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11 January 2001

GUIDELINES FOR THE PROCESSING OF HIGH VOLUME BATHYMETRIC DATA

Dear Sir,

With the advent of multibeam and laser airborne systems, hydrographers are nowadays frequently confronted with the task of processing high data volumes requiring, particularly in an era of declining budgets in many countries, new procedures which allow these data volumes to be handled within acceptable (reasonable) manpower and time constraints while maintaining data integrity. These procedures should conform to internationally accepted principles and fulfil minimum requirements.

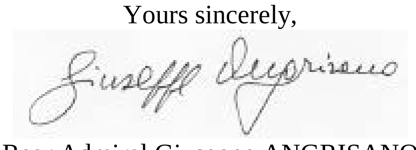
Therefore, in 1999 the Bureau started to draft the "Guidelines for the Processing of High Volume Bathymetric Data" which aim at providing some guidance for the introduction and operation of processing systems for high volume data. Observing these Guidelines – once they have been adopted – might also offer some protection in liability cases, as hydrographic offices continue to be responsible for their products.

The initial draft was edited and refined using the know-how of the members of the IHO Working Group on S-44. All work was done by correspondence.

Attached you will find a copy of the final draft of the Guidelines for your perusal. You are kindly requested to send your comments to the Bureau by **15 March 2001**. Please note that the Guidelines only deal with data processing for a specific case, whereas IHO Publication S-44 covers the data acquisition aspect and general processing rules.

The Bureau intends to further refine this draft taking into consideration any comments received and then will re-circulate the document. Furthermore, it is intended to incorporate the final version of the Guidelines, in the form of an annex, into a future edition of IHO Publication S-44.

On behalf of the Directing Committee
Yours sincerely,



Rear Admiral Giuseppe ANGRISANO
President

Annex A – Draft Guidelines

Final draft (November 2000)

GUIDELINES FOR THE PROCESSING OF HIGH VOLUME BATHYMETRIC DATA

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.

2. General Principles

2.1 Conservation of Data

It is strongly recommended that the original survey data (raw data) 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.

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).

3.2.3 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.

3.2.4 Merging positions and depths

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

3.2.5 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] and Germany. 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.

All flags set during the automatic stage should require explicit operator action. 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. Validation Procedures

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

[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