



REPORT OF THE SYMBOLS AND TERMINOLOGY GROUP

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I GENERAL

1.1 MEMBERSHIP AND MEETINGS

Following the publication of the draft list of the ITTC Standard symbols at the 18th ITTC at Kobe in October 1987 the Symbols and Terminology Group of the 19th ITTC has continued its work towards completing the List, in cooperation with other standards organisations and the other ITTC Technical Committees.

During meetings at

- 1 Genova, March 1988
- 2 The Hague and Berlin, September 1988
- 3 Trondheim, September 1989
- 4 Genova, March 1990

the Group has completed the 1990 review of the ITTC Standard Symbols. However, during this work the Group has realised that the automatic handling of standard symbols, in data bases and in validation work, has resulted in more rigorous requirements than hitherto envisaged. These requirements have been outlined as guiding principles and rules in the Preface to the List. Consequently the goal of finalising the List for the 19th ITTC Conference has not been reached.

The membership of the Symbols and Terminology Group was as follows:

Professor Bruce Johnson (Chairman)
Dr. David Clarke
Dr. Norihiro Matsumoto
Professor Carlo Podenzana-Bonvino
(Secretary)
Professor Michael Schmiechen.

1.2 RECOMMENDATIONS OF THE 18TH ITTC

Recommendations to the Conference:

- The Conference should adopt the structure of the ITTC Standard Symbols and Terminology List outlined by the Symbols and Terminology Group and used as the basis for the 1987 Draft List distributed at the 18th ITTC in Kobe.
- The Conference should urge the Technical Committees and individuals to contribute to the completion of the List of Standard Symbols and should encourage the use of the symbols and their further development in cooperation with the Symbols and Terminology Group.
- The Conference should decide to delay the review and update of the ITTC Dictionary of Ship Hydrodynamics and the official translations of this into principal languages until the final Symbols and Terminology List is published in 1990.

Recommendations for the Future Work of the Group

- The Symbols and Terminology Group should continue cooperation with other organisations to achieve a common agreement on symbols and terminology.

- The Symbols and Terminology Group should continue to monitor and coordinate the development of new symbols and terminology by the Technical Committees of the ITTC.
- The Symbols and Terminology Group should complete the ITTC Standard

Symbols and Terminology List based on the 1987 Draft distributed at the 18th ITTC, following a detailed schedule, in time for the 19th ITTC Conference.

II REVIEW ON SYMBOLS AND TERMINOLOGY OF IMPORTANCE TO THE ITTC

2.1 INTRODUCTION

The Symbols and Terminology Group was formed in October 1985 and produced the 1987 Draft Standard Symbols and Terminology List which was published by the Society of Naval Architects of Japan and distributed at the 18th ITTC in Kobe. Membership in the Symbols and Terminology Group remained the same for the 19th ITTC.

Further input has been received from the Propulsor Committee concerning the orientation of the coordinate system, where the preferred point of view is with respect to the moving fluid and not the propeller. As has been stated in the List of Symbols, concerning coordinate systems, it is not possible to reconcile these different view points, except to state clearly in each case which system of coordinates is being used.

2.2 WORK ACCOMPLISHED BETWEEN THE 18TH AND 19TH ITTC CONFERENCES

2.2.2 Further Developments

2.2.1 Work Accomplished

In the period of the 19th ITTC the Symbols and Terminology Group has continued to incorporate extensive modifications and additions to the Preface and Chapter 1 on General Mechanics in the List of Standard Symbols and Terminology. In particular, changes and clarifications suggested by the Manoeuvrability Committee and S.S. Yuan of MARIC Shanghai have been taken into account.

The concept of an operational notation was pursued and has led to a complete revision of Section 1.1.3 : Time Related Concepts, as shown in the Appendix. The philosophy underlying the development is explained in detail in the Preface of the List of Symbols. This notation has proved to be very efficient in practical applications. For space related concepts a corresponding notation has been developed by one of the Group and tested in a complicated underwater robot problem.

The Group continued to seek suggestions from the other Technical Committees for the development and clarification of the List.

As long as the Symbols for 1.1 : Fundamental Concepts are still under scrutiny, it is felt that it is

premature to finalize the work concerned with the following Sections, 1.4.1 : Waves, 2.3.2 : Seakeeping and 2.3.1 : Manoeuvring.

