Quality Systems Group

Final Report and Recommendations to the 27th ITTC

1. GENERAL

1.1. Membership and Meetings

Benedetti L., CNR-INSEAN (Secretary)
Derradji A., NRC
Ferrando M., University of Genova, (Chair)
Johnson B., US Naval Academy (senior)
Kobayashi E., Kobe Univ.
Morabito M. G., US Naval Academy
Park J. T. NSWC Carderock Div.
Pérez Rojas Luis, ETSIN
Sena Sales Jr J., LabOceano
van Rijsbergen M., MARIN
Woodward M. D., Newcastle Univ

From March 4th 2013 Morabito M. G., US Naval Academy replaced Johnson B., US Naval Academy. Professor Jonson will remain a corresponding member of the group.

From September 2013 Park J. T. Naval Surface Warfare Center Carderock Div. replaced Derradji A., NRC

The Group held four meetings as follows:

Rio de Janeiro, September 3rd 2011
Madrid, June 25th to 27th 2012
Annapolis, July 1st to 3rd 2013
Genoa, January 27th to 29th 2014.

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 26th ITTC to the QSG.

1) Include a definition of the terms Verification and Validation in the ITTC Symbols and Terminology List (to be done within first three months as a basis for the work of other committees).
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) Support the Technical Committees in their work on Recommended Procedures. Supply the chairmen of the new committees at the beginning of the period with the MS Word versions of the relevant procedures and the template for the production of new procedures.
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) Cross-check the ITTC Symbols List and the Dictionary with other standards e.g. ISO.
8) Revise and update the existing ITTC Recommended Procedures according to the comments of Advisory Council, Technical Committees and the Conference.
9) Before 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.
10) Follow the implementation of the Benchmark data repository.
11) Support the technical committees with guidance on development, revision and update of uncertainty analysis procedures.
12) Observe ISO standards for uncertainty analysis, in particular the uncertainty analysis terminology.
13) Maintain Wiki for the 27th ITTC as a trial period and create link to it from the ITTC website.

2. PERFORMED TASKS

2.1. Include a definition of the terms Verification and Validation in the ITTC documents

The QSG has agreed on the following definitions:

"Verification, Validation, and Accreditation are three interrelated but distinct processes that gather and evaluate evidence to determine, based on the simulation's intended use, the simulation's capabilities, limitations, and performance relative to the real-world objects it simulates."

- **Verification** is the process of determining that a model or simulation implementation accurately represents the developer's conceptual description and specification. (i.e., does the code accurately implement the theory that is proposed to model the problem at hand?)
- **Validation** is the process of determining the degree to which a model or simulation is an accurate representation of the real world from the perspective of the intended uses of the model or simulation. (i.e., does the theory and the code that implements the theory accurately model the relevant physical problem of interest?)
- **Accreditation** is the official determination that a model or simulation, is acceptable for use for a specific purpose. (i.e., is the theory and the code that implements it adequate for modeling the physics relevant to a specific platform? In other words, are the theory and code relevant to the type of vessel for which it is being accredited?)

A letter was sent to all of the Chairmen with the definitions proposed by the QSG and agreed upon by the AC Chairman.

The definitions have been entered into the ITTC Dictionary of Hydromechanics.

2.2. Maintain the Manual of ITTC Recommended Procedures and Guidelines

The revision of the Manual of ITTC Recommended Procedures and Guidelines concerned 54 documents:

- 2 existing procedures were deleted
- 17 new Procedures/Guidelines have been evaluated, 16 have been approved and one postponed

- 35 existing procedures have been reviewed or updated, the revision of three of which have been postponed.

The revision outcome is illustrated in Table 1.

In the process of revising the procedures and guidelines submitted by the committees, some apparent inconsistencies have been found between the categorization (Procedure or Guideline) and the contents/titles of the documents.

Specifically, 7.5-01-03-03, 7.5-02-02-02 and 7.5-02-07-03.7 were categorized as Procedures whereas the title and contents refer to them as being Guidelines.

Similarly, 7.5-02-07-04.4 was categorized as a Guideline whereas the contents refer to it as being a Procedure.

To rectify this situation, the Advisory Council agreed to the change of categorization of the mentioned documents. Accordingly, documents 7.5-01-03-03, 7.5-02-02-02 and 7.5-02-07-03.7 will be marked as Guidelines and document 7.5-02-07-04.4 will be labelled as Procedure.

Table 1: Outcome of the Manual of ITTC Recommended Procedures and Guidelines Maintenance

New/ Revi-sed	**Number**	**Pr. /Gl**	**Title**	**AC de-cisio n**
R	1.0-01		Description and Rules of the ITTC	A
R	1.0-02		Committee Structure of ITTC	A
N	1.0-04	P	Decision Making Between Conferences	A
R	4.2.3-01-02	G	Guidelines for Preparation of Technical Committee and Group Reports	A
R	4.2.3-01-03	P	Work Instruction for Formatting ITTC Recommended Procedures	A
R	7.5-01-03-01	P	Uncertainty Analysis, Instrument Calibration	A
R	7.5-01-03-03	P	Guideline on the Uncertainty Analysis for Particle Image Velocimetry	A
N	7.5-01-03-04	G	Benchmark for PIV(2C) and SPIV(3C) setups	A
R	7.5-02-01-01	P	Guide to the Expression of Uncertainty in Experimental Hydrodynamics	A

