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SELECTION CRITERIA FOR SHIPBOARD AUTOMATED SYSTEMS

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INTRODUCTION

When a surveyor selects an instrument he will almost invariably pay great attention to the manufacturer's statement of the instrument's accuracy; in many cases he can also get independent verification from papers published by other users. It is difficult however for the purchaser of an automated hydrographic survey system to use accuracy as a criterion, since with but few exceptions the manufacturers of such systems are not prepared to say what standards the products of their system will meet. Nor are there many independent evaluations which a prospective purchaser can refer to; the published literature tends to describe the time which has been saved, or the increase in output, rather than the accuracy which has been attained, possibly because accuracy is sometimes difficult and time consuming to determine under field conditions.

It would be ill advised to draw the conclusion from this lack of information that accuracy is not important. As will be seen, the users of some automated systems may find that their system has introduced a systematic error of from 50 to 140 feet (15 to 42 metres) in their positions – not a value which can be overlooked in any but the smallest scale surveys.

This paper is an attempt to remedy the situation by suggesting a standard set of questions which the purchaser should ask – and to which he should require written answers. It is arguable whether the system supplier can be expected to supply details of all the algorithms which are used, since to do so might cause him to lose a legitimate advantage over a less knowledgeable competitor,

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but it is surely incontrovertible that he should be required to be specific on the amount of data which is read by the computer, the rate at which positions are computed, or the method adopted to allow for the curvature of the earth's surface.

It is felt that a Questionnaire of the type described – if it were to gain wide acceptance and use – would be of value both to potential users and to the manufacturers. If the manufacturer knows that he is going to be asked the same questions by all prospective customers, it is worth his while to produce a standard set of answers; the user, when he is comparing these sets of answers, knows that he is comparing apples with apples, and that he has all the data he needs to make an informed decision. It is not suggested that these are the only questions that can or should be asked – many users will have unusual requirements that will require elaboration – but work is saved on all sides if the non-standard areas only need be addressed in a proposal.

If these non-standard areas are to be properly addressed, however, it is incumbent upon the user to describe his application in detail – in particular the range of scales to be used, the vessel types and sizes, the maximum speed required, the normal working hours, the need for compatibility of output tapes, and any special problems which exist.

The maintenance question is a particularly important one and it is difficult for the system supplier to make worthwhile recommendations without knowing where the system is to be used, the skill level of the purchaser's technical staff (distinguishing between computer technicians, electronic technicians, and others), and the desired tradeoff between downtime and spares holdings.

A QUESTIONNAIRE ON AUTOMATED HYDROGRAPHIC SURVEY SYSTEMS

PART A – GENERAL

A.1 Give a brief description of the system.

A.2 What are the intended applications ?

A.3 What is the minimum size of vessel on which it has been, or could be, used ?

A.4 Are soundings drawn online or offline ?

A.5 What are the limits of speed and scale at which the system can be used ?

A.6 What types of positioning inputs can be accepted ?
- (a) standard
- (b) at additional cost.

A.7 What types of depth sounders can be used ?
- (a) standard
- (b) at additional cost.

A.8 Could data from other sensors, e.g. water quality sensors, be recorded
  (a) simultaneously with depths ?
  (b) alternatively to depths ?

A.9 What is the maximum distance allowed between the input sensors and the computer ?

A.10 What are the components of the system, listing dimensions and weights ?

A.11 What are the personnel requirements, specifying both number and skill level ?

A.12 What outputs are provided by the system ?
  (a) displays
  (b) hard copy
  (c) computer compatible media (state specifications and limitations)
  (d) other.

A.13 What is the recommended method of maintenance ?

A.14 What is the language of operation and maintenance ?

A.15 Could another language be provided if the purchaser supplied a translation of the dialogue ?

A.16 What warranty is provided ?

A.17 What is the cost ?

PART B – HARDWARE

B.1 What type of computer is used ?

B.2 a. How much memory is supplied ?
  b. How much memory can the computer accept ?
  c. What is the maximum required for any program ?

B.3 What are the standard peripherals ?

B.4 What other peripherals are available ?

B.5 What voltage and frequency is required and how much may they fluctuate ?

