The Quality Systems Group
Final Report and Recommendations to the 29th ITTC

1. GENERAL

1.1 Membership and Meetings

Benedetti, Lanfranco, CNR-INM (Secretary)
Chen, Weimin, SSSRI
Derradji-Aouat ,Ahmed, NRCC
Ferrando, Marco, Genova Univ. (Chair)
Grigoropoulos, Gregory, NTUA
Kitazawa, Daisuke, Tokyo University
Park, Joel, NSWCCD
Reed, Arthur M., NSWCCD
Sena Sales, Joel Jr., UFRJ
Valle, Jesus, CEHIPAR

As of August 8th 2019, Ahmed Derradji-Aouat Joined the Quality Systems Group

On September 1st 2020, Jesus Valle left the Quality Systems Group

The Group held four meetings as follows:

September 22nd 2017, Wuxi,
June 25th to 26th 2018, Madrid
September 2nd to 3rd 2019, Athens
February 20th to 21st 2020, Rome

From here on, in order to save space in the report, the Quality Systems Group will be addressed as QSG.

1.2 Terms of Reference given by the 29th ITTC to the QSG.

1. Update all ITTC Recommended Procedures and Guidelines to conform to the requirements of Recommended Procedure 4.2.3-01-03, Work Instruction for Formatting ITTC Recommended Procedures and Guidelines.
2. Support the Technical Committees in their work on Recommended Procedures. Supply the chairmen of the new committees with the MS Word versions of the relevant procedures.
3. Maintain the Manual of ITTC Recommended Procedures and Guidelines. Coordinate the modification and re-editing of the existing procedures according to the comments made by ITTC member organizations at the Conference and by the Technical Committees.
4. Observe the development or revision of ISO Standards regarding Quality Control.
5. Update the ITTC Symbols and Terminology List.
6. Update the ITTC Dictionary of Hydromechanics.
7. Revise and update the existing ITTC Recommended Procedures according to the comments of Advisory Council, Technical Committees and the Conference.
8. After the third AC Meeting, review and edit new ITTC Recommended Procedures with regard to formal Quality System requirements including format and compliance of the symbols with the ITTC Symbols and Terminology List.
9. Support the Technical Committees with guidance on development, revision and update of uncertainty analysis procedures.
10. Observe ISO standards for uncertainty analysis, in particular the uncertainty analysis terminology.
11. Review developments in metrology theory and uncertainty analysis and issue appropriate Procedures.
12. Continue to maintain the online Wiki keeping it up to date and in line with the adopted documents of the ITTC.
13. At the beginning of the period, organize an electronic repository of information and data on the benchmarks cases. ITTC member organizations should then be invited to participate in the adoption of the benchmark and contribute to the data-base.

2. TASKS PERFORMED

2.1 Update all ITTC Recommended Procedures and Guidelines to conform to the requirements of Recommended Procedure 4.2.3-01-03, Work Instruction for

Formatting ITTC Recommended Procedures and Guidelines.

This task was performed during the 28th ITTC. Its insertion into the 29th QSG ToR is probably due to a "Cut and Paste" error in drafting 29th ITTC QSG ToR

2.2 Support the Technical Committees in their work on Recommended Procedures. Supply the chairmen of the new committees with the MS Word versions of the relevant procedures.

A total of 58 MS Word files containing the procedures to be updated, together with the template to be used for drafting new procedures was sent to the Chairmen of the various ITTC Committees.

QSG cooperated with 29th Conference Chairman to produce the template for Committee report to be distributed for the next Conference

2.3 Maintain the Manual of ITTC Recommended Procedures and Guidelines. Co-ordinate the modification and re-editing of the existing procedures according to the comments made by ITTC member organizations at the Conference and by the Technical Committees.

The revision of the Manual of ITTC Recommended Procedures and Guidelines included 84 documents:

- 9 existing procedures were deleted
- 13 new Procedures/Guidelines have been approved
- 62 existing procedures have been reviewed or updated.
- 125 disclaimers have been inserted in ITTC recommended Procedures and Guidelines as per Executive Committee request
- 82 equations in Recommended Procedures and Guidelines have been translated from the old MathType format to the MS Word equation editor format.

During the activity connected with this ToR the QSG realized that a number of procedures need further revision; especially when dealing with UA. Some procedures require extensive updates to conform to BIPM (2008) GUM. Some procedures still refer to the ISO GUM.

A proposal for future work has been added to this effect.

The table of "revision outcomes" is illustrated in Appendix A.

2.4 Observe the development or revision of ISO Standards regarding Quality Control.

QSG reviewed the current work of the ISO Technical Committees (TC) and Sub-Committees (SC), and established a list of those Working Groups (WG) which are working on items within the scope of ITTC. Eleven relevant documents were under preparation by ISO/TC008 ("Ships and marine technology"), one by ISO/TC043 ("Acoustics") and three by ISO/TC188 ("Small craft"). To be more specific, the following ISO documents under preparation may take into account uncertainty:

ISO/TC 008/SC 02 "Marine environment protection"
ISO/TC 008/SC 02/WG 03 "Environmental response"
ISO/TC 008/SC 02/WG 05 "Anti-fouling systems on ships"
ISO/TC 008/SC 02/WG 08 "Shaft power measurement for ships"
ISO/TC 008/SC 02/WG 11 "Ships' energy efficiency data collection"
ISO/TC 008/SC 06 "Navigation and ship operations"
ISO/TC 008/SC 06/WG 17 "Speed trial data analysis"

ISO/TC 008/SC 08/WG 14 "Propeller"
ISO/TC 008/SC 08/WG 20 "Antifouling paints"
ISO/TC 008/SC 08/WG 23 "Buoyancy support system"
ISO/TC 008/SC 12 "Ships and marine technology - Large yachts"
ISO/TC 008/SC 12/WG 05 "Quality assessment and acceptance criteria"
ISO/TC 008/SC 13 "Marine technology"
ISO/TC 008/SC 13/WG 01 "Submersibles"
ISO/TC 008/WG 09 "Polar (Arctic/Antarctic) regions"

There are another 66 ISO/WG working on Uncertainty Analysis on procedures not directly associated with ITTC scope of interest.

2.5 Update the ITTC Symbols and Terminology List.

As regards the Symbols & Terminology List QSG decided to start a systematic check to be sure that symbols used in the standing procedures are contained in the S&T List.

