, aggressively marketed and impudently [dumm-dreist] promoted by MARIN as 'industry standard', approved *contra legem* by the Executive Committee of the ITTC, though the 27th Conference takes place only in 2014, and prematurely submitted to the MEPC of IMO.

1 Introduction

1.1 That *is missing!*



2 Conventional approaches

2.1 Basic principles and rules
2.2 Intellectual discipline
2.3 Theory of theories
2.4 Coherent interpretations
2.5 Lessons (to be) learned

2.1 Rational conventions

Conventions are languages and their implications (to be) agreed upon.

Traditional conventions are usually not explicit, often incoherent languages.

Rational conventions are formal languages, axiomatic systems, a frightening name for most useful tools.

2.1 Axiomatic, constitutive models

Grammar of formal languages

Calculus of	... **concepts**	... **propositions**
Rules of	... introduction	... formation
basic …	***primitives***	***axioms***
Rules of	... definition	... deduction
'derived' …	***composites***	***theorems***

2.5 Lessons (to be) learned

The most fundamental task is to ***set up rational conventions adequate for the purposes at hand and so simple and self-evident, that they and their consequences are acceptable for the all parties interested in the results***.

The interpretation of the concepts and parameters introduced has to be completely separated from the construction of the axiomatic models, of the formal languages proper.

The concepts and parameters introduced are to be identified only in the contexts of elementary mechanics and of the models or languages adopted.

3 Balance of forces rationalised

3.1 State of the theory
3.2 METEOR project
3.3 Model scale testing

3.1 State of the theory

3.1.1 Basic concepts introduced
3.1.2 Traditional conventions obsolete
3.1.3 Horn's Copernican turn
3.1.4 Rational conventions adopted
3.1.5 Lessons (to be) learned

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3.1.1 Theory of interaction

Axiomatic theory:

'abstract' model, formal language

'Model based' theory:

Theory of ideal propulsors in ideal energy and displacement wakes 'abstracted'.

Advantage:

In the ideal limit not only plausible, but correct.

3.1.3 Horn's Copernican turn

The consequence is the thrust deduction theorem

$$t = (1 + \tau + \chi) / \tau - [(1 + \tau + \chi)^2 - 2\,\tau\,\chi]^{1/2} / \tau$$

with the displacement influence ratio

$$\chi \equiv w_D / (1 - w_E - w_D)$$

'Local' approximations not of interest, but the 'global' approximation

$$t = 0.56\,\chi\,\eta_{TJ}\,.$$

3.1.4 Thrust deduction convention

In accordance with the global approximation of the thrust deduction theorem the thrust deduction convention

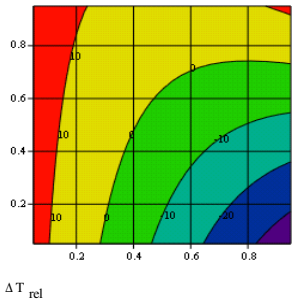
$$t = t_{TJ}\,\eta_{TJ}$$

with the nominal value

$$t_{TJ} = \text{const}$$

has been proposed and successfully applied.

3.1.3 Relative error of 'global' approx'n



3.1.4 Wake conventions

Similarly the 'local' wake convention

$$w = w_{TJ}\,\eta_{TJ}$$

with the nominal value

$$w_{TJ} = \text{const}$$

and the hydraulic efficiency convention

$$\eta_{JP} = \text{max}$$

has been proposed and successfully applied.

The plausibility (!) of these conventions has been checked using an open water propeller chart.

3.1.4 Traditional interpretation

The fact that wake fields in the behind condition are neither uniform nor 'large' is traditionally accounted for by a 'fudge factor' called 'rotative efficiency', in Germany 'Gütegrad der Anordnung' ('efficiency of the arrangement').

The traditional interpretation in terms of hull towing and propeller open water tests is not meaningful in cases of hull and wake adapted propulsors, but it is still in use.

3.1.4 Recent state: robust procedures

In particular the axioms or constitutive laws of thrust deduction and wake fractions have finally reached the state of maturity.

Instead of the 'artificial', kinematical hull advance ratio the **propeller jet efficiency** has been introduced as **'natural', dynamical measure of the propeller loading**.

3.1.5 Lessons (to be) learned

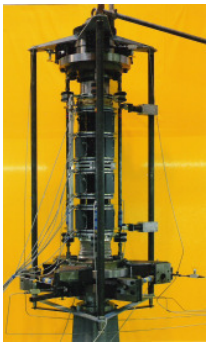
Extremely simple thrust deduction and wake conventions are sufficient to replace hull towing and open water propeller tests model and full scale.

Simple rational conventions replacing Froude's conventions, are 'useful' not only on model scale, but full scale as well, thus permitting *e. g.*, to determine scale effects in thrust deduction and wake experimentally, impossible using any traditional approach.