Work has begun on the new Sections, 3.7 : Catamarans, 3.8 : Sailing Vessels, 3.9 : Submarines and Submersibles, which were not included in the 1987 Draft List.

2.2.3 New Requirements

During the work of the Group it became evident that the computer compatible symbols need to be more than simply identifiers which have been pragmatically agreed upon, but need to be systematically generated.

This is particularly important since it is proposed to use these symbols in a neutral format for exchange between data bases (see Section 2.3). The operational notation proposed will serve this purpose as well (see Appendix).

A major problem in this respect will be to avoid duplicate symbols, which may still be found in the List. It is crucially important that the symbols are unique.

2.2.4 Publications

The first draft of the revised List of Symbols was produced using a manuscript program, which has been found to be too clumsy by today's standards. Very powerful text processor programs are now available on any PC.

Consequently the Symbol and Terminology Group decided to have the whole

document translated onto a widely available text processor system. The list of Standard Symbols may then be distributed to the ITTC Membership, not only on paper but on diskettes. This could be done not only during the development stage but with the finished document, to be used as dictionary in word processors.

Another advantage of using an up to date text processor system will be the ability to include explanatory material which is currently difficult to accommodate within the old system (see Appendix).

2.2.5 Future Work

The main task for the Symbols and Terminology Group of the 20th ITTC will be:

- to continue rationalizing the symbols for the Fundamental Concepts and revise subsequent chapters accordingly,
- to put the computer symbols on the same rational basis in order to make them useful for data exchange purposes,
- to continue stimulating and monitoring inputs from the Technical Committees.

2.3 FUTURE WORK CONCERNING STANDARD FORMATS FOR THE EXCHANGE OF DATA

2.3.1 Introduction

Responding to the needs expressed by various groups, the Symbols and Terminology Group has begun to address

the problem of data exchange between data bases of Member Organisations and their clients, via neutral formats.

Neutral standard formats for the exchange of information and data have been a great concern for all branches of industry for several years. Consequently, ISO Standards have been drafted concerning Electronic Data Interchange (EDI) and Office Document Architecture (ODA). The latter is being implemented under the Open Systems Interconnection (OSI) Standard, which is presently undergoing its second pilot phase (PODA 2), the neutral interface being the Office Interchange Format (ODIF).

Another branch of development is concerned with the neutral interchange of graphic information, with various national developments leading to the International Standards Organisation STEP Standard under which specific industries will have to implement their applications.

2.3.2 Development of Standard Format

In order to facilitate the exchange of information contained in hull form data bases used by ITTC member organizations and their clients, the Symbols and Terminology Group should undertake the following:

To develop a standard neutral format for the efficient exchange of data defined in the ITTC Standard Symbols and Terminology List.

- To utilize the ISO STEP (Standard for Exchange of Product model data) specification as the basis for a standard neutral format for the efficient exchange of data concerned with the definition of hull form, propeller and appendage geometry.

2.3.3 Benefits to ITTC Member Organisations

The benefits to ITTC member organizations in developing ITTC standard formats for the "neutral" exchange of hull form data include:

- The efficient exchange of hull form design data between systems based on different hardware and software, and between various member organizations and clients.
- A more efficient method of performing cooperative projects, including comparative model tests, comparative computational fluid dynamic code tests and validation studies.

2.3.4 Consequences for the Community

The consequences for the ship model tank community include:

- Those organizations which have not yet developed adequate computer databases can use the ITTC standard formats as a guide in developing their hull geometry, hydrostatic characteristics, and hydrodynamic performance databases.

- Those organizations which already have hull form design databases need only to develop a single software package containing input and output translation processors for converting data to the ITTC neutral standard format for data exchange purposes (Figure 1).
- Data exchanges which depend on neutral standards developed within the ITTC community have a higher probability of acceptance and universal use by the ship model tank community than data exchanges that depend on proprietary software.
- The development of ITTC standard formats for the exchange of hull form design and attribute data will require interactions with outside organizations. In this respect, interaction with the parallel development of IGES/PDES/ISO STEP standards and new database technologies may prove fruitful.

2.3.5 Work Plan

Phase 1: Develop the standard format for exchange of data, based on input from ITTC member organizations concerning their existing database structures. Develop the additions to the ITTC Computer Compatible Symbols List required to define the quantities required for standard neutral formats.