N	7.5-02-01-04	G	Guideline on Best Practices for the Applications of PIV/SPIV in Towing Tanks and Cavitation Tunnels	A
N	7.5-02-01-05	P	Model scale noise measurements	A
R	7.5-02-02-02	P	General Guidelines for Uncertainty Analysis in Resistance Tests	A
N	7.5-02-02-02.1	G	Example for Uncertainty Analysis of Resistance tests in Towing Tank	A
N	7.5-02-02-02.2	G	Practical Guide for Uncertainty Analysis of Resistance Measurement in Routine Tests	A
R	7.5-02-03-01.2	P	Uncertainty Analysis Example for Propulsion Test	PP
R	7.5-02-03-01.4	P	1978 ITTC Performance Prediction Method	A
N	7.5-02-03-01.6	G	Hybrid Contra-Rotating Shaft Pod Propulsor Model Test	A
R	7.5-02-03-02.1	P	Open Water Test	A
R	7.5-02-03-02.3	P	Nominal Wake Measurements by LDV, Model Scale Experiments	A
R	7.5-02-03-03.2	P	Description of Cavitation Appearances	A
R	7.5-02-03-03.3	P	Cavitation Induced Pressure Fluctuations Model Scale Experiments	A
R	7.5-02-03-03.4	P	Cavitation Induced Pressure Fluctuations Numerical Prediction Methods	A
R	7.5-02-04-01	P	General Guidelines	PP
R	7.5-02-04-02	P	Test Methods for Model Ice Properties	R
R	7.5-02-04-02.1	P	Resistance Test in Level Ice	PP
R	7.5-02-05-04	P	Seakeeping Tests	A
R	7.5-02-05-05	P	Evaluation and Documentation of HSMV	A
R	7.5-02-06-01	P	Free Running Model Tests	A
R	7.5-02-06-02	P	Captive Model Test Procedure	A
R	7.5-02-06-03	P	Validation of Manoeuvring Simulation Models	A
R	7.5-02-06-04	P	Uncertainty Analysis for manoeuvring predictions based on captive manoeuvring tests	A
N	7.5-02-06-05	G	Uncertainty Analysis for free running model tests	A
R	7.5-02-07-02.1	P	Seakeeping Experiments	A
R	7.5-02-07-02.2	P	Predicting of Power Increase in Irregular Waves from Model Test	A
R	7.5-02-07-02.3	P	Experiments on Rarely Occurring Events	A
R	7.5-02-07-02.4	P	Validation of Seakeeping Computer Codes in the Frequency Domain	D
R	7.5-02-07-03.3	P	Model Tests on Tanker-Turret Systems	D
R	7.5-02-07-03.7	P	Wave Energy Converter, Model Test Experiments	A

N	7.5-02-07-03.8	P	Model Tests for Offshore Wind Turbines	A
N	7.5-02-07-03.9	P	Model Tests for Current Turbines	A
N	7.5-02-07-03.10	G	Guideline for VIV Testing	A
N	7.5-02-07-03.11	G	Guidelines for VIM Testing	PP
R	7.5-02-07-04.2	P	Model Tests on Damage Stability in Waves	A
R	7.5-02-07-04.4	G	Numerical Simulation of Capsize Behaviour of Damaged Ships in Irregular Beam Seas	A
R	7.5-03-02-03	G	Practical Guidelines for Ship CFD Applications	A
N	7.5-03-02-04	G	Practical Guidelines for Ship Resistance CFD	A
N	7.5-03-03-01	G	Practical Guidelines for Ship Self-Propulsion CFD	A
N	7.5-03-03-02	G	Practical Guidelines for RANS Calculation of Nominal Wakes	A
N	7.5-03-04-02	G	V&V of RANS Solutions in the Prediction of Manoeuvring Capabilities	A
R	7.5-04-01-01.1	P	Preparation and Conduct of Speed/Power Trials	A
R	7.5-04-01-01.2	P	Analysis of Speed/Power Trial Data	A
N	7.5-04-04-01	P	Underwater Noise from Ships, Full Scale Measurements	A
Legend			A = Accepted D = Deleted PP = Proposing Postponed	

2.3. Support technical committees in their work on Recommended Procedures

MS Word files containing the procedures to be updated, together with the template to be used for drafting new procedures has been sent to the Chairmen of the ITTC Committees.

The Committees were also supplied with the “Guidelines for Preparation of Technical Committee and Working Group Reports”.

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

The present version of the ISO Standards for Quality Management System is the ISO 9001:2008. This version basically re-narrates ISO 9001:2000. The 2008 version only introduced clarifications to the existing requirements of ISO 9001:2000 and some changes intended to improve consistency with ISO 14001:2004. No new requirements were added.

Nevertheless, a new version of the Standard will be published in December 2015 by the ISO, pending favourable vote by the members in March 2015.

The process involves a number of draft releases and interested parties have been invited to comment at various stages of the Standard’s production. The first draft, called the ‘Committee Draft’, of ISO 9001:2015 was published in May 2013 and was available for consultation among members of ISO/TC 176/SC 2 (the ISO committee that is leading the revision process) until August 2013.

The impact of this revision will be similar to, if not greater than the 2000 edition, which was a major change for accreditation bodies, certification bodies, training organizations, implementing organizations, procurement organizations, consultants and customers. The transition period for ISO 9001:2000 was three years and the expectation is that for the 2015 revision it will be the same, so activity is being planned up to 2018.

The general changes can be summarized as follows:

- Adoption of a high-level structure and terminology of Annex SL, a unified guideline used for the development of all new ISO standards (ISO/IEC, 2013).

- New redaction to increase clarity and accessibility, reducing room for interpretation.

- Introduction of two new clauses relating to the context of the organization: understanding the organization and its context and understanding the needs and expectations of interested parties.

- Renders the adoption of a process approach in the implementation of a quality management system more explicit, by including a clause, which specifies the requirements for the adoption of a process approach.

- Replaces the term ‘products’ by ‘goods and services’, in order to remove the existing bias towards organizations dealing with physical products. As a result, the new standard will be applicable for organizations of any kind.

- Does not contain a clause with specific requirements for preventive action. ISO motivates this decision by arguing that prevention is the task of the quality management system in its entirety, as opposed to a specific subsection of it.

However, this updated edition makes reference only to the Quality Management System and the Technical Procedures are not affected. The Technical Procedures are normally based on ITTC Procedures.

QSG feels obliged to submit to the Conference another quality standard that could be appropriate for our experimental activity: the ISO 17025 (ISO 2013), which sets general requirements for the competence of testing and calibration laboratories, being the global quality standard for testing and calibration laboratories. It is the basis for accreditation from an accreditation body, but an accreditation body for towing tanks does not exist. The current release was published in 2005.

Two main clauses are included in ISO/IEC 17025 – Management Requirements and Technical Requirements. Management requirements are related to the operation and effectiveness of the quality management system within the laboratory, and this clause has similar requirements to ISO 9001. Technical requirements address the competence of staff; testing methodology; equipment and quality; and reporting of test and calibration results.

Implementing ISO/IEC 17025 has benefits for laboratories, but the work and costs involved should be considered before proceeding.

2.5. Update the ITTC Symbols and Terminology List.

After the last revision, the List is found to be up-to-date and does not require a major check.