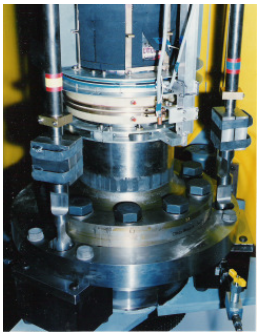
3.2 METEOR project

3.2.1 METEOR in the Greenland Sea 1988

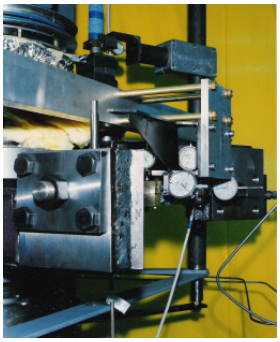
3.2.2 Shaft calibrated at full service load profile



3.2.2 Shaft calibrated: longitudinal loads



3.2.2 Shaft calibrated: torsional loads



3.2.5 Lessons (to be) learned

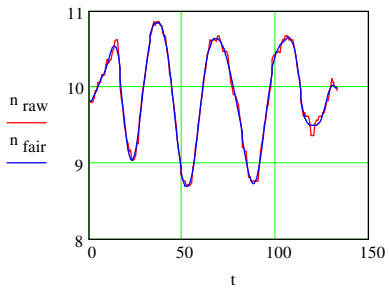
Quasi-steady, arbitrary changes of the shaft frequency provide for the necessary variability of the data.

Systematic errors due to the feed back of noise have to be avoided by introducing and correlating all data with 'reference' changes of the shaft frequency, independent of the omnipresent noise.

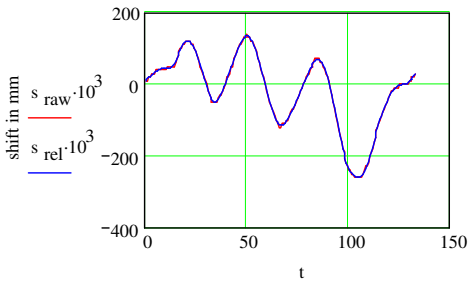
Prior to the monitoring of all interactions the propeller has to be calibrated in traditional trials, to be discussed in the next chapter.

3.3 Model scale testing

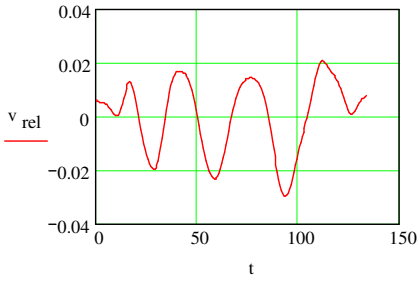
3.3.1 Raw data: rate of revolutions



3.3.1 Raw data: surge



3.3.1 Derived data: speed variation



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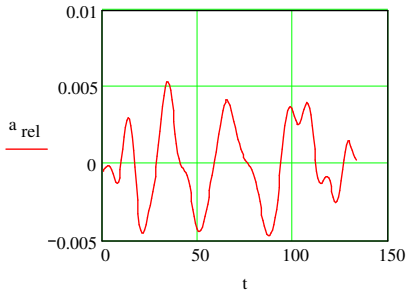
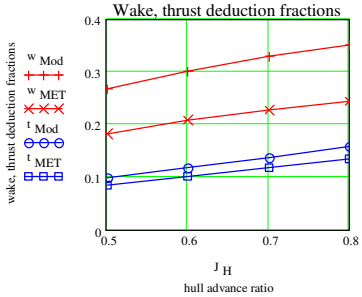
3.3.1 Derived data: acceleration



3.3.4 Scale effects 'measured' 1988



3.3.5 Lessons (to be) learned

The simple conventions replacing hull towing and propeller open water tests, respectively, permit extremely efficient propulsion tests on model scale.

Quasi-steady full scale and model tests performed in the same way permit to identify scale effects in thrust deduction and wake fractions.

This theoretically solidly founded technique should be tested routinely in model basins and further developed to be prepared for the needs and demands of researchers and clients.

4 Balance of powers promoted

4.1 State of the theory

4.2 ISO 15016: *et cetera*

4.3 ANONYMA trials

4.1 State of the theory

4.1.1 Thrust (to be) abandoned

4.1.2 Lagrangean approach adopted

4.1.3 Propeller convention

4.1.4 Current convention

4.1.5 Lessons (to be) learned

4.1.3 Propeller convention

As ‘local’ model of the ***powering performance of the propeller in the behind condition*** I have used from the beginning of the development the 'pump' function

$$\mathbf{P_{S\,sup} = p_0 N_S^3 + p_1 N_S^2 V_H}$$

relating the supplied shaft power $P_{S\,sup}$, frequency of shaft revolutions N_S and hull speed through the water V_H.