The documents belonging to the following sections of the Register have been checked for symbol usage:

- 7.5-02-01
- 7.5-02-02
- 7.5-02-03
- 7.5-02-04
- 7.5-02-05
- 7.5-02-06
- 7.5.02-07-01
- 7.5-02-07-03

A total of 70 documents have been checked. The result of the check has been disappointing, since many documents make use of symbols not included into the Symbols and Terminology list or of incorrect symbols with respect to those included in the List.

The observations regarding symbols have been sent to the relevant committees requesting action to rectify this situation.

Changes made to the Symbols & Terminology List are as follows:

- The definition of C_{DA} has been updated following an AC suggestion.
- *Hw1/3*, *Hw1/3d*, *Hw1/3u* need to be checked against the procedures and eventually deleted as non-necessary symbols. The new symbols will be: $H_{w1/3}$, $H_{1/3w}$ (for waves) and $H_{1/3s}$ (swells), in procedure 7.5-04-01-01.1.
- The left-hand coordinate axes system has been removed from the Symbols and Terminology List.
- Several other symbols have been added, including: Linear momentum (**P**) and Angular momentum (**L**).
- A number of new symbols have been added according to a Resistance and Propulsion Committee proposal.

2.6 Update the ITTC Dictionary of Hydro-mechanics.

A new section has been developed and added to the ITTC Dictionary of Hydrodynamics, it is: Offshore Engineering. This initial version of the new section has focused on offshore oil and gas production, all from the perspective of hydrodynamics—those platforms, vessels and components for which model testing and/or performance related calculations would be performed. Those components for which no hydrodynamic issues or requirements would be expected (e.g., blowout preventers) are not included, which is not to say that these components are not critical parts of the entire system.

The Offshore Engineering additions start with a definition of offshore platforms, in general and specifically those related to oil and gas drilling and production. It then contains definitions and descriptions of various types of drilling platforms, fixed and mobile (Fixed Platforms, Compliant Towers, Jack-up rigs, Mobile

Offshore Drilling Units, (MODUS), Semi-submersible drilling units, Drill ships and Ultradeep water drilling units). It then presents the various systems used for production (Gravity-based structure (GBS); Tension Leg Platform—Conventional, New Generation; Semisubmersible floating production units (semi-FPU); Spar Platforms—Classic, Truss, Cell, Mini-Doc; Floating production systems (FPS); Floating, production, storage and offloading (FPSO) vessels—Shipshape, circular; and Floating liquefied natural gas (FLNG) vessels), and specialty vessels, particularly Anchor Handler Vessels (AHV) and Anchor Handling Tug Supply Vessels (AHTS). Illustrations or photographs are provided for many of many of the above platforms and vessels.

The contributions to the new section end with specific components involved in offshore platforms and some of the performance issues that they may experience. The particular components included are: Risers, Strakes, Bottom Templates or Guides, and Mooring systems. The particular issues particular to offshore platforms are Vortex induced vibration (VIV) and Vortex Induced motion (VIM).

2.7 Revise and update the existing ITTC Recommended Procedures according to the comments of Advisory Council, Technical Committees and the Conference.

The QSG updated 8 documents, as listed in Appendix C.

The following 11 documents were reviewed:

- 4.2.3-01-01 — Guide for the Preparation of ITTC Recommended Procedures
- 4.2.3-01-03 — Work Instruction for formatting ITTC Recommended Procedures and Guidelines
- 7.5-02-01-06 — Determination of a type A uncertainty estimate of a mean value from a single time series measurement
- 7.5-02-01-07 — Guideline to Practical Implementation of Uncertainty Analysis
- 7.5-02-02-02 — General Guidelines for Uncertainty Analysis in Resistance Tests
- 7.5-02-02-02.1 — Example for Uncertainty Analysis of Resistance Tests in Towing Tanks
- 7.5-02-05-05 — Evaluation and Documentation of HSMV
- 7.5-02-06-04 — Uncertainty Analysis for Manoeuvring Predictions based on Captive Manoeuvring Tests
- 7.5-02-06-05 — Uncertainty Analysis for Free Running Model Tests
- 7.6-02-01 — Calibration of a Steel Ruler
- 7.6-02-08 — Calibration of Weights
- 7.6-02-09 — Calibration of Load Cells

As regards the outcome of the review:

4.2.3-01-01: this procedure did not contain a reference section and consequently has been updated.

4.2.3-01-03: this work instruction has been updated to correct minor errors and inconsistencies.

7.5-02-01-06: the first version of the document only included the equations for analog computations and the purposes of this revision was to include the equations for digital data processing. Martin van Rijsbergen, one of the original authors agreed to participate to the revision process. This procedure has been updated and includes the most recent recommendations of the Manoeuvring Committee.

7.5-02-01-07: Equations (9) and (12) have been corrected; data were correct in tables; a Central finite difference form was added as Equation (4); the Reference list has been updated

7.5-02-02-02: this guideline has been reviewed for consistency with guideline 7.5-02-02-02.1 and updated. Significant revisions have been made, and some editorial changes by the Resistance and Propulsion Committee were included. The following sections were added:

- Outlier and non-linear detection methods
- Force computation from mass loading for dynamometers in a calibration fixture
- Distinction between methods for confidence and prediction limits with relevant equations
- Running sinkage and trim
- List of symbols was added. A running sinkage and trim section was added.

7.5-02-02-02.1: The guideline has been reviewed for consistency with guideline 7.5-02-02-02 and updated. The main changes are as follows:

- Force reported in Newton (N) rather than kilogram force (kgf)
- Uncertainty estimates in expanded uncertainty, U, rather than standard uncertainty, u.
- Sinkage and trim data processing equations with uncertainty analysis
- Equations for confidence and prediction limits
- List of symbols
- Reference list updated

For repeat tests, a distinction is made between confidence limit and prediction limit. An uncertainty estimate for a series of tests is computed from the standard deviation of the mean value. The uncertainty estimate for total resistance, R_T, is from the 95 % confidence limit

$$U_{\bar{R}_T} = k\, s_{R_T}/\sqrt{N} \quad (1)$$

where k is the coverage factor, s the computed standard deviation of N samples. For a small number of samples, the coverage factor k can be the Student-t distribution $t_{0.025,\ N\text{-}1}$ at the 95 % confidence level. However, if the uncertainty is applied to some future event such as an uncertainty estimate for a single sample from a previous estimate of the standard deviation or estimate at full-scale from model-scale, then the uncertainty from the prediction limit is

$$U = ks\sqrt{1 + 1/N} \quad (2)$$

or for a large number of samples at the 95 % prediction limit $U = 2s$.

7.5-02-05-05: this procedure was updated regarding symbols usage. The revision number remains 02 and the date of approval 2014.

