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CIRCULAR LETTER 27/2002
8 August 2002

GUIDELINES FOR THE PROCESSING OF HIGH VOLUME BATHYMETRIC DATA

References: a) CL 1/2001
b) CL 45/2001

Dear Sir,

You will recall that the Bureau distributed the refined final draft of the "Guidelines for the Processing of High Volume Bathymetric Data" under cover of CL 45/2001; the refined draft took into account Member States' comments in response to CL 1/2001.

Member States were invited to send their comments on this refined draft to the Bureau. The Bureau is grateful to the 14 Member States who responded. A summary of the comments provided by some Member States is provided in Annex A to this Circular Letter.

The Bureau would like to propose that the issue of the Guidelines be considered as closed for the time being. It should be re-considered in conjunction with the development of a new edition of IHO Publication S-44. The Working Group should then review the Guidelines and make proposals on the integration with S-44 and whether the Guidelines are to be considered part of the S-44 Standard.

On behalf of the Directing Committee
Yours sincerely,

Rear Admiral Giuseppe ANGRISANO
President

Annex A – Summary of Comments
Annex B – Refined Draft Guidelines (July 2002 version)

Summary of Comments made by Member States
(in response to CL 45/2001)

Brazil
Agrees with the text of the refined draft.

Chile
Has no further comments.

Colombia
Considers the Guidelines very useful.

Denmark
Supports the refined final draft. No further comments.

France
In the last sentence of the last paragraph of the Introduction "principle" should be replaced by "principal".

IHB: Correct.

Proposes to add "heave" to the list in parenthesis in 3.2.3.

IHB: Done.

Some text should be added to paragraph 2.4 saying that data decimation is permitted provided that it is not done arbitrarily and after having eliminated outliers.

IHB: The Guidelines aim at specifying minimum requirements.

Points out that there area some translation errors in the French version of CL 45/2001.

IHB: Sorry.

Some comments provided by SHOM in response to CL1/2001 do not appear in Annex A of CL 45/2001. It had been proposed to add to paragraph 3.3 that the algorithms should be easy to understand and manage by operators.

IHB: Correct; generally we try to summarize the comments and to avoid a lengthy reproduction. Again, minimum requirements.

The IHB did not draw any conclusions with regard to the comments made by Sweden on the integration of S-44 and the Guidelines.

IHB: See cover page of this CL.

Greece
Agrees with the Guidelines.

India
Concurs with the refined draft and agrees to annex the Guidelines to S-44.

New Zealand
Has no further comments.

Norway
Is happy with the text of the refined final draft. No further comments.

Portugal
Although reiterating its previous comments related to paragraph 3.3 (removal of 2nd paragraph to avoid promoting of robust estimation techniques), Portugal agrees with the content of the refined final draft.

Russian Federation
Supports the initiative and agrees with proposals and comments in CL 45/2001.

Sweden
Supports the refined final draft. Finds that it is a useful document as it stands.

Turkey
Considers the Guidelines useful and sufficient in general. Proposes to add to paragraph 2.2 “Doubtful data should be checked using data from other sensors (i.e. single beam echosounders)”.

IHB: Cross checklines, which are usually surveyed with single beam sounders, are mentioned in this paragraph. Furthermore these Guidelines deal with processing and not collection of data.

UK
No further comments. Considers that the refined final draft should be approved as the final draft.

Refined Final Draft (July 2002)
GUIDELINES FOR THE PROCESSING OF HIGH VOLUME BATHYMETRIC DATA

N.B.: Modifications are indicated in italics and additionally by strikethrough for deletions.

1. Introduction

With the advent of multibeam echosounders (MBES) and laser airborne systems, hydrographers and oceanographers are nowadays confronted with the task of processing high data volumes collected during surveys. The main advantages of MBES and laser airborne systems are increased bottom coverage and potentially wider spacing of track lines, due to the greater swath, when compared to single beam echosounder (SBES) surveys which may result in a reduction of time required for a survey.

However, processing procedures used prior to the introduction of MBES and laser airborne systems are inefficient, in terms of both manpower and time required to process the high volume of data gathered by these systems. Therefore, new processing procedures are needed to allow the reduction, processing and production of the final data set within acceptable manpower and time constraints while maintaining data integrity.

As hydrographic offices continue to be responsible (liable) for their products, these processing procedures should be well documented and fulfil, at least, certain requirements. The following processing guidelines concentrate on principles and describe **minimum requirements**; they do not specify details as, for example, computer hardware, operating system, use of screen colours etc. *The ~~principle~~ principal purpose of these guidelines is to provide guidance to hydrographic offices and not to set standards.*

2. General Principles

2.1 Conservation of Data

It is strongly recommended that the original survey data (raw data *from the different sensors*) be conserved adequately before commencing with the processing of data. The final processed data set should also be conserved.

2.2 Statistics

Statistical algorithms employed for detecting erroneous and/or doubtful data should be adequately tested to prove their suitability.

For the control of positions, a Kalman filter or comparable mechanism is deemed adequate. *Compliance with the criteria specified in IHO Publication S-44 (4th edition) has to be ascertained.*

The minimum control of depths should consist of defining areas where the number of, and distance between, depths allow the calculation of meaningful statistics to ensure compliance with the standards specified in IHO Publication S-44 (4th edition). Furthermore, cross checklines have to be used for the quality control of depths.