4.1.3 Propeller convention

Only the shaft frequency (of revolutions) and the shaft torque Q_S , and thus the power

$$P_S = 2\,\pi\,N_S\,Q_S$$

can be measured directly. Further the hull speed over ground V_G can now reliably be measured by means GPS-Systems.

4.1.4 Current convention

The hull speed over ground and through the water are related by the current velocity V_C prevailing at the time and location of the trials

$$V_G = V_C + V_H .$$

Thus the parameters of the propeller powering function in the behind condition **cannot** *be identified trustworthy unless the current velocity is determined reliably as well.*

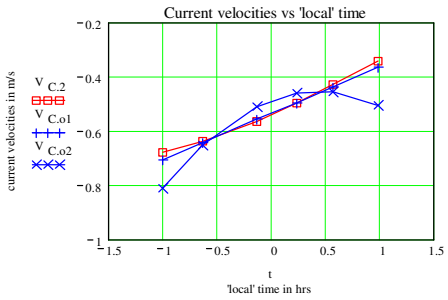
4.1.4 Current convention

In many cases the current may be conceived as a mean constant current superimposed by a harmonic tidal current. And the simplest convention adequate in this case is the two parameter model

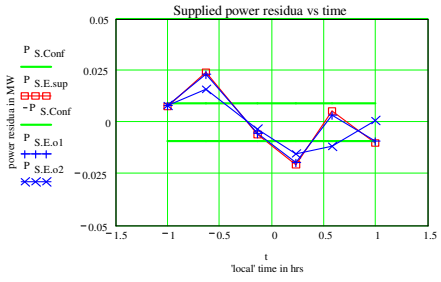
$$V_C = v_0 + v_1 \sin\,[\,\omega_T\,(\,t - t_T\,)]$$

with the 'universal' circular tidal frequency ω_T and the time of high tide t_T at the day and the location of the trials, known from the tidal tables.

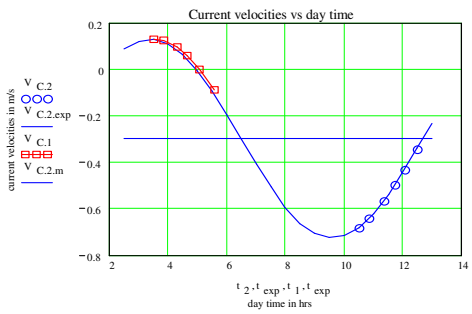
4.1.4 Current conventions compared



4.1.4 Required power residua



4.1.4 Current identified a. extrapolated



4.1.5 Lessons (to be) learned

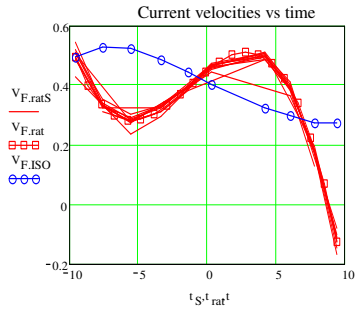
An adequate propeller convention is a function of two parameters only.

An adequate current convention is a function of only two parameters as well.

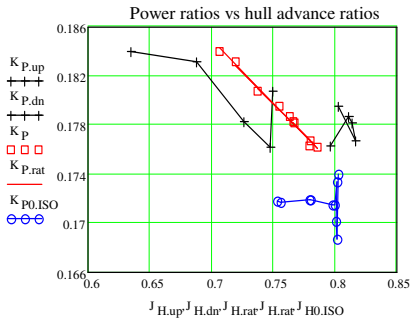
Both sets of parameters are jointly identified as the solution of only one set of linear equations.

4.2 ISO 15016: *et cetera*

4.2.1 ISO Example 1988: current velocities



4.2.1 ISO Example 1988: powering performances



4.2.5 Lessons (to be) learned

The traditional methods, including that of ISO 15016: 2002-06, are error prone, mostly inadequate, even in cases of ships with traditional hull-propeller configurations at fully loaded conditions.

You have to order 'full stop' of any further evaluation, if you cannot identify the current velocity reliably in the coherent fashion described.

Any other 'invention' to measure the hull speed through the water is causing unnecessary new conflicts and is an irresponsible waste of resources.

4.3 ANONYMA trials

4.3.2 Required power convention

Subsequently in a second step the parameters of simple models for the partial shaft powers required have to be identified, conveniently again as solutions of a system of linear equations.

Being traditionally trained myself I have of course at first been thinking of the partial powers required due to the motions through water, wind and waves. But during my numerical exercises I realised that these connotations, belonging to the 'folklore' of naval architecture, as *e. g.*, in the 'industrial STA standard', are not only misleading, but even unnecessary.

