

## **AUTOMATION IN HYDROGRAPHIC SURVEY THE HYDRAUT SOLUTION**

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### **SUMMARY**

General aspects are treated, to aid in the decision making process for the introduction of automation in hydrography. Partial automation of only one or several of the tasks of data logging, computing, plotting, survey preparation and navigation may be preferable.

Design of an optimal system requires close cooperation by experts in automation and hydrography. Flexibility is of extreme importance so that a basic — and relatively cheap — system can be gradually extended to grow with an organisation's need for more sophistication.

The article concludes with the example of a configuration of the Hydraul system, designed by Applied Dynamics Europe and in use by the Dutch Hydrographic Service.

### **1. INTRODUCTION**

Automation has penetrated into all fields of human activity and hydrography is no exception. One particular aspect this article emphasizes is that two entirely different disciplines should cooperate very closely when designing an automated hydrographic navigation, data acquisition and processing system. They are :

— Hydrography. Much practical knowledge and a thorough analysis of the entire hydrographic process are required.

— Automation. Extensive experience in designing user-friendly systems is a prerequisite. More often than not this experience will be for completely different and even non-nautical applications.

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The input of an automation expert with an unprejudiced look at the survey process is considered an essential factor in the design of an optimal system.

## 2. WHY AUTOMATION ?

Before looking at the hydrographic application, it is useful to list some of the most commonly used arguments for automation.

- Personnel can be relieved of routine work.
- Jobs can be done by personnel with lower qualification.
- Fewer personnel are required.
- Processes can be speeded up.
- Complex processes that cannot possibly be monitored by humans can be effected under computer control.
- Critical situations — either concerning safety or quality — can be easily detected and highlighted.
- Human errors, especially those caused by tiring from continuous vigilance, can be reduced.
- All pertinent data and conditions can be recorded and logged in a standard manner.

In general, these points fall in two categories : namely, increase in cost effectiveness, and better process control. For the general public, the cost effectiveness gets most of the attention. This was initially also the case in hydrography but, with the increase in complexity for specialized application, the last four of the list are gaining in importance. It is very reassuring for the hydrographic officer that he can devote his full attention to such matters as considering traffic avoidance manœuvres, whilst survey recording and quality control goes on automatically. And if the system signals a critical situation in the quality of the survey data, he can give his undivided attention to it, without the need to stop the survey immediately.

Examples of the benefits of automation in civil life are easy to find. Many industrial manufacturing processes are unimaginable without computer control and the safety at busy railway junctions and level crossings depends also largely upon it. Automation experts have reached a high degree of perfection in the presentation of control options and alarms to the users and it would be unwise not to apply such expertise to hydrographic systems. Neglecting this would fit the well known expression of "re-inventing the wheel".

## 3. BLACK BOX APPROACH

The question of how much a user should know about the working of an automated system is often a controversial subject. The fact that part of the routine hydrographic data acquisition work is often delegated to personnel of lower qualifications shortly after such a system is introduced implies that for operational

practice this knowledge is not really essential. It is soon being accepted as another aid to navigation (and survey) of which the capabilities and limitations should be known, but the details of which are not of interest as long as it does the job it was bought for. Compare this with an inertial navigator, which could be considered as the ultimate in "black boxes". There are probably very few Boeing 747 pilots who know the intricacies of the soft- and hardware of this tool that aids them in navigating across the oceans.

Automation will never DO the work, but it will enable the surveyor in charge to DO IT BETTER. The quality of the end result will continue to be fully dependent on the expertise of the staff on the job.

Reluctance to accept automation is understandable and often the result of unpleasant experiences when working with insufficiently tested systems. Success can only be achieved after a considerable acceptance test period under fully operational conditions. Even after final installation, a long period of feedback from the user to the designer is needed to iron out problems occurring under exceptional conditions. But eventually a fail-safe status should be reached. Then, the hydrographic officer need know no more about the software than will satisfy his own curiosity. And he should display considerable self restraint not to "improve" it, because experience has shown that most program bugs are introduced by such improvements !

#### 4. HISTORY OF AUTOMATION IN HYDROGRAPHY

In the past, automation has crept little by little into hydrographic survey practice. It has been more a matter of incidental needs, and possibilities becoming available, than a coordinated approach.

For a better understanding of the subject, an overview is given of how this gradual change took place.