7.5-02-06-04: this procedure has been reviewed by QSG as regards format issues. The updated document has been forwarded to the Manoeuvring Committee for further review.

7.5-02-06-05: this procedure has been reviewed and updated by QSG as regards format issues. The updated document has been forwarded to the Manoeuvring Committee for further review.

7.6-02-01: After a long discussion QSG reconsidered its proposal to review the document. Considering that UA procedures prescribe traceability to a National Metrology Laboratory, internal calibration of steel rulers cannot be used anymore. To this effect, QSG proposed to delete the document. That proposal has been rejected by the AC, which asked QSG to prepare a procedure on the internal calibration of steel rulers or a practical way to check length measurement devices in towing tanks.

QSG did not manage to produce this document in time and this task has been inserted into the Recommendations for Future Work

7.6-02-08: This working instruction has been updated with modifications for consistency with other documents. The minimum tolerance for weights was changed to OIML Class M_2.

7.6-02-09: This working instruction has been greatly simplified. A calibration example is included that compares random to sequential loading of weights on a calibration stand. The following equation is included for the conversion of mass in kg to force in N.

$$F = mg(1 - \rho_A/\rho_M) \quad (3)$$

where m is the mass in kg, g is local acceleration of gravity in m/s^2, ρ_A is air density, and ρ_M

is the density of the weight in kg/m^3. The nominal values for Equation (3) are as follows:

g	9.80665 m/s^2 for standard gravity
ρ_A	1.2 kg/m^3
ρ_M	8000 kg/m^3

Local gravity is typically less than standard gravity. The last term in Equation (3) is an air buoyancy correction from Archimedes principle and is typically 0.017 %. The mass in Equation (3) is the sum of the weights added to the calibration stand.

$$m = \sum_{i=1}^{n} m_i \quad (4)$$

If the tolerance of the weights is applied as the uncertainty estimate, the uncertainty is the tolerance of the total mass, m.

The procedure also includes an example for the comparison of sequential loading to random loading. An example of the loading is given in Figure 1.

The calibration result is presented in Figure 2 as a residual plot. By a hypothesis test, the calibration constants are statistically the same for the two methods, but the uncertainty is significantly less by the random method.

2.8 After the third AC Meeting, review and edit new ITTC Recommended Procedures with regard to formal Quality System requirements including format and compliance of the symbols with the ITTC Symbols and Terminology List.

The QSG review process regarded 56 existing and 13 new procedures adding to a total of 69 documents, as illustrated in Appendix B.

The document 0.0 Register has been updated accordingly.

A template in word format has been prepared to write new procedures during the next ITTC period. To write a new procedure, an author will open the new file with the following template: ProcTemplate.dotx. The file will be available on the ITTC Web site.

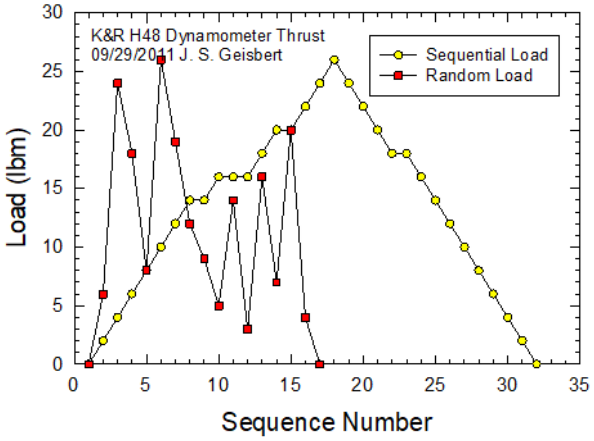

Figure 1. Loading sequence for Kempf & Remmers H48 dynamometer in thrust.

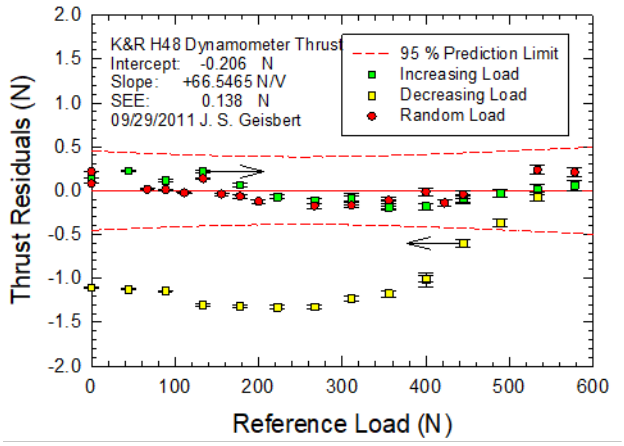

Figure 2. Calibration data for Kempf & Remmers H48 dynamometer in thrust.

2.9 Support the Technical Committees with guidance on the development, revision and update of uncertainty analysis procedures.

QSG liaised with Stability in Waves committee on the revision of procedures 7.5-02-07-04.3, 7.5-02-07-04.4, 7.5-02-07-04.5, their proposed change of formulation in ITTC Procedure 7.5-03-02-03, Practical Guidelines for ship CFD application, and the development of new ITTC Procedures: Inclining Tests, and Extrapolation for direct assessment stability in waves

7.5-02-01-06; Manoeuvring Committee supplied a revised version for QSG check

QSG assisted the Ocean Engineering Committee on the uncertainty analysis of a benchmark test.

2.10 Observe ISO standards for uncertainty analysis, in particular the uncertainty analysis terminology.

The responsibility for the ISO Guide to the Uncertainty in Measurement (GUM) is now the Bureau International des Poids et Mesures (BIPM). The focus in the future should be with BIPM not ISO. The Joint Committee for Guides in Metrology (JCGM) within BIPM is now tasked with the GUM. JCGM is divided into two working groups as follows:

- Working Group on the Expression of Uncertainty in Measurement (JCGM-WG1: GUM)
- Working Group on the International Vocabulary of Metrology (JCGM-WG2: VIM)

Each working group meets twice per year.