Some minor maintenance has been performed as follows:

- The symbol C_{APP} has been added;
- The symbol L_{PP} has been added to the alphabetical list where it was missing;
- The symbol $c_{0.7}$ has been added as a consequence of the cross check with the ISO Standards;
- The symbol $Re_{0.7}$ has been added.

2.6. Update the ITTC Dictionary of Hydromechanics.

Revised or new entries:

- Rake angle;
- Skew;
- Pod.

Added figures:

- Co-ordinate planes;
- Rake;
- Set back;
- Blade section.

2.7. Cross-check the ITTC Symbols List and the Dictionary with other standards e.g. ISO.

QSG considered the following standards, which were provided by the AC and were not cross checked during the preceding period because of time shortage:

ISO 3715-1:2002; Ships and marine technology – Propulsion plants for ships -- Part 1: Vocabulary for geometry of propellers,

ISO 3715-2:2001; Ships and marine technology -- Propulsion plants for ships -- Part 2: Vocabulary for controllable-pitch propeller plants,

ISO 7255:1985; Shipbuilding -- Active control units of ships – Vocabulary,

ISO 7462:1985; Shipbuilding -- Principal ship dimensions -- Terminology and definitions for computer applications,

ISO 8384:2000; Ships and marine technology -- Dredgers – Vocabulary,

ISO/TR 13298:1998; Ships and marine technology -- Vocabulary of general terms,

ISO 19018:2004; Ships and marine technology -- Terms, abbreviations, graphical symbols and concepts on navigation.

As regards ISO/TR 13298, ISO 19018 and ISO 8384, no modification to the dictionary is required.

The following gives a list of the additions/modifications required by the relevant standard.

ISO 3715-1:

- Leading edge, blade;
- Leading edge, foil section;
- Pitch;
- Pitch angle;
- Pitch, at a certain radius;
- Pitch, blade mean;
- Pitch, propeller mean;
- Propeller reference system, cylindrical;
- Propeller reference system, rectangular;

- Trailing edge, blade;
- Trailing edge, foil section.

ISO 3715-2:

- Propeller;
- Pitch angle, range of;
- Pitch, design propeller;
- Pitch, maximum ahead;
- Pitch, maximum astern;
- Pitch, nominal;
- Blade position;
- Blade position, angle of;
- Propeller Windmilling.

ISO 7462:

- Axis co-ordinate;
- Baseline;
- Section;
- all occurrences of Beam replaced with Breadth;
- Displacement Volume;
- Moulded.

ISO 7255: added 6 new definitions:

- Lateral thruster;
- Retractable lateral thruster;
- Rudder-propeller;
- Swivelling rudder-propeller;
- Retractable Rudder-propeller;
- Active rudder.

The Symbol and Terminology List has been accordingly updated where required.

Some definitions given in the ISO Standards conflict with the relevant ITTC definitions:

- the definition of Body Axes given in ISO 3715-1;
- the definition of Skew given in ISO 3715-1 ;
- the definition of Propeller reference system, cylindrical given in ISO 3715-1;
- the definition of Baseline given in ISO 7462.

For the time being, pending decisions of the AC or the Conference, a statement was added to the questioned definitions warning that 'the definition is not in line with ISO'.

2.8. Revise and update the existing ITTC Recommended Procedures.

The QSG updated the following procedures:

4.2.3-01-03	Work Instruction for formatting ITTC Recommended Procedures and Guidelines
7.5-01-03-01	Uncertainty Analysis, Instrument Calibration
7.5-02-01-01	Guide to the Expression of Uncertainty in Experimental Hydrodynamics

Procedure 4.2.3-01-03 has been updated in order to ameliorate the format of the Recommended Procedures.

Minor corrections have been made to the ITTC version of the GUM, Procedure 7.5-02-02-02 ITTC (2014a). Equations (20) and (21) have been corrected where a factor of 4 was omitted from the coefficient for the shaft rotational rate, u_n, for the thrust and torque coefficients. The explanation on the tolerance for weights has been restated in Section 14.1, and equation (31c) has been corrected. The references to ISO have been replaced with JCGM.

Errors were also discovered in the Instrument Calibration Procedure, 7.5-01-03-01 ITTC (2014b). A sign error has been corrected in equation (19). The tolerance of weights in section 5 has been re-stated, and equation (24) corrected. The reference list has been updated.

Section 7 has been added on Direct Digital Calibration. Frequency signals from shaft rotational rate and carriage speed from a wheel have been processed with frequency to voltage (f-v) convertors. F-v converters are subject to drift. Current data acquisition cards have a counter port and built-in timing so that frequency can be measured directly without the need for an f-v converter.

During the revision process the QSG observed the non-compliance of procedures on sea-trials 7.5-04-01-01.2.1 and 7.5-04-01-01.2.2 with UA concepts and JCGM GUM standards. Furthermore QSG noted some inconsistencies in the use of symbols and the use of symbols not in the SaT List (such as RAW Rwave, rho and rho0).

Since these procedures are somehow connected with IMO and cannot be promptly corrected, Postponing the further updating of these documents to the next ITTC period is recommended.

In the framework of above-mentioned procedures QSG suggests the develop of a new procedure on full-scale torque measurements.

2.9. Review and edit new ITTC Recommended Procedures with regard to formal Quality System requirements

The QSG review process regarded 35 existing and 17 new procedures adding to a total of 52 documents, as illustrated in Table 2.

Table 2: List of the reviewed procedures

Committee	**Procedure No.**	**Procedure title**
Advisory Council / Executive Committee/Secretariat	1.0-01	Description and Rules of the ITTC
	1.0-02	Committee Structure of ITTC
	1.0-04	Decision Making between Conferences
	4.2.3-01-02	Guidelines for Preparation of Technical Committee and Group Reports
Resistance	7.5-02-02-02.1	Example for Uncertainty Analysis of Resistance Tests in Towing Tank
	7.5-02-02-02.2	Practical Guide for Uncertainty Analysis of Resistance Measurement in Routine Tests
	7.5-02-02-02	General Guideline for Uncertainty Analysis in Resistance Tests
Propulsion	7.5-02-03-01.4	1978 ITTC Performance Prediction Method
	7.5-02-03-01.6	Hybrid Contra-Rotating Shaft Pod Propulsors Model Test
	7.5-02-03-02.3	Nominal Wake Measurement by LDV Model Scale Experiments