B.6 What is the power consumption ?

B.7 What is the acceptable range of temperature and humidity
  (a) while operating ?
  (b) in storage ?

B.8 Is protection against shock and vibration
  (a) provided ?
  (b) necessary ?

PART C – SOFTWARE

General

C.1 What programming language is used ?

C.2 What Operating System is used ?

C.3 What provision is made for the user to modify the programs ?

C.4 What high level languages are available for user programming
(a) without additional hardware ?
(b) with additional hardware ?
In each case specify the number of decimal digits of accuracy provided.

C.5 Describe briefly the standard programs and their interaction.

PART D – POSITION PROCESSING

D.1 How many position inputs can be processed simultaneously ?

D.2 Describe any smoothing or filtering that is applied or can be applied to the raw data.

D.3 When data is smoothed is the raw data recorded ?

D.4 How often is position converted to xy ?

D.5 Describe the procedure for correlating positions and other data, and for correcting any time delays between measurement and acceptance by the computer.

D.6 Do position computations use spheroidal, spherical or plane geometry ?

D.7 If plane geometry is used, explain in detail the method of correcting for the curvature of the earth's surface.

D.8 What projections are acceptable ?

D.9 What distance limitation is imposed by the position conversion algorithm ?

D.10 What is the method of providing steering guidance ?

D.11 Is any indication given to the helmsman of distance along track ?

D.12 What assistance is provided in maintaining whole lane count of 2 MHz positioning systems ?

D.13 Can errors in the positioning inputs or in the position data be corrected
(a) online ?
(b) offline ?

PART E – DEPTH PROCESSING

E.1 If 600 depths per minute are available from the sounder how many are processed or recorded ?
(a) maximum
(b) average
(c) minimum.

E.2 Is depth selection performed online or offline ?

E.3 Describe the method used for rejecting false echoes.

E.4 Describe the method used to select soundings.

E.5 How are tidal corrections applied ?

E.6 What provision is made for correcting depth sounder errors ?

E.7 Is there any provision to correct for the vertical motion of the vessel ?

PART F – CHART PREPARATION

F.1 What are the limits on chart size ?
F.2 What are the limits of chart scale ?
F.3 What are the limits of chart orientation ?
F.4 What is the method of graduation ?
F.5 What annotation is provided ?
F.6 Can points or lines be pre-plotted by their co-ordinates ?
F.7 Can the radio position values of the points and/or lines drawn in F.6 be calculated by the system ?
F.8 What means is provided to correct for distortion of the plotter paper ?
F.9 What size figures are used to plot soundings ?
F.10 How are decimal values shown, e.g. metres and decimetres ?
F.11 What is the location of a sounding shown by a group of digits ?
F.12 What sounding orientation choices are available ?
F.13 When soundings are obtained over banks that dry at low water, how are these shown ?

PART G – QUANTITY CALCULATION

G.1 Are quantities calculated online or offline ?
G.2 Describe the method of entering the channel template.
G.3 What range of scales is available for cross sections
(a) horizontal
(b) vertical ?
G.4 If 600 depths per minute are measured by the sounder, how many are used
(a) to draw the profile ?
(b) to calculate cross-sectional areas ?
G.5 Describe how variations in course while running the cross section are corrected.
G.6 Describe how the cross-sectional areas are calculated.
G.7 If allowed overdredge is required, is this obtained in one pass or two ?

PART H – ACCURACY

H.1 Describe the means provided to relate the final chart to the raw data, so that soundings may be checked.
H.2 What is the accuracy of computing an xy position ?
H.3 What accuracy of depth selection is warranted by the manufacturer with respect to
(a) frequency of bad soundings ?

(b) standard deviation of the remaining soundings ?

For the purpose of this question, the standard of comparison is the analog record of the sounder in use at the time, and a bad sounding is defined as one more than 5 decimetres different from the seabed echo on that record.

H.4 If the manufacturer will not warrant the accuracy, what statement is he prepared to make ? Is this statement based on theoretical considerations or actual field trials ? In the latter case quote a published reference or the name and address of the organization that conducted the trials.

H.5 What is the accuracy of computing cross-sectional areas, assuming the positioning system and depth sounder to be without error ?