The following are the documents issued by WG1:

- JCGM 100:2008, "Evaluation of measurement data—Guide to the expression of uncertainty in measurement," GUM 1995 with minor corrections
- JCGM 101:2008, "Evaluation of measurement data—Supplement 1 to the 'Guide to the expression of uncertainty in measurement'—Propagation of distributions using a Monte Carlo method"
- JCGM 102:2011, "Evaluation of measurement data—Supplement 2 to the 'Guide to the expression of uncertainty in measurement'—Extension to any number of output quantities"
- JCGM 103:2020, "Evaluation of measurement data—Concepts and basic principles," in review
- JCGM 104:2009, "Evaluation of measurement data – An introduction to the 'Guide to the expression of uncertainty in measurement' and related documents"
- JCGM 106:2012, "Evaluation of measurement data—The role of measurement uncertainty in conformity assessment"

The following will be developed in the future:

- JCGM 107, "Applications of the least-squares method"
- JCGM 108, "Bayesian methods"
- JCGM 109, "Statistical Models and Data Analysis for Inter-Laboratory Studies (with application to Key Comparisons)"
- JCGM 110, "Examples of uncertainty evaluation"

A revision to the GUM was circulated at the end of 2014. After a rejection of the draft revision, the effort is now focused on the development of the supplements to the GUM. The current version of the VIM is version 3: JCGM 200:2012, "International vocabulary of metrology—Basic and general concepts and associated terms (VIM)." WG2 anticipates publishing version 4 in the near future. The web page for JCGM is as follows: https://www.bipm.org/en/committees/jc/jcgm/ .

2.11 Review developments in metrology theory and uncertainty analysis and issue appropriate Procedures.

On 20 May 2019, a new International System of Units (SI) was adopted. Details are described in Bureau International des Poids et Mesures (BIPM). The new logo for SI units is in Figure 3, which consists of seven constants, and the following definitions are from BIPM (2019).

"The definitions below specify the exact numerical value of each constant when its value is expressed in the corresponding SI unit. By fixing the exact numerical value the unit becomes defined, since the product of the ***numerical value*** and the ***unit*** has to equal the ***value*** of the constant, which is postulated to be invariant.

The seven constants are chosen in such a way that any unit of the SI can be written either through a defining constant itself or through products or quotients of defining constants.

The International System of Units, the SI, is the system of units in which

- the unperturbed ground state hyperfine transition frequency of the caesium 133 atom $\Delta\nu_{Cs}$ is 9 192 631 770 Hz,
- the speed of light in vacuum c is 299 792 458 m/s,
- the Planck constant h is 6.626 070 15 × 10^{-34} J s,
- the elementary charge e is 1.602 176 634 × 10^{-19} C,
- the Boltzmann constant k is 1.380 649 × 10^{-23} J/K,
- the Avogadro constant N_A is 6.022 140 76 × 10^{23} mol^{-1},
- the luminous efficacy of monochromatic radiation of frequency 540 × 10^{12} Hz, K_{cd}, is 683 lm/W,

where the hertz, joule, coulomb, lumen, and watt, with unit symbols Hz, J, C, lm, and W, respectively, are related to the units second, metre, kilogram, ampere, kelvin, mole, and candela, with unit symbols s, m, kg, A, K, mol, and cd, respectively, according to Hz = s^{-1}, J = kg m^2 s^{-2}, C = A s, lm = cd m^2 m^{-2} = cd sr, and W = kg m^2 s^{-3}." Since the numerical values are exact, no uncertainty is associated with these values.

The web page for BIPM and the new standard for SI units is as follows: https://www.bipm.org/en/measurement-units/ .

Two tools are available for the computation of uncertainty estimates, which are based on the GUM, JCGM (2008) and include the Monte Carlo method. The first is located on the National Physical Laboratory (NPL) web page: https://www.npl.co.uk/resources/software/measurement-uncertainty-evaluation . The software consists of MATLAB routines that are downloaded from the web page. NPL is the National Metrology Institute (NMI) of the United Kingdom (UK). The user manual is included in the software.

Figure 3. BIPM logo for SI units.

The second is on-line software at the National Institute of Standards and Technology (NIST), the NMI of the USA. The web page for the NIST Uncertainty Machine is as follows: https://uncertainty.nist.gov/. Lafarge and Possolo (2018) is the latest version of the user's manual.

The NIST web page also includes an on-line Engineering Statistics Handbook. That web page is as follows and was last updated October 2013: https://www.itl.nist.gov/div898/handbook/ .

The journal Metrologia is published by IOP Science for BIPM. Metrologia should be reviewed for articles on uncertainty analysis. The American Society of Mechanical Engineers (ASME) also a journal dedicated to uncertainty analysis and verification and validation (V&V), Journal of Verification, Validation, and Uncertainty Quantification. The first issue was published in March 2016.

ASME continues to host an annual "Verification and Validation Symposium". The first was in Las Vegas, Nevada, on 2-4 May 2012. Presentations are accepted on the basis of an abstract. No technical papers are published, but presentations are available on the ASME conference web page.

ASME has also published two standards related to uncertainty analysis. ASME V&V 20-

2009 is one of the more detailed documents on the application of V&V to computational fluid dynamics (CFD). ASME PTC 19.1-2018 is on test uncertainty and is compatible with the GUM, JCGM (2008).

A value of the local acceleration of gravity is necessary for the calculation of force in a calibration stand from mass per Equation (3). Previously, a global tool was available for the computation of local gravity at the Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany, but that on-line calculation tool is no longer available. PTB provides a link another calculation tool, but it is applicable only to locations within Germany. That calculation tool is located at Bundesamt für Kartographie und Geodäsie (BKG) in Frankfurt, Germany, on the following web page: http://gibs.bkg.bund.de/geoid/gscomp.php?p=s. The input parameters are latitude and longitude in degrees and elevation in metres.

The USA has a similar web page at the National Geodetic Survey (NGS) as follows: https://geodesy.noaa.gov/cgi-bin/grav_pdx.prl. The default elevation for NSWCCD in that tool is 78.95 m. Another tool, which provides the elevation from the latitude and longitude, yields an elevation of 40 m, and different value in local gravity is obtained. The NGS tool also provides an uncertainty estimate. Elevation is determined from the address in the following web page globally: https://elevation.maplogs.com/. When a laboratory is located on the GPS map, the latitude and longitude may be adjusted for a location within the facility.

Another tool, which appears to provide international data, is at the Bureau Gravimétrique International (BGI), Toulouse, France. That web page is as follows: http://bgi.obs-mip.fr/data-products/outils/prediction-of-gravity-value/ . It does not provide data for CSSRC. A comparison of the values of local gravity, g, is summarized in Table 1 for example ITTC laboratories by the different tools. The PTB values in the table are from ITTC (2017), Table 1.

As a final note, the QSG observes that the ITTC focuses on uncertainty, while neglecting the incorporation of confidence bands in the results from committees dealing with stochastic processes. The size of the confidence bands will in general be significantly larger than the uncertainty bounds. And half or more (if the Manoeuvring Committee is dealing with manoeuvring in waves) of the General Committees are working with stochastic processes.