Phase 2: Demonstrate the efficient exchange of data concerning

geometry, hydrostatic characteristics and resistance and propulsion data.

Phase 3: Develop a proposed standard format for the efficient exchange of data concerned with the definition of hullform, propeller and appendage geometry. This will involve working with various other standardization organizations.

Phase 4: Develop a proposed standard format for the efficient exchange of time series and other data, concerning wind and wave data, seakeeping, manoeuvring, cavitation, unsteady propeller forces and other dynamic phenomena.

Phase 5: Publish the ITTC Standard Neutral Formats for the Exchange of Data.

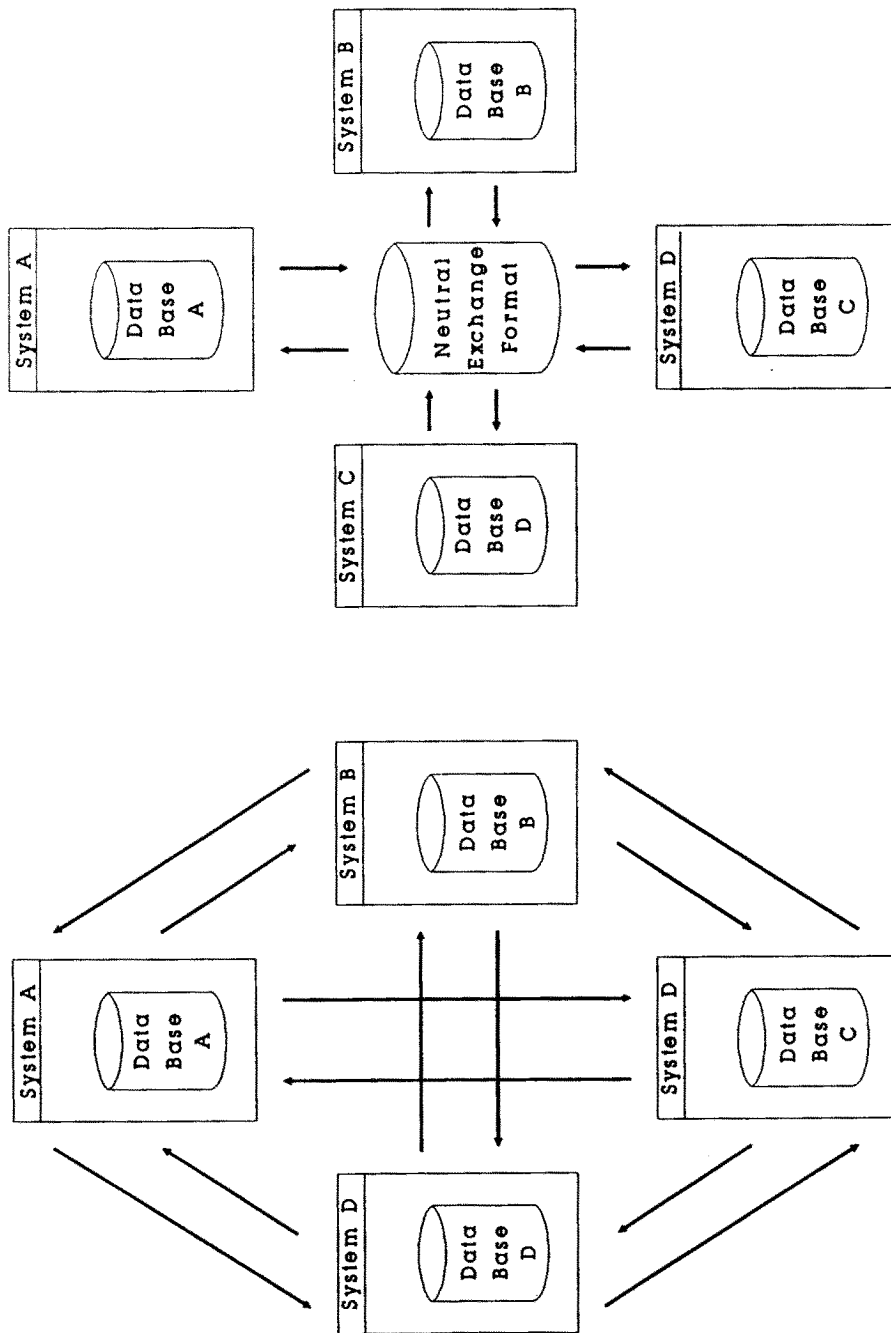
2.4 REFERENCES

International Towing Tank Conference, Standard Symbols 1971, BSRA Technical Memorandum No.400, August 1971.