	7.5-02-03-03.2	Description of Cavitation Appearances
	7.5-02-03-03.3	Cavitation Induced Pressure Fluctuations Model Scale Experiments
	7.5-02-03-03.4	Cavitation-Induced Pressure Fluctuations: Numerical Prediction Methods
Manoeuvring	7.5-02-05-05	Evaluation and Documentation of HSMV
	7.5-02-06-01	Free Running Model Tests
	7.5-02-06-02	Captive Model Test Procedure
	7.5-02-06-03	Validation of Manoeuvring Simulation Models
	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
	7.5-03-04-02	Validation and Verification of RANS Solutions in the Prediction of Manoeuvring Capabilities
Seakeeping	7.5-02-05-04	Seakeeping Tests
	7.5-02-07-02.1	Seakeeping Experiments
	7.5-02-07-02.2	Seakeeping prediction of Power Increase in Irregular Waves from Model Tests
	7.5-02-07-02.3	Experiments on Rarely Occurring Events
Ocean Engineering	7.5-02-07-03.10	Guideline for VIV Testing
	7.5-02-07-03.11	Guideline for VIM Testing
Stability in Waves	7.5-02-07-04.2	Model Tests on Damage Stability in Waves
	7.5-02-07-04.4	Simulation of Capsize Behaviour of Damaged Ships in Irregular Beam Seas
CFD in Ship Hydrodynamics	7.5-03-02-03	Practical Guidelines for Ship CFD Applications
	7.5-03-02-04	Practical Guidelines for Ship Resistance CFD
	7.5-03-03-01	Practical Guidelines for Ship Self-Propulsion CFD
	7.5-03-03-02	Practical Guidelines for RANS Calculation of Nominal Wakes
Detailed Flow Measurements	7.5-01-03-03	Guideline on the Uncertainty Analysis for Particle Image Velocimetry
	7.5-01-03-04	Benchmark for PIV(2C) and

		SPIV(3C) setups
	7.5-02-01-04	Guideline on Best Practices for the Applications of PIV/SPIV in Towing Tanks and Cavitation Tunnels
Performance of Ships in Service	7.5-04-01-01.1	Preparation and Conduct of Speed/Power Trials
	7.5-04-01-01.2	Analysis of Speed/Power Trial Data
Hydrodynamic Noise	7.5-02-01-05	Model scale noise measurements
	7.5-04-04-01	Underwater Noise from Ships, Full Scale Measurements
Testing of Marine Renewable Devices	7.5-02-07-03.7	Wave Energy Converter Model Test Experiments
	7.5-02-07-03.8	Model Tests for Offshore Wind Turbines
	7.5-02-07-03.9	Model Tests for Current Turbines
Ice	7.5-02-04-01	General Guidelines for Ice Model Testing
	7.5-02-04-02	Test Methods for Model Ice Properties
	7.5-02-04-02.1	Resistance Test in Ice
Quality Systems Group	4.2.3-01-03	Work Instruction for formatting ITTC Recommended Procedures and Guidelines
	7.5-01-03-01	Uncertainty Analysis, Instrument Calibration
	7.5-02-01-01	Guide to the Expression of Uncertainty in Experimental Hydrodynamics

The great majority of the procedures required an enormous amount of editing with respect to format. This is probably due to the fact that procedure 4.2.3-01-03 was not sufficiently clear about the use of Styles. The new version of the document will help to obtain documents in line with the ITTC agreed format.

The document 0.0 Register has been updated accordingly.

A template in word format has been prepared to write new procedures in the next ITTC period. To write a new procedure, an author will open the new file with the following template:

ProcTemplate_2017.dotx

The file is included in the CD.

2.10. Follow the implementation of the Benchmark data repository.

The Benchmark Data Repository structure has been decided by the 26th ITTC.

The QSG has tried to locate the benchmark data, in order to supply them to the web-site administrator for publication. The task proved to be extremely difficult since nobody seems to know who actually has the required data.

To this effect, a request was forwarded to the AC through the ITTC Secretary aimed go obtain information about the benchmark data location, but no news has been obtained.

The QSG proposes to the Conference to insert into the ToR of each of the Committees an item regarding the location of the performed benchmark data about relevant topics, and to provide the information to the next QSG.

2.11. Support the technical committees with guidance on development, revision and update of uncertainty analysis procedures.

During the first meeting in Rio de Janeiro the Group decided to support the technical committees by appointing a QSG member to follow their work and provide guidance and assistance if required.

Liaison	Committee
Rojas	Resistance and Propulsion
Woodward	Manoeuvering - Stability in Waves
Sales	Seakeeping - Ocean Engineering
Rijsbergen	CFD - Detailed Flow Measurement and Noise
Benedetti	Perfomance of Ships in Service
Derradij	Marine Renewable Devices – Ice

On December 2011 letters have been sent to all Chairmen asking to appoint a person to liaise with QSG.

Following the invitation letter, a request for support was received from the Manoeuvring Committee. The Manoeuvring Committee (MC) agreed at their first meeting to invite the QSG representative on uncertainty analysis to subsequent meetings. Attending the 2nd meeting of the MC (19-21 Nov 2012 – Nantes, France) the QSG representative presented an overview of the changes needed to come in line with ISO and assisted in a workshop to review/develop one procedure:

- 7.5-02-06-04 – “Force and Moment Uncertainty Analysis, Example for Planar Motion Mechanism Test”, Effective date 2008, Rev. 00.

Attending the 3rd meeting of the MC (5-7 June 2013 – Antwerp, Belgium) the QSG representative assisted with the development of two procedures:

- 7.5-06-05 – “Uncertainty Analysis for Free-running Model Tests”, Effective date 2014, Rev. 00.
- 7.5-02-06-04 – “Uncertainty Analysis for Manoeuvring Prediction based on Captive Manoeuvring Tests”, Effective date 2014, Rev. 01.

Following the 3rd meeting, additional materials were worked on in collaboration to assist with the development of the procedures.

Furthermore, the adoption of uncertainty analysis in hydrodynamic metrology is a necessary and on-going task. However, expertise, in this ever-developing field, cannot reasonably be expected to be present in every technical committee.

The format of maintaining a core group of uncertainty specialists within the QSG, provides a critical mass for the cross-fertilisation of ideas while at the same time providing consistency in the support to the ITTC community.

Maintain a core group of uncertainty specialists within QSG is recommended, which is sufficient in size to achieve succession planning and knowledge transmission.