2.12 Continue to maintain the online Wiki keeping it up to date and in line with the adopted documents of the ITTC.

In ITTC (2011), when the ITTC-wiki was established, some positive feedbacks visits and returning visitors were counted, as time has passed, the level of feedback has been continuously decreasing. The thrust of the wiki tool has been to build, refine and review concepts and notions around the definitions contained in the Dictionary of Hydromechanics through collective knowledge. However, because the content of the Dictionary of Hydromechanics is endorsed by the Conference such interactions and modification of the wiki tool were quite limited, defeating the wiki approach. Furthermore, the Wiki server was down for various technical problems during most of the period between the two ITTC conferences.

In view of the abovementioned considerations it is proposed to discontinue the wiki tool and to maintain the Dictionary updated, maintained and furtherly expanded as necessary; and freely available for download on the ITTC website.

2.13 At the beginning of the period, organize an electronic repository of information and data on the benchmarks cases. ITTC member organizations should then be invited to participate in the adoption of the benchmark and contribute to the data-base.

The ITTC web page now contains a link to the Benchmark repository.

The data structure to host data pertaining to benchmarks was defined during the 26th ITTC and is illustrated in Figure 4.

According to the 29th QSG TOR, one task is to organize an electronic repository of information and data on the benchmark cases at the beginning of the period. Then, ITTC member organizations shall be invited to participate in the adoption of the benchmarks and contribute to the database.

To date, the work of 29th QSG has been to review the benchmarks and their data as much as possible. After discussing with relative technical committee members and ITTC community, the frequently used benchmarks are listed in Table 2. As the survey has only engaged with a small part of ITTC community, and information has been collected from several conference websites, QSG would like to describe the situation at the current time.

Table 3 shows the sources of the benchmarks and their applications, including the website and conference name. Some of the benchmarks are somewhat obsolete, however, others are still widely referenced. Data cleaning and data sorting needs to be performed in the future. This work should be performed together with the relevant technical committee.

Take the 'KCS' from Tokyo 2015 A Workshop on CFD in Ship Hydrodynamics as an example, it is describe as following.

"The KCS was conceived to provide data for both explication of flow physics and CFD validation for a modern container ship with a bulbous bow (i.e., ca. 1997). The Korea Research Institute for Ships and Ocean Engineering (KRISO) performed towing tank experiments to obtain resistance, mean flow data and free surface waves (Van et al, 1998a,b, Kim et al, 2001). Self propulsion tests were carried out at the Ship Research Institute (now NMRI) in Tokyo and are reported in the Proceedings of the CFD Workshop Tokyo in 2005 (Hino, 2005). Later, resistance tests were also reported by NMRI (See Zou and Larsson, 2014). Data for pitch, heave, and added resistance are available from Force/Dmi measurements reported in Simonsen et al. (2008)."

The keywords is "Resistance Test, Self-propulsion test, Added resistance test, CFD simulation", and manoeuvring as well as SIMMAN.

Therefore, QSG would like to setup a questionnaire to all the ITTC committees at the start of the next term to obtain the definition, objective, data format and other information of the various benchmarks.

Many of the technical committees are engaged in collecting benchmarks. Therefore, an inter-committee liaison mechanism shall be established to communicate the demands and application of benchmarks, as well as the data sources. The QSG shall be involved in this organization, and will establish a standard format for the use of all the ITTC committees and community.

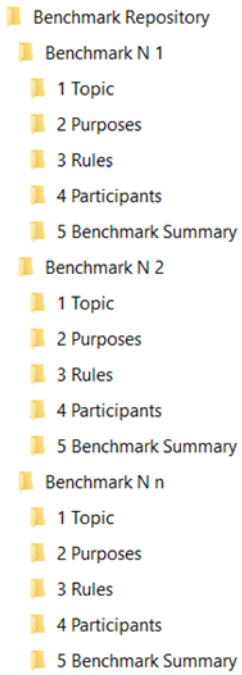

Figure 4. Benchmark Repository data structure.

Table 1. Comparison of local gravity for Example ITTC laboratories.

ITTC Laboratory	Elevation (m)	Acceleration of Gravity, g (m/s^2)			
		BGI	BKG	NGS	PTB
AMC, Newnham, TAS, Australia	21.0	9.80282			
CSSRC, Wuxi, China	5.0				9.79439
HSVA, Hamburg, Germany	13.0	9.81378	9.80378		
CNR-INM, Rome, Italy	55.0	9.80347			
NSWCCD, Bethesda, MD, USA	41.2 40.0	9.80112		9.80108	9.80106

Table 2. Benchmark data used in technical fields.

Fields	KCS	JBC	ONRT	DTC	DTMB 5415	KVLCC1	KVLCC2
Resistance and Propulsion	●	●				●	●
Maneuvering			●	●	●	●	●
Seakeeping	●					●	●
Ocean Engineering							
Stability in Waves			●	●			

Notes: the information is collected from several conference website, needed to be updated

Table 3. Benchmark data used in technical fields.

	website	Conference
KCS	http://www.t2015.nmri.go.jp/kcs.html	Tokyo 2015 A Workshop on CFD in Ship Hydrodynamics
JBC	https://t2015.nmri.go.jp/jbc.html	Tokyo 2015 A Workshop on CFD in Ship Hydrodynamics
ONRT	https://t2015.nmri.go.jp/onrt.html	Tokyo 2015 A Workshop on CFD in Ship Hydrodynamics
DTC	http://www.mashcon2019.ugent.be/EN/mashcon2019_call_EN.htm	5th International Conference on Ship Manoeuvring in Shallow and Confined Water
dtmb 5415	https://simman2014.dk/ship-data/us-navy-combatant/	SIMMAN 2014
KVLCC 1	http://www.simman2008.dk/KVLCC/KVLCC1/tanker1.html	SIMMAN 2008
KVLCC 2	https://simman2014.dk/ship-data/moeri-kvlcc2-tanker/	SIMMAN 2014
Series	http://www.shipstab.org/index.php/data-access (needs register)	International Ship Stability Workshop

So far, the benchmark is mostly focused on model scale. However, due to the future demand from several technical committees and research from the community, full-scale benchmarks are also of great interest.

3. CONCLUSIONS

The format of S.I. units should be considered with a view to achieving consistency with respect to the use of a multiplication symbol when referring to sub-units, such as when referring to milliseconds, ms versus meter seconds, m s (separated by a hard space (Ctrl+Shift+space) or by a half-high center dot).

It is necessary to complete the list of symbols used for Uncertainty Analysis.