International Towing Tank Conference, Standard Symbols 1976, BSRA Technical Memorandum No.500, 1976.

ITTC Dictionary of Ship Hydrodynamics. RINA Maritime Technology Monograph No.6, 1978.

Translation of Overall Index of Titles of Dictionary of Ship Hydrodynamics. Vol.1 publ. by CETENA, Genova, 1984.



Translation Processors = $2N$

Translation Processors = $N(N-1)$

FIGURE 1

Bibliography and Proposed Symbols on Hydrodynamic Technology as Related to Model Tests of High Speed Marine Vehicles. Prep. by 17th ITTC High-Speed Marine Vehicle Committee, SSPA Maritime Research and Consulting, Report No.101, 1984.

Schmitt, R.A.M., "State of the Art of Interfaces for the Exchange of Product Model Data in Industrial Applications" Report N 96.4, Institut für Rechneranwendung in Planung und Konstruktion, Karlsruhe, December 1989.

Wilson, Peter R., "A Short History of CAD Data Transfer Standards", IEEE Computer Graphics and Applications, Vol.7, pp64-67, June 1987.

Carson, George S., "The Future of ISO Graphics Standards", IEEE Computer Graphics and Applications, Vol.8, pp82-83, July 1988.

III CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS OF THE GROUP

3.1.1 Symbols

In the light of the present developments the Symbols and Terminology Group envisages major revisions in the 1990 version of the List of Standard Symbols especially concerning the computer compatible symbols.

3.1.2 Formats

The Symbols and Terminology Group feels that standards for the efficient exchange of data are necessary and it is the opportune time to develop them.

3.2 DRAFT RECOMMENDATIONS TO THE CONFERENCE

3.2.1 Symbols

The 1990 version of the List of Standard Symbols should be used as a working document without the formal approval of the Conference.

3.2.2 Formats

The Conference should discuss the need for the introduction of standard formats for the exchange of data.

3.3 DRAFT RECOMMENDATIONS FOR THE FUTURE WORK OF THE GROUP

3.3.1 Symbols

The Symbols and Terminology Group to put the computer compatible symbols on a more rational basis in order to make them useful for data exchange purposes.

3.3.2 Formats

The Symbols and Terminology Group to develop standard formats for the exchange of data defined in the List of Standard Symbols and hull form, propeller and appendage data on the basis of international standards.

APPENDIX 1

Draft February 1990

ITTC Standard Symbols

1 General Mechanics

1.1 Fundamental Concepts

1.1.3 Time related Concepts/1

Standard Symbol	Computer Symbol	Name of symbol	Definition or Explanation	SI-Unit
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Variables for basic quantities:

a	A	damping	s^x , in Laplace variable	1/s
δ		impulse function		
f	FR	frequency		Hz
f_C	FC	basic frequencies in repeating functions	$1/T_C$	Hz
f_S	FS	frequencies of sampling	$1/T_S$, periods in repeating spectra	Hz
i		imaginary unit	$\text{sqrt}(-1)$	1
j	J	integer values	$-\infty \dots +\infty$	1
r	R	complex variable	$\exp(sT_S)$, in Laurent transform	1
s	S	complex variable	$a + 2\pi f$, in Laplace transform	1/s
t	T	time	$-\infty \dots +\infty$	s
t_j	T(J)	sample time instances	jT_S	
T_C	TC	periods of cycles	$1/f_C$, duration of cycles in periodic, repeating processes	s
T_S	TS	periods of sampling	duration between samples	s
x	X	variables for values of real quantities	$X(t)$	
X		real "valued" functions		
x_j	X(J)	variables for sampled values of real quantities	$X(t_j) = \int X(t) \delta(t-t_j) dt$	
x^D		sampled functions	$\sum x_j \delta(t-jT_S)$	