4.3.2 Required power convention, cont'd

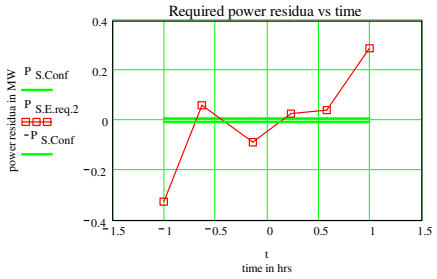
In case of the ANONYMA the two parameter 'required power convention'

$$P_{S\,req} = q_0 V_H^3 + q_1 | V_{W.rel.x} | V_{W.rel.x} V_H ,$$

which I had used many times before, turned out to be 'perfectly' adequate to model the data in the confidence range.

The 'environmental parameters' of the partial powers unambiguously, 'objectively' identified have nothing, to stress: definitely nothing whatsoever, to do with the 'resistance coefficients' traditionally considered in this context.

4.3.2 Required power residua



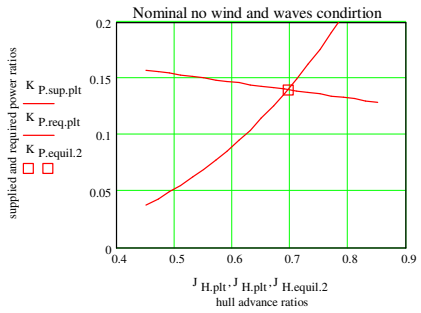
4.3.3 *Nominal* no wind and waves condition

The required power convention permits further to define the nominal no wind and waves condition

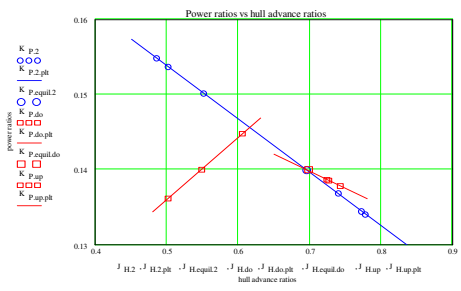
$$P_{S\,NoW} = (q_0 + q_1) V_H^3 \equiv C_{PV} V_H^3 .$$

.

4.3.3 Balance of powers established



4.3.3 All ANONYMA results



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4.3.4 The emperor's new clothes

Incredibly naive STA procedure developed by practitoners, hopelessly 'trapped in the past' and aggressively marketed and promoted by MARIN, claiming to have established an 'industrial standard'.

By the ITTC PSS SC (!), leading the foolish crowd following the emperor in his new clothes, has integrated in the 'ITTC 2012 Guideline' prematurely and (!) contra legem claimed to be approved, although the 27th ITTC will take place only in 2014.

And last, but not least, the Guidelines have even been forwarded by the ITTC EC to the IMO MEPC.

4.3.4 The 'mechanism'

"A vain Emperor who cares for nothing except wearing and displaying clothes hires two swindlers who promise him the finest, ***best suit of clothes from a fabric invisible to anyone*** **who is unfit for his position or 'hopelessly stupid'.** The Emperor's ministers cannot see the clothing themselves, **but pretend that they can for fear of appearing unfit for their positions** ***and the Emperor does the same.*** Finally the swindlers report that the suit is finished, they mime dressing him and the Emperor marches in procession before his subjects. …

4.3.4 The 'mechanism', cont'd

The townsfolk play along with the pretense not wanting to appear unfit for their positions or stupid. Then a child in the crowd, too young to understand the desirability of keeping up the pretense, blurts out that the Emperor is wearing nothing at all and the cry is taken up by others. ***The Emperor cringes, suspecting the assertion is true, but continues the procession.***" *Italics: MS.*

4.3.5 Lessons (to be) learned

Only three two parameter models are serving the purpose of objective, observer invariant evaluation of measured trial data, even in the delicate cases investigated.

In view of the few data available only these models provide the confidence in the results, only six parameters to be identified from the data recorded.

The prediction of the performances at the trials conditions and any other conditions is thus no longer a matter of 'assessing' the trials.

5 Conclusions

5.5 Lessons (to be) learned

The departure from the inherited traditional approach will result in dramatic gains in efficiency and quality of research and teaching.

The costs for testing model and full scale can be drastically reduced, if performed quasi-steadily, the reliability of the results increased at the same time.

These considerable returns are to be obtained for only little effort, using only some common sense.

The disruptive innovations are in the interest of the industries we serve.

From METEOR 1988 to ANONYMA 2013

Warning!

Reading [my draft paper] **endangers Your principles!**

"You cannot have a theory without principles.
'Principles' is another name for 'prejudices'."
Mark Twain: 'The Disappearance of Literature'
Speech, 20 November 1900.

Warning!

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