A new section addressing new techniques such as ASME Validation and Verification methodology should be added to procedure 7.5-02-01-01 Guide to the Expression of Uncertainty in Experimental Hydrodynamics.

Consideration should be given by the Conference to new emerging technologies in artificial intelligence (such as machine learning techniques) with respect to data quality assessment.

Consideration should be given by the Conference to further development of liaison with International Ship and Offshore Structures Congress (ISSC) for the purpose harmonization and common understanding of the state of the art in Uncertainty Analysis.

QSG noted that many procedures do not comply with the format required by 4.2.3-01-01 Guide for the Preparation of ITTC Recommended Procedures, in particular many documents do not include the sections:

3. PARAMETERS; SYMBOLS

3.1 parameters to be taken into account,

3.2 recommendations of ITTC for parameters if there are any (e.g. friction line 57).

An effort should be made to resolve this inconsistency.

4. RECOMMENDATIONS TO THE CONFERENCE

The QSG recommends to the Full Conference to:

Adopt the revised procedures and guidelines and work instructions:

- 4.2.3-01-01 – Guide for the Preparation of ITTC Recommended Procedures.
- 4.2.3-01-03 – Work Instruction for Formatting ITTC Recommended Procedures
- 7.5-02-01-06 – Determination of a type A uncertainty estimate of a mean value from a single time series measurement
- 7.5-02-01-07 – Guideline to Practical Implementation of Uncertainty Analysis
- 7.5-02-02-02 – General Guidelines for Uncertainty Analysis in Resistance Tests
- 7.5-02-02-02.1 – Example for Uncertainty Analysis of Resistance Tests in Towing Tanks
- 7.6-02-08 – Calibration of Weights
- 7.6-02-09 – Calibration of Load Cells

Adopt the revised Symbols and Terminology List Version 2021;

Adopt the revised ITTC Dictionary of Hydromechanics Version 2021;

5. RECOMMENDATIONS FOR FUTURE WORK

The following future work is recommended:

1. Support the Technical Committees in their work on Recommended Procedures. Supply the chairmen of the new

committees with the MS Word versions of the relevant procedures.

2. Maintain the Manual of ITTC Recommended Procedures and Guidelines. Coordinate the modification and re-editing of the existing procedures according to the comments made by ITTC member organizations at the Conference and by the Technical Committees.
3. After the third AC Meeting, review and edit new ITTC Recommended Procedures and Guidelines with regard to formal Quality System requirements including format and compliance of the symbols with the ITTC Symbols and Terminology List.
4. Revise and update existing ITTC Recommended Procedures according to the comments of Advisory Council, Technical Committees and the Conference.
5. Prepare a procedure on the internal calibration of steel rulers or a practical way to check length measurement devices in towing tanks.
6. Introduce New Uncertainty Analyses Guidelines to include data anomalies in Machine Learning Algorithms for Autonomous and Intelligent ships.
7. Update ITTC procedures and Guidelines still referring to the ISO GUM to conform to BIPM (2008) GUM
8. Observe the development or revision of ISO Standards regarding Quality Control.
9. Update the ITTC Symbols and Terminology List.
10. Update the Uncertainty Analysis section of the Symbols & Terminology List.
11. Update the ITTC Dictionary of Hydromechanics.
12. Expand the content of current ITTC dictionary version, considering CFD, MASS, etc.
13. Support the Technical Committees with guidance on development, revision and update of uncertainty analysis procedures.
14. Support the Technical Committees dealing with stochastic processes with guidance on development, revision and update of procedures for the inclusion of confidence bands on their computational and experimental results.
15. Observe BIPM/JCGM standards for uncertainty analysis, in particular the uncertainty analysis terminology.
16. Review developments in metrology theory and uncertainty analysis and issue appropriate Procedures.
17. Setup an effective way to collect benchmark data.
18. Upload all the collected and verified benchmark data into the ITTC benchmark data repository
19. Liaise with relative technical committees to complete a questionnaire about the demand and use of benchmarks, not be limited in model scale
20. Cooperate with Technical Committees to establish the ITTC benchmarks, including definition, raw data, data format, etc.

Appendix A. OUTCOME OF THE MANUAL OF ITTC RECOMMENDED PROCEDURES AND GUIDELINES MAINTENANCE.

New/ Rev./ Del	Number	P /G	Title	Effec-tive Date
R	1.0-06	G	Guidelines for ITTC Conference Organisers	2021
R	4.2.3-01-01	P	Guide for the Preparation of ITTC Recommended Proce-dures	2021
R	4.2.3-01-03	W	Work Instruction for Formatting ITTC Recommended Procedures	2021
D	7.5-02-01-05	G	(Model-Scale Propeller Cavitation Noise Measurements) Moved to 7.5-02-03-03.9	2021
R	7.5-02-01-06	P	Determination of a type A uncertainty estimate of a mean value from a single time series measurement	2021
R	7.5-02-01-07	G	Guideline to Practical Implementation of Uncertainty Analysis	2021
R	7.5-02-02-01	P	Resistance Tests	2021
R	7.5-02-02-02	G	General Guidelines for Uncertainty Analysis in Re-sistance Tests	2021
R	7.5-02-02-02.1	G	Example for Uncertainty Analysis of Resistance Tests in Towing Tanks	2021
R	7.5-02-02-02.2	G	Practical Guide for Uncertainty Analysis of Resistance Measurements in Routine Tests	2021
N	7.5-02-02-04		Wave Profile Measurement and Wave Pattern Re-sistance Analysis	2021
R	7.5-02-03-01.1	P	Propulsion/ Bollard pull Test	2021
D	7.5-02-03-01.2	P	(Uncertainty Analysis Example for Propulsion Test) De-leted	2021
R	7.5-02-03-01.3	PC	Podded Propulsor Tests and Extrapolation	2021
R	7.5-02-03-01.4	P	1978 ITTC Performance Prediction Method	2021
R	7.5-02-03-01.7	P	Performance Prediction Method for Unequally Loaded, Multiple Propeller Vessels	2021
R	7.5-02-03-01.8	G	Scaling Method for ship wake fraction with pre-swirl de-vices	2021
R	7.5-02-03-02.1	P	Open Water Test	2021
D	7.5-02-03-02.2	P	(Uncertainty Analysis, Example for Open Water Test) Deleted	2021
R	7.5-02-03-03.9	G	Model-Scale Propeller Cavitation Noise Measurements	2021
R	7.5-02-04-01	G	General Guidance and Introduction to Ice Model Testing	2021
R	7.5-02-04-02	P	Test Methods for Model Ice Properties	2021
R	7.5-02-04-02.3	PC	Manoeuvring Tests in Ice	2021
R	7.5-02-04-03	G	Guidelines for Modelling of Complex Ice Environments	2021
R	7.5-02-05-04	P	Seakeeping Tests	2021
R	7.5-02-05-06	P	Structural Loads	2021
D	7.5-02-05-07	P	(Dynamic Instability Tests) Withdrawn	2021
R	7.5-02-06-01	P	Free Running Model Tests	2021
R	7.5-02-06-02	P	Captive Model Test Procedure	2021
R	7.5-02-06-03	P	Validation of Manoeuvring Simulation Models	2021