2.12. Observe ISO standards for uncertainty analysis.

Since the publication of the uncertainty procedures from the 25th ITTC, which were based upon the ISO Guide to the Uncertainty in Measurement, the responsibility of the GUM and the International Vocabulary for Metrology (VIM) has been transferred to the Bureau International des Poids Measures (BIPM) and the Joint Committee for Guides in Metrology (JCGM). The latest information may be found on the BIPM web page:

http://www.bipm.org/en/committees/jc/jcgm/

The GUM has been re-released as JCGM (2008a) and the VIM as JCGM (2008b). A total of seven documents are being developed in support of the GUM. Four have been completed: JCGM (2008c), JCGM (2009), JCGM (2011), and JCGM (2012). Three more are in preparation: JCGM (20xxa, b, c).

JCGM (2009) is an introduction to the GUM. The body of this report is 15 pages and serves as a good introduction to the GUM. The other six supplemental documents apply to more advanced users of uncertainty analysis.

2.13. Maintain Wiki for the 27th ITTC as a trial period and create link to it from the ITTC website.

The link to Wiki Dictionary has been added into the ITTC website and it is operative (www.ittc.info). The Wiki is also accessible directly from:

http://www.ittcwiki.org/doku.php

The ITTC Wiki online tool has been maintained operative as instructed by 26th ITTC. The online version of the Wiki Dictionary has been updated to reflect the changes approved at the 26th ITTC.

The way of operating and updating the Wiki has followed so far the policy to implement changes on line only after the ITTC has approved the Dictionary itself (i.e. updates happen every 3-year period). In the spirit of Wiki as a tool, inter-session updates should be allowed under the disclaimer that the online version is not an adopted version of the ITTC Dictionary. This proposal is included in the recommendations of Section 5.

A report on the analytics of the usage of the website is contained in Annex A to this report.

3. OTHER MATTERS

3.1. Survey of Uncertainty Analysis Procedure Usage

Anecdotal evidence exists in the ITTC community in difficulty in the application of the ITTC uncertainty analysis procedure, ITTC (2014a). For the 28th ITTC, a survey is proposed on the application of ITTC (2014a). From the survey results, a simplified step-by-step procedure will be developed on uncertainty analysis for novices. Perhaps a second workshop on uncertainty analysis should be conducted by the 28th ITTC.

Further, a surveying of the extent and breadth of uptake of uncertainty analysis techniques and procedures by the hydrodynamic testing community is recommended. This should evaluate the extent to which the four key stages of uncertainty analysis are implemented; viz.:

1. Type-B evaluation of zero-order replication level uncertainties including calibration with traceability to a national standard.

2. Type-A evaluations of the above mentioned uncertainty sources instead.

3. Evaluation of random uncertainties assessed by time series analysis, repeat measurements or reproduction measurements.

4. Evaluation of systematic modeling uncertainties due to model size and inter-facility bias.

3.2. New Procedure on Torsionmeters

Development of a new procedure on torsionmeters is proposed for ship trials. Modifications to ships have been proposed for fuel savings such as Cusanelli and Karafiath (2012). The claim is made that 1 % fuel savings from improved ship performance of DDG 51 class ships would result in an annual fuel savings of 100,000 USD per ship. However, if the fuel consumption is known with an uncertainty of 2 %, the 1 % savings is meaningless. No estimate exists on the uncertainty in fuel consumption for the U. S. Navy. This dilemma is what Kline (1985) has called the “hopeless” experiment.

An accurate measure of fuel consumption by the propulsion system may not be possible since fuel consumption may go to other sources. Consequently, the only direct measurement of the ship propulsion performance is the computation of power from the shaft speed and torque. Insel (2008) has described some of the challenges associated with ship powering measurements. Insel (1985) concludes that the uncertainty in ship powering is between 3 and 5 % of full-power. Environmental conditions will increase the uncertainty; consequently, ship trials should be conducted at a low sea state (low waves and wind speed) and low current. With current estimates in powering, the claimed reduction in power is likely smaller than the estimated uncertainty. Again the ship modification and the ship trial would be a “hopeless” experiment.

If a ship trial is performed at favourable environmental conditions, the uncertainty in powering must reduced to as low a value as practical. The primary contributor to the uncertainty in power is from the torque measurement. At present, the best device is a calibrated torsionmeter such as the one in Figure 1.

Torque is measured as the relative rotational displacement of the two rings in the figure. The displacement is measured by strain gages mounted in the connecting bar. The displacement and voltages are measured in a calibration fixture with instruments traceable to a National Metrology Institute (NMI). Data are transmitted by a wireless device.

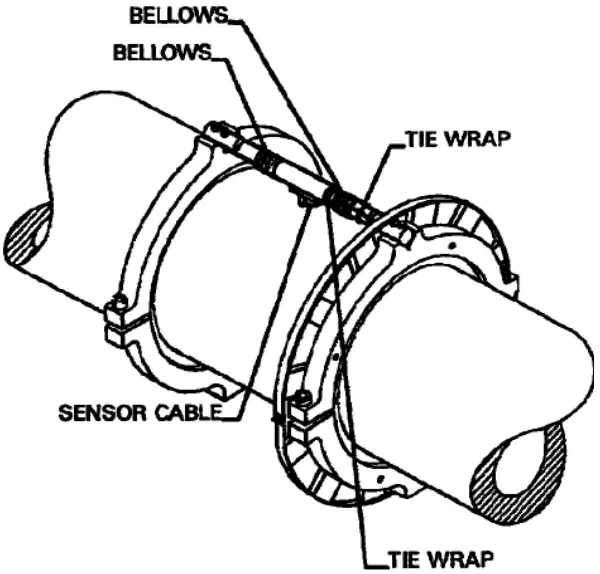

Figure 1. Drawing of torsionmeter installation.

The torque is then computed from the following:

$$Q = \delta GJ/(RL) \qquad (1a)$$

where δ is the measured deflection, G the modulus of rigidity or shear modulus of elasticity, R the radial distance to the sensor, L the length of the span between the two rings, and J is the polar moment of inertia. For a hollow shaft,

$$J = (\pi/32)/(D_o^4 - D_i^4) \qquad (1b)$$

and D_o is the outside diameter of the shaft and D_i the inside diameter.