APPENDIX 1

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ITTC Standard Symbols

1 General Mechanics

1.1 Fundamental Concepts

1.1.3 Time related Concepts/2

Standard Symbol	Computer Symbol	Name of symbol	Definition or Explanation	SI-Unit
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Operators for complex transforms of (real) functions:

x^A	X^A	of analytic functions	$X^A(t) = X(t) + i X^H(t)$
x^{DF}	X^{DF}	of Fourier transforms of sampled functions	$X^{DF}(f) = \sum x_j \exp(-i2\pi f j T_S)$ <p>i.e. periodic, repeating:</p> $= X(0)/2 + f_S \sum X^F(f + j f_S)$ <p>sample theorem: aliasing!</p>
x^{DL}	X^{DL}	of Laurent transforms of sampled functions	$X^{DL}(s) = \sum x_j \exp(-s j T_S)$
x^F	X^F	of Fourier transforms	$X^F(f) = \int X(t) \exp(-i2\pi f t) dt$ <p>inverse transform:</p> $= \int X^F(f) \exp(-i2\pi f t) dt$ <p>If $X(t) = 0$ and $a = 0$ then $X^F(f) = X^L(f)$</p>
x^F_j	$X^F(J)$	of Fourier transforms of periodic functions	$1/T_C \int_0^{T_C} X(t) \exp(-i2\pi j t / T_C) dt$ $X^F(f) = \sum x^F_j \delta(f - j / T_C)$ <p>inverse transform:</p> $X(t) = \sum x^F_j \exp(-i2\pi f j T_C)$
x^H	X^H	of Hilbert transforms	$X^H(t) = 1/\pi \int X(\tau) / (t - \tau) d\tau$
x^{HF}	X^{HF}	of Fourier transforms of Hilbert transforms	$X^{HF}(f) = X^F(f) (-i \operatorname{sgn} f)$ $(1/t)^F = -i \operatorname{sgn} f$

APPENDIX 1

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ITTC Standard Symbols

1 General Mechanics

1.1 Fundamental Concepts

1.1.3 Time related Concepts/3

Standard Symbol	Computer Symbol	Name of symbol	Definition or Explanation	SI-Unit
x^L	X^L	of Laplace transforms	$X^L(s) = \int_0^\infty X(t) \exp(-st) dt$ if $X(t < 0) = 0$ then $= (X(t) \exp(-at))^F$	
x^R	X^R	of Laurent transforms	$X^R(r) = \sum_0 x_j r^{-j} = X^{DL}$	
x^S	X^S	of single-sided complex spectra	$X^S(f) = X^F(f) (1 + \text{sgn } f)$ $= X^{AF}$, i.e. = 0 for $f < 0$	
x^S_j	$X^S(J)$	of single-sided complex Fourier series	$x^F_j (1 + \text{sgn } j)$ (line spectra)	

Operators for components of complex quantities:

z	Z	variable for complex quantities	$z^r + i z^i = z^a \exp(i z^p)$
z^a	ZA	amplitudes	$\text{mod}(z) = \text{sqrt}(z^{r2} + z^{i2})$
z^c	ZC	cosine components	$z^a \cos(z^p) = z^r$
z^i	ZI	imaginary components	$\text{imag}(z) = z^s$
z^j	ZJ	conjugates	$z^r - i z^i$
z^l	ZL	(phase) lags	$-z^p$
z^p	ZP	phases	$\text{arc}(z) = \text{arctg}(z^i/z^r)$
z^r	ZR	real components	$\text{real}(z) = z^c$
z^s	ZS	sine components	$z^a \sin(z^p) = z^i$

e.g.

q^{Sa}_j $Q^{SA}(J)$ amplitudes of single-sided of complex Fourier series of the periodic "signal" $q=Q(t)$

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ITTC Standard Symbols

1 General Mechanics

1.1 Fundamental Concepts

1.1.3 Time related Concepts/4

Remarks

Fourier transforms and spectra

The notation proposed has proved to be adequate for "real" problems at hand, these notes giving some useful background information in the most concise form.

The complex "values" may be quantities of any "complexity", e.g. tensors, matrices, and tensors of matrices as e.g. encountered in 6-D parameter identification.

The uniform use of the "natural" frequency instead of artificial circular frequency has the advantage that no factors are occurring in the Fourier transform pair.