R	7.5-02-06-04	P	Uncertainty Analysis for manoeuvring predictions based on captive manoeuvring tests	2021
R	7.5-02-06-05	G	Uncertainty Analysis for free running model tests	2021
N	7.5-02-06-06	G	Benchmark Data for Validation of Manoeuvring Predictions	2021
N	7.5-02-06-07	G	Captive Model Test for Underwater Vehicles	2021
R	7.5-02-07-01.2	G	Laboratory Modelling of Waves	2021
D	7.5-02-07-01.3	G	(Guidelines for Modelling of Complex Ice Environments) Moved to 7.5-02-04-03	2021
N	7.5-02-07-01.5	G	Laboratory Modelling of Wind	2021
N	7.5-02-07-01.6	G	Laboratory Modelling of Currents	2021
R	7.5-02-07-02.1	P	Seakeeping Experiments	2021
R	7.5-02-07-02.2	P	Predicting of Power Increase in Irregular Waves from Model Tests	2021
R	7.5-02-07-02.3	P	Experiments on Rarely Occurring Events	2021
R	7.5-02-07-02.5	P	Verification and Validation of Linear and Weakly Nonlinear Seakeeping Computer Codes	2021
R	7.5-02-07-02.6	P	Global Loads Seakeeping Procedure	2021
R	7.5-02-07-02.7	P	Sloshing Model Tests	2021
R	7.5-02-07-02.8	P	Calculation of the weather factor fw for decrease of ship speed in waves	2021
R	7.5-02-07-03.1	P	Floating Offshore Platform Experiments	2021
R	7.5-02-07-03.2	P	Analysis Procedure for Model Tests in Regular Waves	2021
D	7.5-02-07-03.4	P	(Active Hybrid Model Tests of Floating Offshore Structures with Mooring Lines) Deleted	2021
R	7.5-02-07-03.5	P	Passive Hybrid Model Tests of Floating Offshore Structures with Mooring Lines	2021
R	7.5-02-07-03.6	P	Dynamic Positioning System Model Test Experiments	2021
R	7.5-02-07-03.7	G	Wave Energy Converter Model Test Experiments	2021
R	7.5-02-07-03.8	P	Model Tests for Offshore Wind Turbines	2021
R	7.5-02-07-03.9	P	Model Tests for Current Turbines	2021
R	7.5-02-07-03.10	G	Guideline for VIV Testing	2021
R	7.5-02-07-03.11	G	Guideline for Model Tests of Stationary Multi-Bodies Operating in Close Proximity	2021
R	7.5-02-07-03.12	G	Uncertainty Analysis for a Wave Energy Converter	2021
R	7.5-02-07-03.13	G	Guideline for VIM Testing	2021
R	7.5-02-07-03.14	P	Analysis Procedure of Model Tests in Irregular Waves	2021
R	7.5-02-07-03.15	G	Uncertainty analysis - Example for horizontal axis turbines	2021
N	7.5-02-07-03.16	G	Model Construction of Offshore Systems	2021
N	7.5-02-07-03.17	G	Uncertainty Analysis for Model Testing of Offshore Wind Turbines	2021

N	7.5-02-07-03.18	G	Practical guidelines for numerical modelling of wave energy converters	2021
R	7.5-02-07-04.3	G	Predicting the Occurrence and Magnitude of Parametric Rolling	2021
R	7.5-02-07-04.4	P	Simulation of Capsize Behaviour of Damaged Ships in Irregular Beam Seas	2021
R	7.5-02-07-04.5	P	Estimation of Roll Damping	2021
N	7.5-02-07-04.6	P	Extrapolation for Direct Stability Assessment in Waves	2021
N	7.5-02-07-04.7	P	Inclining Tests	2021
R	7.5-03-01-01	P	Uncertainty Analysis in CFD, Verification and Validation Methodology and Procedures	2021
R	7.5-03-01-02	G	Quality Assurance in Ship CFD Applica-tion	2021
D	7.5-03-01-03	P	(CFD User's Guide) Deleted	2021
D	7.5-03-01-04	P	(CFD Verification) Deleted	2021
R	7.5-03-02-02	P	Benchmark Database for CFD Validation for Resistance and Propulsion	2021
R	7.5-03-02-04	G	Practical Guidelines for Ship Resistance CFD	2021
N	7.5-03-02-05	G	Use of CFD methods to calculate wind resistance coefficient	2021
R	7.5-03-04-01	G	Guideline on Use of RANS Tools for Manoeuvring Prediction	2021
R	7.5-03-04-02	G	Validation and Verification of RANS Solutions in the Prediction of Manoeuvring Capabilities	2021
R	7.5-04-01-01.1	P	Preparation, Conduct and Analysis of Speed/Power Trials	2021
R	7.5-04-02-01	P	Full Scale Manoeuvring Trials Procedure	2021
N	7.5-04-02-02	G	UV Full Scale Manoeuvring Trials	2021
R	7.5-04-04-01	G	Underwater Noise from Ships, Full Scale Measurements	2021
R	7.5-04-05-01	G	Guideline on the determination of model-ship correlation factors	2021
D	7.6-02-01	W	Calibration of Steel Rulers	2021
R	7.6-02-08	W	Calibration of Weights	2021
R	7.6-02-09	W	Calibration of a Load Cells	2021