The largest contributing factor was no doubt the introduction, at the end of the 1950's, of radio positioning systems. It became clear that survey did not have to stop for hydrographic officers having a meal or otherwise needing a break from the tiring job of constantly reading sextant angles. If somebody was given the task of writing down the readings on the positioning system's dials, work could temporarily proceed with less expert supervision. But also fog, darkness or moving out of shore sights were no longer a problem, so production increased tremendously.

Computing and plotting the survey position gradually became, however, a major effort. This led to the first step in automation, being the key punching of the handwritten readings, followed by computer conversion into coordinates. Shortly afterwards, post-plotting these by hand (possibly with the aid of a coordinatograph) became the new bottleneck and the combination of computer and mechanical plotter was required to avoid a backlog in presenting final survey results.

Simultaneously, the reverse procedure was introduced of converting line coordinates into output lists of positioning system readings to help in conning the

vessel along a desired track. The next step was the graphic display of these readings on, for instance, Decca pre-plots — first by hand, later by automatic plotter — to aid the helmsman in staying on line. This stage was reached in about 1965.

Manual logging of the readings was next due for automation. After a short period of photographing dials every minute (which still required key punching) a major step forward was the conversion of readings to digital information, and interfacing this to a datalogger for output on a punched paper tape. In the 1970's these were gradually replaced by cassettes and other magnetic media. This required considerable adaptivity from the staff on the job, because many liked to see holes in tape or cards as confirmation that data was being recorded !

After the positioning, the echo sounders followed suit, enabling automatic depth annotation on the post-plot from the digital records.

Up to this point in time, no computers were installed on board; both the track-plots and the post-plots were produced onshore. Introduction of (mini) computers and micro processors on the ship have made it possible to combine most of the hydrographic survey functions into one integral system.

In such a system, coordinates for the desired track can be typed in. The instantaneous navigation system readings are in real time converted to positions for display on a screen relative to the desired track, to guide the helmsman. Alternatively, this information can be sent to a left-right indicator or fed into an autopilot that keeps the vessel automatically on track. Meanwhile, all pertinent data are logged for future use, but a post-plot can also be made in real time, so that at all times an up-to-date chart is available of work completed thus far.

From this point onwards, many sophistications are possible. A great variety of positioning equipment can be incorporated, including gyro, speedlog and satellite navigator. Quality control checks are possible from redundant positioning information. Automatic heave compensation can be applied to the soundings. In more specialized applications, meteorological and oceanographic data can be logged. In some cases (e.g. dredging) real time tidal reduction can be applied by a telemetric link to a tide gauge. For seismic surveys, automatic shot firing can be incorporated and, for 3-D surveys, streamer positioning. The same navigation computer may be used for entirely different work, such as financial administration or program development or post-plotting previous work on different scales, simultaneous with the normal survey operations.

Especially, preparing the final post-plots on board can substantially reduce work on shore and enables queries to be resolved by the personnel directly involved in the original survey. Gaps can be filled whilst still in the area.

It will be evident that all these sophistications need additional soft- and hardware. Space and power requirement and system complexity will also increase, and therewith the cost.

## 5. CHOICES IN AUTOMATION

The foregoing indicates that at present there is considerable choice in sophistication and a decision to introduce or increase automation therefore calls for a thorough study of all factors involved.

Some organisations have only occasional requirement to carry out a survey. Others have only a very small vessel. Availability of specialist staff can be a problem for, no matter how well designed, a complex system will require more expertise than a simple one. Importation of spare parts and availability of servicing can be problematic. So many local factors have to be considered when making the right choice for purchasing a system.

Some basic choices are :

- Data logging of positioning system and echo sounder at sea; manual processing only.
- As above, but computer processing at shore base.
- Small computer on board to aid in line tracking, quality control and some pre-processing. Final processing on shore.
- Full track guiding, quality control, data logging and final post-plotting at sea.
- Incorporation of various special sophistications in either ship's system, shore base system or both.

Important factors to consider are :

- Can electric power requirements (voltage stability, etc.) be met ?
- Is enough installation space available ?
- Are the system's specifications in agreement with the normal work environment (spray, temperature, etc.) ?
- Is equipment servicing available within reasonable time and cost frames ?
- Can the system be extended for future capabilities without major costly refit ?
- Can existing equipment be interfaced ?

In general, it is desirable for an organisation starting to automate its hydrographic navigation, data collection and processing to begin on a modest scale, gradually extending as additional needs arise.