In addition to statistics, threshold values for survey data can be used to facilitate the detection of blunders.

2.3 Treatment of Doubtful Data

Data considered erroneous and/or doubtful, either by the statistical algorithms employed or by an operator, shall be flagged (marked) accordingly and shall not be deleted. To classify errors in accordance with their magnitude, use of error classes is recommended.

2.4 Data Reduction

The rules and mechanisms employed for data reduction have to be documented. When reducing the data density, the selection of shoal biased depths must be possible.

3. Processing Stages

The processing of high volume bathymetric data can be divided into the following stages:

- Data Preparation
- Data Processing
- Automatic (Non-interactive) quality control
- Manual (Interactive) quality control

3.1 Data Preparation

Data preparation files contain either fixed values, e.g. system calibration factors and sensor offsets, or variable values such as sound velocity profiles and tide values for the reduction of soundings. Data files are either prepared by direct operator interaction or automatically. The data in these files are needed for processing raw survey data.

All of these files should be subject to automatic or manual plausibility checks to avoid contamination of the survey data during processing. If, for example, the athwartship offset between the positioning antenna and the transducer is incorrect, a systematic error will be introduced in the positions of all depths.

Files prepared manually by direct operator interaction should be subject to an independent check by a second operator.

3.2 Data Processing

The processing steps outlined below are only to be interpreted as an indication, also with regard to their sequence, and are not necessarily exhaustive. Adaptations may be required due to the configuration of the survey as well as the processing system actually used. In general, processing should strive to use all available sources of information to confirm the presence of navigationally significant soundings.

3.2.1 Position

This step should comprise merging of positioning data from different sensors (if necessary), qualifying positioning data, and eliminating position jumps. Doubtful data should be flagged and not be deleted.

3.2.2 Depth corrections

Corrections should be applied for water level changes, measurements of attitude sensors, and changes of the draught of the survey vessel (e. g. squat changing with speed; change over time caused by fuel consumption). *It should be possible to re-process data for which corrections were applied in real-time.*

3.2.3 Attitude corrections

Attitude data (heading, heave, pitch, roll) should be qualified and data jumps be eliminated. Doubtful data should be flagged and not be deleted.

3.2.4 Sound velocity

Corrections due to refraction should be calculated and applied during this step. If these corrections have already been applied in real-time during the survey, it should be possible to override them by using another sound velocity profile.

3.2.5 Merging positions and depths

For this operation the time offset (latency) and the geometric offset between sensors have to be taken into consideration.

3.2.6 Analysis of Returning Acoustic signal

When a representation of the time series of the returning acoustic signal is available, the processing methods should attempt to use this information to qualify soundings.

3.3 Automatic (Non-interactive) Quality Control

During this stage, the coordinates (i.e. positions and depths) obtained should be controlled automatically by a programme using suitable statistical algorithms which have been documented, tested and demonstrated to produce repeatable and accurate results.

Selecting an algorithm, robust estimation techniques should be taken into consideration as their adequacy has been confirmed by extensive and independent research conducted by –inter alia- China[1], France[2], *Denmark*, Germany, and *the NATO*[3]. Employing automated object detection tools using angle-independent time-sampled backscatter from the acoustic signal might be considered as well as a check on automated processing algorithms.

All blunders and erroneous and doubtful data should be flagged for subsequent operator control. The type of flag used should indicate that it was set during the automatic stage.

3.4 Manual (Interactive) Quality Control

For this stage the use of 3-D visualisation tools is strongly recommended. These tools should allow viewing the data using a zoom facility. The interactive processing system should also offer different display modes for visualisation, e.g. depth plot, error plot, single profile, single beam, backscatter imagery etc. and should allow for the visualisation of the survey data in conjunction with other useful information as e.g. shoreline, wrecks, aids to navigation etc.; editing of data should be possible in all modes and include an audit trail. If feasible, data displays should be geo-referenced.

If feasible, these tools should include the reconciliation of normalised backscatter imagery with bathymetry and, provided that automated object detection tools were used, display of flagged data for both data modes should be possible.

The rules to be observed by operators during this stage should be documented.

The flags set during the automatic stage, *which correspond to depths shallower than the surrounding area*, should require explicit operator action, *at least, for Special Order and Order 1 surveys (cf. S-44, Table 1)*. If the operator overrules flags set during the automatic stage, this should be documented. If a flag is set by the operator, the type of flag used should indicate this.

~~*It may be possible to exclude areas where depths are not relevant for the safety of navigation (cf. IHO Publication S-44, Table 1).*~~

4. Metadata

Metadata should be associated with each processed dataset. Chapter 5 of S-44 contains recommendations on the scope of metadata.

5. Validation Procedures

The final data should be subject to independent in-house validation employing documented quality control procedures.

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[1] Huang Motao et al. "Robust Method for the Detection of Abnormal Data in Hydrography" in International Hydrographic Review, Monaco, LXXVI(2), September 1999, pp. 93-102

[2] N. Debese, H. Bisquay "Automatic Detection of Punctual Errors in Multibeam Data Using a Robust Estimator" in International Hydrographic Review, Monaco, LXXVI(1), March 1999, pp. 49-63

[3] *G. Canepa, O. Bergen "An approach to robust map generation from multibeam bathymetric data" in SACLANTCEN Report Nr. SR-285*