PART I — ADDITIONAL FEATURES

I.1 Describe the procedure to be followed to delete, amend or insert soundings on the output tapes.

I.2 Describe any features which will help to detect or prevent operator error.

I.3 Describe any features which provide greater convenience for the operator.

I.4 Describe any facility for checking correct hardware operation.

I.5 Describe any other features of the system not covered above.

WHAT TO LOOK FOR IN THE ANSWERS

Most of the questions, and their answers, should be self evident, but it is felt that it might be of value to discuss some of them in detail, and to indicate the answers that should be looked for.

B.1 What type of computer is used ?

The answer to this question should not be given too much weight in itself. One computer may have greater precision or greater speed than another, but to the person who is buying a system — as opposed to building one — it is the use made of these features by the software that is important, and this should be revealed by the later questions.

On the other hand if the service organization for a particular computer is non-existent in the country of use, or has a bad reputation, the answer to this question becomes very signifiant.

B.2 Memory requirements

The point to watch here is whether the memory requirement of any program is approaching the computer's maximum capacity. If it does, then the capability for future expansion is severely limited.

C.3 Can the user modify the programs ?

This is a capability most users would like to have, but, as far as is known, no manufacturer currently provides it. The question is included to remind the manufacturers that it is a desirable feature to provide.

C.4 What high level languages are provided ?

Most users feel that if they have an expensive computer they should be able to use it for other survey computations. The answer does not normally lie in the system supplier's hands, since he can only offer what the computer manufacturer provides, and if this feature is important it is probably best discussed with the local office of the latter organization. One problem here is that different dialects of the same language may differ widely in their capabilities; for example, single user BASIC as supplied by the Digital Equipment Corporation is unusable for any serious survey computation – principally because it only offers 6 significant decimal digits – whereas BASIC as implemented by Hewlett Packard is a very powerful language, closely comparable to FORTRAN.

D.2 What smoothing or filtering can be applied to the raw data ?

There is no question that a computer can improve the quality of data by reducing random errors and by discarding invalid readings – for example erratic microwave ranges caused by reflections. Unfortunately, however, smoothing improperly used can magnify errors – and in the extreme can even manufacture apparently valid position readings, long after the system has been turned off.

D.5 How are positions and data correlated ?

The measurement of positions, depth and other data proceeds asynchronously and they must be correctly correlated by time. However it must be the time of measurement, not the time at which the data arrives in the computer, which necessitates in some cases applying a time correction to the time tag. This concern for fractions of a second may seem unnecessarily pernickety to someone brought up in the days when the time was recorded to the nearest minute and correlation was achieved by the cry of 'Fix', but automation invites the use of high speeds on large scales. The Portland District of the U.S. Army Corps of Engineers, for example, customarily surveys the Columbia River at speeds of up to 16 knots, working at a scale of 1:5 000 and they have recently taken delivery of an air cushion vessel which will allow them to work at 22-23 knots. Even at 20 knots the vessel travels 33 feet in a second, or almost the extent of one sounding on that scale, so it can be seen that the fractions of a second become important.

D.6 & D.7 The type of geometry and method of correcting for the curvature of the earth's surface

Radio positioning systems can measure ranges upwards of 250 nautical miles and there are two theoretically sound methods of converting positions – the geodetic formulae which compute on the spheroid, in terms of latitude and longitude, and the use of plane trigonometry on the survey grid, which requires that the spheroidal position values first be multiplied by the appropriate scale factor to give the corresponding grid distances. Within the accuracy limitations and relatively short range of a line of sight system, a single scale factor value for an area might well be sufficient, but at longer ranges it is essential that Simpson's Rule be used to determine the mean scale factor along each section of signal path.

The plane calculation requires fewer significant digits than the geodetic one, each calculation is completed appreciably more quickly, and the output is ready to plot, whereas latitude and longitude must still be converted to x-y. On the other hand, there is a limit on the length of line that can be accurately calculated and it may not be possible to use the method on certain Loran-C chains, for example.