## 6. THE HYDRAUT PHILOSOPHY

Applied Dynamics Europe started its HYDRographic AUTomation activities in 1968, in close cooperation with the Royal Netherlands Navy as its main client. Continuous updating with newly available technology has taken place ever since.

In 1984, a major upgrading was decided. It was a fresh start of coordinated approach to automation, rather than adding state-of-the-art components. In this way it was possible to make optimum use of all lessons learned in the past. Early in 1985, the new system was introduced successfully on a Dutch Navy vessel.

Attention focussed in particular on :

- Flexibility and modularity, for easy future expansion and replacement by more modern components.
- Standard commercial hardware for good serviceability, worldwide. Many Hewlett Packard products are used.
- Standard interfaces (IEEE 488, RS232, etc.).
- Redundancy : in hardware (avoids downtime) and in the collection of survey data (enabling quality control).
- Fail-safe aspects and optimal presentation of alarms, control options and quality checks to the user.

The system can be configured from a very simple data logging and track control system — operating in a 25 foot launch — to a complete control centre for survey, logging, quality supervision and post-processing on board a large survey vessel. The launch version is — except for the operator's terminal — contained in a splash-proof box of 30 × 60 × 70 cm and requires 800 watts from 24-volt batteries or from a 110/220 V AC power supply. The principal characteristics of the large system as installed for the Dutch Navy are briefly described hereafter.

## 7. A HYDRAUT SYSTEM DESCRIPTION

The scope of this article does not allow the giving of too many details, so only some idea of the possibilities can be conveyed.

The main hardware and its capabilities are :

(a) Computer. The HP 1000 model A700 system has 1024 Kbyte memory and is capable of several tasks simultaneously, such as post-processing and software development from a second terminal, while survey operations are being controlled and monitored on the bridge terminal. Battery backup diminishes the disastrous effects of a power failure. Memory can be extended to 8 megabyte.

(b) Two terminals with keyboard. The HP 150 touch-screen terminal on the bridge allows the operator to control and monitor the survey process by merely touching the required options displayed for him on the screen.

(c) Storage media. These are an HP Winchester disc with 65 Mbyte capacity for storage of both data and programs, and two cartridge tape units, for backup and data storage. Survey data is first stored on the disc. Once every half hour this is transferred to the tape for permanent storage. The tape can have 67 Mbyte storage capacity and will hold survey data covering some five days of 24 hours.

(d) Printer. This may be an HP82905B, dot matrix, 80 column, impact printer, for printing of all essential survey data on fanfold, A4 format paper, but many alternative types are possible.



FIG. 1. — The HYDRAUT touch-screen, keyboard, dual floppy drive and computer with single floppy drive

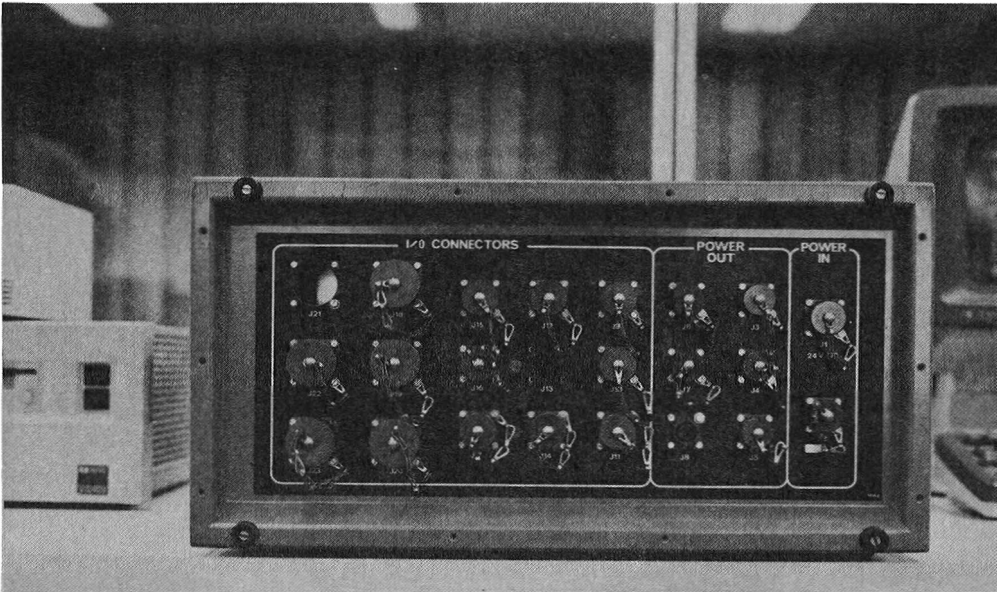


FIG. 2. — The connector plane at the rear of the portable HYDRAUT-XL system

(e) Plotters. On the bridge is a Houston Instruments DP3 track plotter. This plots the ship's position in real time on paper of about 50 cm wide to a maximum length of 320 cm. Again, alternative types are possible. Furthermore a Calcomp 965A plotter is available for final post-plotting on sheets of about 85 × 150 cm.