The only item that cannot be measured directly is the value of G. From ITTC (2002), the expanded relative uncertainty in G is ±2.3 %. From an uncertainty analysis, G is the dominant term. Thus, the uncertainty in torque and power is 2.3 % of the full-scale calibration value. In an example calculation, ITTC (2002) estimated the expanded uncertainty in power from all sources as 2.8 % by comparison with Insel (2008) of 3 to 5 %. A reduction in the uncertainty requires a measured value of G with an uncertainty estimate.

However, an ultrasonic gage can measure the shear-wave velocity, V_s of the shaft material and G computed by the following:

$$G = \rho V_s^2 \qquad (2)$$

where ρ is the density of the material. Although density may not have been measured for a particular shaft, the density probably has a relatively low uncertainty. In principle, density can be computed from the shaft weight and geometry, but such a calculation would require NMI traceable measurements of the weight and shaft dimensions.

The outside diameter, D_o, of the shaft may be measured directly with a micrometer caliper or indirectly from a circumference measurement with a tape, and the inside diameter, D_i, from the wall thickness, t, as follows:

$$D_i = D_o - 2t \qquad (3)$$

or

$$D_i = C/\pi - 2t \qquad (4)$$

where C is the shaft circumference as measured with a tape measure. The wall thickness is measured with an ultrasonic gage. For calibration of the ultrasonic gage, gage blocks should be manufactured from the same-class material as the shaft with documented measurements of

G, the dimensions, density, and their uncertainties.

The uncertainty in torque may be computed from Equations (1) from the law of propagation of uncertainty either by analytical methods or central finite differencing from JGCG (2008a) and ITTC (2014a). The result for the relative standard uncertainty is

$$\frac{u_Q}{Q}=\sqrt{\left(\frac{u_\delta}{\delta}\right)^2+\left(\frac{u_G}{G}\right)^2+\left(\frac{u_J}{J}\right)^2+\left(\frac{u_R}{R}\right)^2+\left(\frac{u_L}{L}\right)^2} \tag{3}$$

The uncertainty in the polar moment of inertia for the shaft is

$$u_J=(\pi/8)\sqrt{(u_{D\mathrm{o}}D_\mathrm{o}^3)^2+(u_{D\mathrm{i}}D_\mathrm{i}^3)^2} \tag{4}$$

If the outside diameter is measured by a micrometer, the uncertainty of the inside diameter is

$$u_{D\mathrm{i}}=\sqrt{u_{D\mathrm{o}}^2+4u_t^2} \tag{5}$$

If the outside diameter is computed from a measurement of the circumference, the uncertainty in the inside diameter is

$$u_{D\mathrm{i}}=\sqrt{(u_C/\pi)^2+4u_t^2} \tag{6}$$

The standard uncertainty in G from the shear wave velocity measurement from Equation (2) is

$$u_G=\sqrt{(2\rho V_s u_{Vs})^2+V_s^4u_\rho^2} \tag{7}$$

For conventional steel, the values for the shear modulus of elasticity are as follows:

- G = 8.0 x 10^6 Pa
- ρ = 7800 kg/m^3
- V_s = 3200 m/s

The estimated uncertainties for the various elements are listed in Table 3. A complete estimate requires the dimensions of the torsionmeter. As a preliminary estimate, the uncertainty G is computed from Equation (7), where the uncertainties in the shear wave velocity and density are assumed as 1 % and 2 %, respectively. The uncertainties in G from the two elements are respectively, ±120 x 10^6 and ±164 x 10^6 Pa. The combined expanded uncertainty in G is then ±200 x 10^6 Pa or ±0.25 %. An accurate assessment of density uncertainty is then necessary. If G is the dominant term in the uncertainty estimate, the uncertainty in torque and power is approximately ±0.25 %. With the inclusion of the other terms, ±0.50 % expanded uncertainty in power appears to be reasonable.

Table 3. Uncertainty estimates for elements of torque calculation.

Symbol	Units	Value
C	mm	1.0
D_i	mm	0.025
D_o	mm	0.025
L	mm	0.10
R	mm	0.10
t	mm	0.025
V_s	m/s	2.4
ρ	kg/m^3	16

For a better assessment of the uncertainty the following procedures should be followed:

- Calibration of the displacement sensor per the ITTC calibration procedure, ITTC (2014b).

- Calibration of the ultrasonic device for the shear velocity and thickness with gage blocks.
- Multiple measurements of the shaft outside diameter, wall thickness and shear wave velocity. Measurements are recommended at eight (8) equal increments or 45° increments around the shaft both forward and aft of the torsionmeter for a total of 16 measurements. If the outside diameter is computed from the circumference, the circumference should be measured forward and aft of the torsionmeter.
- Measurements of *R* and *L* should be provided by the manufacturer with uncertainty estimates.
- Measurement of shaft speed by direct digital methods per ITTC (2014b).

4. CONCLUSIONS

The revision of the ITTC Quality Manual concerned 54 documents. Two existing procedures were deleted, 17 new procedures/Guidelines have been added, 35 existing procedures have been reviewed or updated, of which 3 have been postponed.

The cross checking of the Dictionary and the Symbols and Terminology List with ISO standards has been completed and produced a number of new entries in the ITTC documents. A decision is still required by the Conference about the discrepancy in the definition of Skew between ISO and the ITTC definitions.

The Dictionary and the Symbol and Terminology List have been updated and some mistakes have been rectified.

The development of three new documents is proposed to the Conference for the next ITTC period:

- a new procedure on full scale torque measurements,
- a guideline with number 7.5-02-01-02 and working title: “Guideline to Practical Implementation of Uncertainty Analysis”
- a procedure on the determination of a type A uncertainty estimate of a mean value from signal analysis

5. RECOMMENDATIONS TO THE CONFERENCE

The QSG recommends to the Full Conference to:

adopt the revised procedure 4.2.3-01-03 Work Instruction for formatting ITTC Recommended Procedures and Guidelines;

adopt the revised procedure 7.5-01-03-01 Uncertainty Analysis, Instrument Calibration;

adopt the revised procedure 7.5-02-01-01 Guide to the Expression of Uncertainty in Experimental Hydrodynamics;adopt the revised Symbols and Terminology List;

adopt the name of “ITTC Dictionary of Hydromechanics” in place of “Dictionary of Ship Hydrodynamics”;

adopt the revised ITTC Dictionary of Hydromechanics Version 2014;

enhance the liaison with ISO with a view to reconcile the differences in definitions between ISO standards and ITTC definitions as laid down in the abovementioned procedures

allow the Wiki tool to implement updates to the Dictionary also between conferences.