There are automated systems on the market which use plane geometry without applying a scale correction, and these should be used with considerable care. The designer is, in effect, assuming that the earth is flat – which is a valid assumption within the constraints of a line of sight system, provided that it is recognized that the output is in terms of a purely local grid. These systems however are often used to survey dredged channels, and dredged channels are normally defined on the local Plane Co-ordinate System; if the unwary user were to enter his station positions in, say, UTM co-ordinates, ranges of 15 miles would be 36 feet in error when he was at the centre of the grid zone, and the resulting position would have an error of 50 feet (15 metres) if the position lines cut at 90°, increasing to 139 feet (42 metres) when the cut is down to 30°.

E.1 How many depth measurements reach the computer ?

The accuracy of depth selection is primarily determined by the success of the computer in distinguishing the seabed echo from the false echoes caused by fish, seaweed, airbubbles and floating garbage. This success is determined not by the size of the computer but by the quantity of data available to the computer. In other words, a small mini-computer on board the ship can select depths more accurately than the biggest computer ashore, if the shore computer is only provided with a percentage of the data while the ship computer receives it all.

The question is worded in the way it is because some systems can read 10 soundings per second – but only for some seconds. Hardware constraints may prevent soundings from being read while data is being recorded or fixes are printed, for example.

E.7 Correction for heave

Heave, or the vertical motion of the vessel during sounding, is an error that can only be fully eliminated by an effective heave sensor. However it has been shown that computer processing can effectively reduce the effects, provided that every measured depth is available to the computer.

F.8 Distortion of plotter paper

The errors caused by the shrinkage and expansion of his medium have bedevilled the surveyor from the time he worked on the stretched skin of a sheep until the invention of modern plastics. The plastic materials, however, are expensive and are normally restricted to the final chart, so the surveyor who needs to plot each day's work on a paper working chart must have a means of correcting the daily variation in the dimensions of the sheet.

It is not always appreciated that paper distortion affects a mechanical plotter more than it does a draughtsman, since the draughtsman can achieve a local fit in the area where he is working while a plotter plots relative to the origin of the chart – which may be over a metre away.

H.1 Provision for checking

The surveyor must be able to defend his work – in court if need be. This requires that he be able to confirm both the depth and position of any suspect sounding against the raw data, and it is for the system designer to ensure that he has the means of doing so.

H.2 The accuracy of computing position

If the manufacturer is not prepared to explain in detail the algorithms used, the user has the right to expect both a clear statement of the accuracy to be expected and an opportunity to put the statement to the test – for example, with test data.

H.3 & H.4 The accuracy of depth selection

This being both the primary task of the computer and the most difficult for the computer to accomplish, the user is entitled to know how well the manufacturer has succeeded. Unlike the preceding question, shortcomings in this respect cannot be overlooked on the grounds that the system is only to be used for small scale surveys, in fact, almost the reverse, since the percentage of bad soundings to good ones will tend to be higher on smaller scales. This may sound paradoxical, but false soundings are almost invariably shoal ones and the sounding selection procedure will inevitably favour the shoal soundings. Certainly the labour of investigating and disproving the shoal soundings will be as great on a small scale survey as on a large scale.

1.1 The ability to edit

An automated survey will almost inevitably yield a number of redundant soundings where cross lines have been run or where blocks of sounding lines overlap. These redundancies give a valuable check on overall accuracy, but, after checking, they need to be deleted from the data tape before the final chart is drawn. In addition there may well be some missing soundings – caused by a faulty section of tape, perhaps – or some erroneous ones. It is very desirable that there should be an easy means of accomplishing these corrections.

1.2 Detection and prevention of operator error

Operators, being human, make errors. Some – such as the entry of incorrect co-ordinates – cannot be detected by the computer; others, however – such as the selection of a chart which is not in memory, or the entry of the letter O in the place of zero – often can be, if the computer is programmed to do so.

Tracing errors of the first category is facilitated if all data is printed out as it is entered.

CONCLUSION

Computer systems, like people, are never perfect; like people, they have their strengths and their weaknesses, so that a system that is ideal in one application might be inappropriate in another. This paper will have served its purpose if it helps the user to gather the information he needs to make the proper choice – it will have doubly served its purpose if it inspires manufacturers to remove some of the weaknesses that currently exist.