Appendix B. RECOMMENDED PROCEDURES AND GUIDELINES REVIEWED WITH REGARD TO FORMAL QUALITY SYSTEM REQUIREMENTS

Procedure No.	Procedure title	Committee
1.0-06	Guidelines for ITTC Conference Organisers	EC
7.5-02-02-01	Resistance Tests	R&P
7.5-02-02-02	General Guidelines for Uncertainty Analysis in Resistance Tests	R&P
7.5-02-02-02.1	Example for Uncertainty Analysis of Resistance Tests in Towing Tanks	R&P
7.5-02-02-02.2	Practical Guide for Uncertainty Analysis of Resistance Measurements in Routine Tests	R&P
7.5-02-02-04	Wave Profile Measurement and Wave Pattern Resistance Analysis	R&P
7.5-02-03-01.1	Propulsion/ Bollard pull Test	R&P
7.5-02-03-01.3	Podded Propulsor Tests and Extrapolation	R&P
7.5-02-03-01.4	1978 ITTC Performance Prediction Method	R&P
7.5-02-03-01.7	Performance Prediction Method for Unequally Loaded, Multiple Propeller Vessels	R&P
7.5-02-03-01.8	Scaling Method for ship wake fraction with pre-swirl devices	ESM
7.5-02-03-02.1	Open Water Test	R&P
7.5-02-03-03.9	Model-Scale Propeller Cavitation Noise Measurements	HN
7.5-02-04-01	General Guidance and Introduction to Ice Model Testing	ICE
7.5-02-04-02	Test Methods for Model Ice Properties	ICE
7.5-02-04-02.3	Manoeuvring Tests in Ice	ICE
7.5-02-04-03	Guidelines for Modelling of Complex Ice Environments	ICE
7.5-02-05-04	Seakeeping Tests	SKC
7.5-02-05-06	Structural Loads	SKC
7.5-02-06-01	Free Running Model Tests	MAN
7.5-02-06-02	Captive Model Test Procedure	MAN
7.5-02-06-03	Validation of Manoeuvring Simulation Models	MAN
7.5-02-06-04	Uncertainty Analysis for manoeuvring predictions based on captive manoeuvring tests	MAN
7.5-02-06-05	Uncertainty Analysis for free running model tests	MAN
7.5-02-06-06	Benchmark Data for Validation of Manoeuvring Predictions	MAN
7.5-02-06-07	Captive Model Test for Underwater Vehicles	MAN
7.5-02-07-01.2	Laboratory Modelling of Waves	MEC
7.5-02-07-01.5	Laboratory Modelling of Wind	MEC
7.5-02-07-01.6	Laboratory Modelling of Currents	MEC
7.5-02-07-02.1	Seakeeping Experiments	SKC
7.5-02-07-02.2	Predicting of Power Increase in Irregular Waves from Model Tests	SKC
7.5-02-07-02.3	Experiments on Rarely Occurring Events	SKC
7.5-02-07-02.5	Verification and Validation of Linear and Weakly Nonlinear Seakeeping Computer Codes	SKC
7.5-02-07-02.6	Global Loads Seakeeping Procedure	SKC
7.5-02-07-02.7	Sloshing Model Tests	SKC
7.5-02-07-02.8	Calculation of the weather factor fw for decrease of ship speed in waves	SKC
7.5-02-07-03.1	Floating Offshore Platform Experiments	OEC
7.5-02-07-03.2	Analysis Procedure for Model Tests in Regular Waves	OEC
7.5-02-07-03.5	Passive Hybrid Model Tests of Floating Offshore Structures with Mooring Lines	OEC
7.5-02-07-03.6	Dynamic Positioning System Model Test Experiments	OEC
7.5-02-07-03.7	Wave Energy Converter Model Test Experiments	MRED

7.5-02-07-03.8	Model Tests for Offshore Wind Turbines	MRED
7.5-02-07-03.9	Model Tests for Current Turbines	MRED
7.5-02-07-03.10	Guideline for VIV Testing	OEC
7.5-02-07-03.11	Guideline for Model Tests of Stationary Multi-Bodies Operating in Close Proximity	OEC
7.5-02-07-03.12	Uncertainty Analysis for a Wave Energy Converter	MRED
7.5-02-07-03.13	Guideline for VIM Testing	OEC
7.5-02-07-03.14	Analysis Procedure of Model Tests in Irregular Waves	OEC
7.5-02-07-03.15	Uncertainty analysis - Example for horizontal axis turbines	MRED
7.5-02-07-03.16	Model Construction of Offshore Systems	OEC
7.5-02-07-03.17	Uncertainty Analysis for Model Testing of Offshore Wind Turbines	MRED
7.5-02-07-03.18	Practical guidelines for numerical modelling of wave energy converters	MRED
7.5-02-07-04.3	Predicting the Occurrence and Magnitude of Parametric Rolling	SIW
7.5-02-07-04.4	Simulation of Capsize Behaviour of Damaged Ships in Irregular Beam Seas	SIW
7.5-02-07-04.5	Estimation of Roll Damping	SIW
7.5-02-07-04.6	Extrapolation for Direct Stability Assessment in Waves	SIW
7.5-02-07-04.7	Inclining Tests	SIW
7.5-03-01-01	Uncertainty Analysis in CFD, Verification and Validation Methodol-ogy and Procedures	R&P
7.5-03-01-02	Quality Assurance in Ship CFD Applica-tion	R&P
7.5-03-02-02	Benchmark Database for CFD Validation for Resistance and Propul-sion	R&P
7.5-03-02-04	Practical Guidelines for Ship Resistance CFD	R&P
7.5-03-02-05	Use of CFD methods to calculate wind resistance coefficient	SOS
7.5-03-04-01	Guideline on Use of RANS Tools for Manoeuvring Prediction	MAN
7.5-03-04-02	Validation and Verification of RANS Solutions in the Prediction of Manoeuvring Capabilities	MAN
7.5-04-01-01.1	Preparation, Conduct and Analysis of Speed/Power Trials	SOS
7.5-04-02-01	Full Scale Manoeuvring Trials Procedure	MAN
7.5-04-02-02	UV Full Scale Manoeuvring Trials	MAN
7.5-04-04-01	Underwater Noise from Ships, Full Scale Measurements	HN
7.5-04-05-01	Guideline on the determination of model-ship correlation factors	SOS

Appendix C. DOCUMENTS UPDATED BY QSG

Number	P / G	Title
4.2.3-01-01	P	Guide for the Preparation of ITTC Recommended Procedures
4.2.3-01-03	W	Work Instruction for formatting ITTC Recommended Procedures and Guidelines
7.5-02-01-06	P	Determination of a type A uncertainty estimate of a mean value from a single time series measurement
7.5-02-01-07	G	Guideline to Practical Implementation of Uncertainty Analysis
7.5-02-02-02	G	General Guideline for Uncertainty Analysis in Resistance Tests
7.5-02-02-02.1	G	Example for Uncertainty Analysis of Resistance Tests in Towing Tanks
7.6-02-08	W	Calibration of Weights
7.6-02-09	W	Calibration of Load Cells

P = Procedure
G = Guideline
W = Work Instruction