6. RECOMMENDATIONS FOR FUTURE WORK

The following future work is recommended:

support the Technical Committees in their work on Recommended Procedures. Supply the chairmen of the new committees at the beginning of the period with the MS Word versions of the relevant procedures and the template for the production of new procedures,

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,

observe the development or revision of ISO Standards regarding Quality Control,

update the ITTC Symbols and Terminology List,

update the ITTC Dictionary of Hydromechanics,

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

before 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,

follow the implementation of the Benchmark data repository,

support the Technical Committees with guidance on development, revision and update of uncertainty analysis procedures,

observe ISO standards for uncertainty analysis, in particular the uncertainty analysis terminology,

review developments in metrology theory and uncertainty analysis and issue appropriate Procedures,

continue to maintain the online Wiki tool keeping it up to date and in line with the adopted documents of the ITTC,

include a new section of the Dictionary dedicated to Offshore Engineering, as preparation for an extension of ITTC procedures to this fast developing field,

include into the Dictionary a section dealing with planing craft and a section on pods,

include into the Dictionary a section on pods,

develop a guideline with number 7.5-02-01-02 and working title: “Guideline to Practical Implementation of Uncertainty Analysis”. This guideline should assist committee members (primarily beginners but also experienced in the field of UA) in making an adequate uncertainty analysis in both pre-test and post-test situations. It should provide an overview of all the steps to be taken in an uncertainty analysis and refers to existing procedures such as 7.5-02-01-01 on basic techniques and 7.5-01-03-01 on calibration,

develop a procedure on the determination of a type A uncertainty estimate of a mean value from signal analysis, based on Brouwer et al. (2013). This analysis provides an uncertainty estimate in cases where instead of multiple repeat or reproduction measurements, only a single time series is available,

surveying the extent and breadth of uptake of uncertainty analysis techniques and procedures by the hydrodynamic testing community,

develop a new procedure on torsionmeters for ship trials.

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JCGM, 20xxc, Evaluation of measurement data — Applications of the least-squares method, JCGM 20xx:107, Joint Committee for Guides in Metrology, Bureau International des Poids Mesures (BIPM), Sèvres, France, in preparation.

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8. ANNEX A – REPORT ON THE ACTIVITY ON THE WIKI WEBSITE.

As agreed at 26th ITTC in 2011, QSG maintained and further developed the ITTC Wiki page dedicated to the Dictionary of Hydromechanics at the following web address:

http://www.ittcwiki.org/doku.php/start

hosted at CNR-INSEAN, Roma, Italy.

ITTC Wiki Home page

The structure of the ITTC Wiki dictionary is:

General
Vessel Geometry and Stability
Resistance
Propeller (including propeller geometry)
Cavitation
Seakeeping
Manoeuvrability
Performance (in the context of speed and power)
Alphabetic dictionary

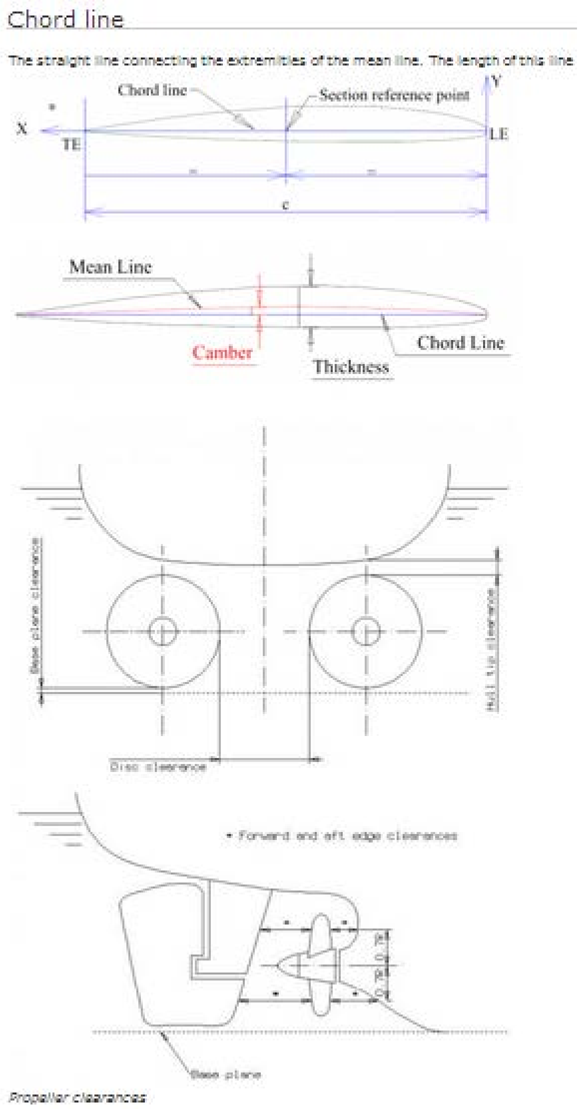
and fully reflects the structure of the ITTC Dictionary as agreed at 26th ITTC contained in the pdf version.

As for the pdf version it is also possible to browse the Alphabetic version.

Table A1 lists some of the modifications implemented on the online tool after the 26th ITTC to match the changes approved by the Conference.

As can be seen looking at the table, quite relevant effort has been dedicated to figures and schemes to be included in the web pages. This is an area that still needs attention and further work in order to achieve a uniform acceptable level in terms of quality of the images, drawings, table, sketches that are present in the Dictionary. Several schemes have been redrawn from scratch.

An example is shown below:



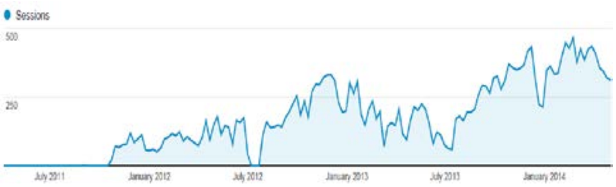
If the proposal of the QSG on the Dictionary is accepted by the 27th ITTC, the web pages will be aligned again with the new proposed structure. Then, the occasional further improvement can be implemented.

A link to the ITTC Wiki pages has been added on the ITTC web site to increase the visibility.

An analysis of the visitors and their behaviour when visiting the ITTC Wiki has been carried out and in the following most relevant data collected between September 2011 (26th ITTC) and April 2014 are showed below.