(f) Interfacing. A total of 13 devices can be connected, i.e. positioning systems (Hyperfix and Decca), echo sounder (Atlas Deso 10), speedlog and gyro, left/right indicator and autopilot, heave compensator, and on-line track plotter, leaving four spare slots for additional hydrographic sensors and equipment. Further expansion is possible.

The main operational characteristics are :

(a) Practically all control and monitoring is through the touch-screen.

(b) During routine operation the screen is divided into ten sections, each giving the most essential data on different subjects such as position, depth, heave, relation to desired track, plot data, time, course, speed, etc. This screen layout is called the main-page (see fig. 3).

(c) If more detailed data are required, sub-pages can be called to the screen for each separate subject. These sub-pages are also used to change parameter settings.

(d) The sub-page for position will, for instance, display which radio position lines are in use (and allows other selections to be made); what is the standard deviation; what are the coordinates in geographicals and X-Y. Thresholds can be

Applied Dynamics Europe - Hydraul MS - Page 00				
TIME 10:32	POSITION	DEPTH	HEAVE	FIXES
DAY 79	E 588093.	MIN 20.00	MIN .49	INT. 2.0
YEAR 1985	N 5878961.	NOM 20.75	NOM -.08	
WED.20 MAR.	RMS 0.6	MAX 20.95	MAX -.49	
	LOG 6.0			
HYDRAUT ON	GYRO 030.0	S.RATE 10	AVR .01	
DEVICES ON	SPEED 6.1	DRAUGHT 3.80		
LEFT / RIGHT (179 / ) ON	NEXT TRACK	TRACK PLOT ON	METEO	NEXT CHAPTER
DIST EOT 19832	LOGGING ON	LLC E 588250.	WIND 210/06	
TIME EOT 01:50	TAPE 67:12	N 5878700.		
	TURN DIR S8			
TRCK NR 1	TRCK SPC 250	SCAL 1: 25000		
TRCK DIR 005.0	TRCK DIR 185.0	SKEW 005		

FIX		COMMENTS	RESET ERRORS		MAIN PAGE

FIG. 3. — The "main page". By touching the relevant rectangle on the screen, the operator can monitor and control other functions in detail



set or changed for the standard deviation and for the changes in pattern reading per time unit to detect laneslips or noisy signals, etc.

(e) The depth sub-page allows thresholds to be set for change in depth with time (i.e. malfunctioning or wreck/pinnacle detection), minimum and maximum values for depth and heave, etc. Also, the depth profile — with and without heave compensation — can be displayed.

(f) Exceeding critical thresholds will always be monitored and signalled by audio and visual alarms, the so-called “watch dog” function for staying within quality specifications and for safety hazards.

Site requirements for this system are space for a  $44 \times 38 \times 66$  cm terminal and for a  $25 \times 46 \times 92$  cm track plotter on the bridge or in the chart room. Furthermore, there should be space in a recording room for a 19-inch cabinet, 160 cm high (computer and various peripherals), for a desktop mounted printer ( $11 \times 38 \times 30$  cm), one more terminal and for the large plotter. This latter is mounted vertically to save space. The positioning equipment, echo sounder and other hydrographic sensors are of course not included here.

Power requirement is for 115 V, 48-66 Hz, about 2 kW, free from switching and interference pulses. All equipment is specified to work in temperature ranges from  $5-35$  °C and in non-condensing humidity from 5-95 pct., but the recording tapes and paper have 20-80 pct humidity specifications.

Though power and space requirements for the portable launch system differ greatly from those described above, it has practically the same operational characteristics. The data is fully compatible with the main system, so that — at the end of a day's work — launch data can be combined with data acquired by the mother vessel in one final post-plot.

In this way the hydrographer in charge of either small or large survey projects can have access to useful automation tools. But it should never be forgotten that the quality of the final product will — as always — be completely in his own hands.