Group properties

The Fourier and Hilbert transforms are the unit elements of cyclic groups with the following properties:

$$X(t)^F = X^F(f), X^F(f)^F = X(-t), X(-t)^F = X^F(-f), X^F(-f)^F = X(t)$$

$$X(t)^H = X^H(t), X^H(t)^H = -X(t), -X(t)^H = -X^H(t), -X^H(t)^H = X(t)$$

Consequently among others the following fundamental relations hold:

$$F^4 = 1 \text{ and } H^4 = 1.$$

Fourier series

Due to the fact that in most cases only real functions and single-sided spectra are used the usual format of the Fourier series is

$$X(t) = \text{real} (\sum x^S_j \exp(i2\pi jt/T_C))$$

$$= \sum_0 x^{SC}_j \cos(2\pi jt/T_C) + \sum_0 x^{SS}_j \sin(2\pi jt/T_C)$$

The reason for this step is that the spectra are in fact Fourier transforms not of the real function being studied but of the corresponding analytic function.

For ready reference the following formulae are given

$$x^S_j = x^F_j (1 + \text{sgn } j),$$

$$x^{FC} = 1/T_C \int_0^{T_C} X(t) \cos(2\pi jt/T_C) dt,$$

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ITTC Standard Symbols

1 General Mechanics

1.1 Fundamental Concepts

1.1.3 Time related Concepts/5

Remarks

$$x^{FS} = 1/T_C \int_0^{T_C} X(t) \sin(2\pi jt/T_C) dt.$$

Causal functions

Causal functions, defined by

$$X(t < 0) = 0,$$

are conveniently expressed as

$$X(t) = X^e(t) (1 + \text{sgn } t)$$

with the even function

$$X^e(t) = (X(t) + X(-t))/2.$$

Noting the property

$$x^{eF} = x^{Fr}$$

the Fourier transform

$$x^F = x^{eF} - i x^{eFH}$$

leads to the relations

$$x^{Fi} = -x^{FrH}, \text{ i.e. } x^{FiF}(t) = -x^{FrF}(t) (-i \text{sgn } t)$$

and, taking advantage of the group properties,

$$x^{Fr} = +x^{FiH}, \text{ i.e. } x^{FrF}(t) = +x^{FiF}(t) (-i \text{sgn } t).$$

These relationships are known under various names and guises, the derivations sometimes obscured by irrelevant or misleading arguments, the worst being hydrodynamic.

Minimal phase functions

From the format

$$x^F = x^{Fa} \exp(ix^{Fp})$$

the logarithm

$$\ln(x^F) = \ln(x^{Fa}) + i x^{Fp}$$

is derived and it can be proved that the relations

APPENDIX 1

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ITTC Standard Symbols

1 General Mechanics

1.1 Fundamental Concepts

1.1.3 Time related Concepts/6

Remarks

$$x^{FP} = -(\ln(x^{Fa}))^H, \text{ i.e. } x^{FPF}(t) = -(\ln(x^{Fa}))^F(t) (-i \operatorname{sgn} t)$$

and

$$\ln(x^{Fa}) = +x^{FPH}, \text{ i.e. } (\ln(x^{Fa}))^F(t) = +x^{FPF}(t) (-i \operatorname{sgn} t)$$

hold for phase minimal functions; s.e.g. Papoulis, A.: The Fourier integral and its applications. New York: McGraw-Hill, 1964.

Spectral estimates

While for periodic functions the estimation of Fourier transforms, spectra, etc can be efficiently performed by fast Fourier algorithms (FFA) the same is not true in general. Due to necessary truncation FFT will in general produce results with systematic errors. These are a consequence of the implied periodic repetition, which in most cases is simply inadequate.

In these cases only autoregressive model techniques lead to unbiased estimates of the transforms. The reason is that these models provide proper harmonic descriptions of the truncated records; s.e.g. Childers, D.G.: Modern spectrum analysis. New York: IEEE Press, 1978.

In any case the algorithm used has to be clearly identified, possibly by reference to a full description or, ideally and unambiguously, a subroutine. At this stage it appears premature to try and introduce standard symbols for various standard procedures.

So far standard procedures not been agreed upon by the ITTC community, but in the near future it will be necessary to do so in order to arrive at comparable results. Agreement should not be reached by "vote", as has been tried by Ocean Engineering Committee. The standard adopted by the hydrographic institutes (for the estimation of power spectra) is in general quite disputable as well.

A proposal dealing with the problem of noisy data has been published in 1984 and further developed; s. Schmiechen, M.: FTP: Fourier transform proper. Optimum estimates of Laplace and Fourier transforms of transient functions from finite sets of sampled noisy data. A proposed standard procedure. Berlin: Unpublished, 1988.