SESSIONS	***27.141***
USERS	***20.269***
PAGE VIEWS	***64.129***
BOUNCE RATE	***61.85%***

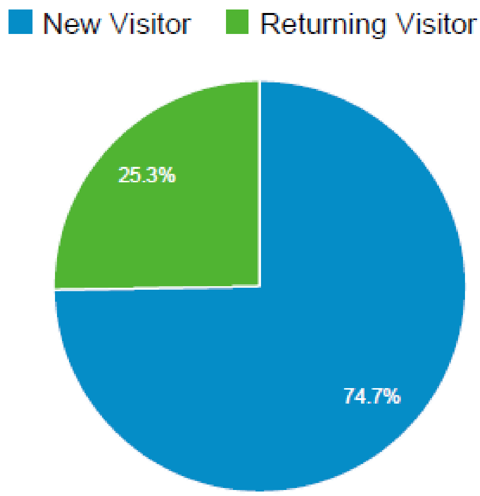
More than *27.000 Sessions* and more than **20.000 users** have been registered.



Trend of the Sessions between 26th ITTC and April 2014

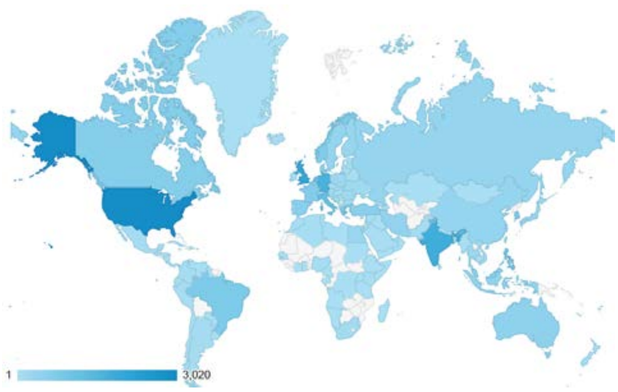
Trend of the users Analytics between 26th ITTC and April 2014

The Trends above show slow constant increase of the number of visitors.

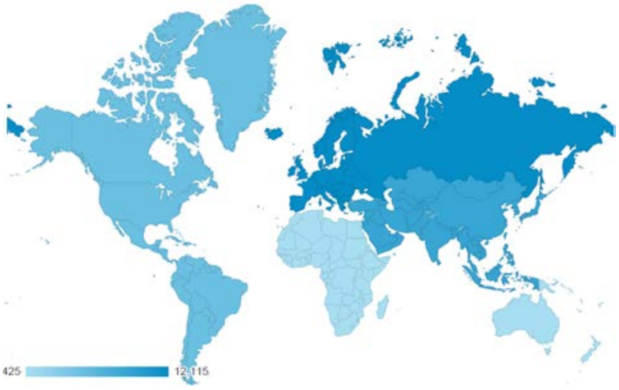


New Visitors vs. Returning Visitors

Looking into how visits are geographically distributed is also interesting.



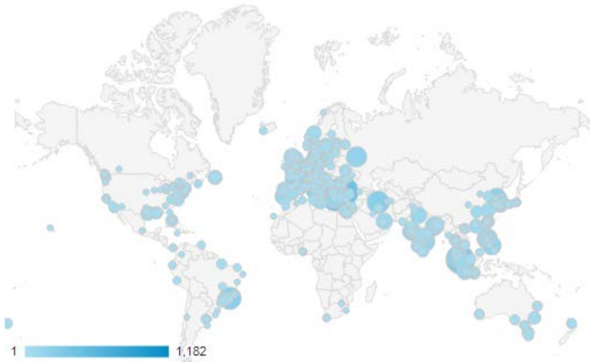
Visits by Country



Visits by Continent

Continent	Sessions	Sessions
	27,141 % of Total: 100.00% (27,141)	27,141 % of Total: 100.00% (27,141)
1. Europe	12,115	44.64%
2. Asia	8,536	31.45%
3. Americas	4,903	18.06%
4. Africa	600	2.21%
5. Oceania	562	2.07%
6. (not set)	425	1.57%

Visits by Continent – figures



Visits by Citiy

Country / Territory	Sessions	Sessions
	27,141 % of Total: 100.00% (27,141)	27,141 % of Total: 100.00% (27,141)
1. United States	3,020	11.13%
2. United Kingdom	2,027	7.47%
3. India	1,779	6.55%
4. Germany	1,665	6.13%
5. Italy	1,137	4.19%
6. Philippines	992	3.65%
7. Netherlands	968	3.57%
8. South Korea	817	3.01%
9. Singapore	778	2.87%
10. Brazil	764	2.81%

Visits:First 10 Countries

As can be seen by the previous analysis Europe has registered more than 12.000 visitors followed by Asia and the Americas. This result is not coming as a surprise given the large number of ITTC members in Europe and Asia. For the Americas the two countries that have shown significant interest are US and Brazil.

Singapore with more than 700 visits is ranked 9th. This suggests that not only researchers and technicians belonging to ITTC members' organization have been visiting the ITTC Wiki pages but also other type of professionals with a maritime interest. A big part of those are (with an educated guess) students and maritime universities in general. This fact is an extremely positive signal that should not be underestimated given the constant shortage of qualified human capital experienced by several ITTC organizations.

For improved visibility, further dissemination actions could be imagined such as ITTC members to add a link to the ITTC Wiki to the web pages of their organizations.

Table A1: Modifications approved by the 26th ITTC Conference implemented on the Wiki tool

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2014/02/26 18:42 structured_dictionary:shipgeometry – [Beam] ubuwiki
2014/02/26 18:35 structured_dictionary:general – [Axes co-ordinate] ubuwiki
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2014/01/10 10:05 manoeuvrability:manoeuvrability7_1_ok.png – created ubuwiki
2014/01/10 10:00 structured_dictionary:performance – [Admiralty coefficient] ubuwiki
2014/01/10 09:54 start – [ITTC Dictionary] ubuwiki
2013/10/09 15:18 document – [reference] ubuwiki
2013/10/09 15:05 structured_symbols_list2011.pdf – created ubuwiki
2013/10/09 15:05 ittc_alphabet_dictionary_2011.pdf – created ubuwiki
2013/10/09 15:05 ittc_structured_dictionary_2011.pdf – created ubuwiki
2013/10/09 15:05 alphabetic_ittc_symbols_list2011.pdf – created ubuwiki
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