ACQUISITION, TRANSMISSION AND AUTOMATIC

REALTIME PROCESSING OF HYDROMETRIC DATA

(WHO Onchocerciasis Control Project, West Afica)

ABSTRACT

Bernard Pouyaud and Luc Le Barbe

The western extension of the World Health Organization (WHO) project to combat onchocerciasis (river blindness), mainly in Guinea, calls for realtime access to flow level data concerning the rivers to be treated. The correct amount of larvicide to be applied, as a function of flow, can thus be calculated.

The Argos system was chosen for data transmission. The transmitter is connected to water depth measurement hardware produced by Elsyde and CEIS-Espace and designed around a relative piezoelectric sensor and an EPROM-based data storage unit. This unit stores the hydrometric data and transmits messages containing the last 15 water depth measurements made on the hour and half-hour. The direct readout station contains a microcomputer which inputs data to the hydrometric data bank in real time and is itself connected to a second microcomputer. This converts water depths into flow terms and makes a prediction, either by correlation or by inter-station analysis, of the flow at each relevant position over the coming five or ten hours. It also calculates the concentration of insecticide to apply to each stretch of the river.

Only by automating the acquisition, data transmission, and flow prediction functions can the program be conducted on an operational basis at low cost.

1 - INTRODUCTION

River blindness, or onchocerciasis, is a parasite-borne disease that has already afflicted several million West Africans living close to rivers in the savanna regions. The parasite is a species of the *filaria* threadworm, *Onchocerca Volvulus,* that proliferates under the skin and can induce ocular lesions leading to total and irreversible blindness. The vector is a fly, *Simulia Damnosum,* which is vulnerable only at the larval stage, when it colonizes submerged objects in fast-flowing streams that provide the oxygen and nutrition it needs to develop.

To combat the disease, the Onchocerciasis Control Project (OCP) is being conducted across an area of more than a million square km. The aim is to destroy the larva in situ by continued application of larvicide, added directly in the water, to break the man - fly - man cycle for a period of twenty years, i.e. longer than the parasite's life-cycle. Calculation of the correct concentration of larvicide demands that the flow of the rivers to be treated be accurately known. The first phase of the project, begun in 1974, used hydrological data acquired through conventional hydrological networks. The second phase, and in particular the western extension of the OCP project, uses the latest data acquisition methods (Chloe-C limnigraph and Elsyde SPI2 piezoelectric sensor) and transmission methods (CEIS-Espace Argos PTTs). All the hardware is integrated in an unattended, solar-powered, composite structure.

We now give an overview of the hydrological network of the western extension, and describe the limnigraph designed specifically for the project, the Argos direct readout station, and the software that outputs the vital hydrological data in minimum time.

2 - GEOGRAPHICAL BACKGROUND AND STATUS OF HYDROLOGICAL NETWORK

Phase I of the western extension chiefly concerns the upper Niger basin, most of which is situated in Guinea, and to a lesser extent, the basins of the Bakoye, Baoulé and Bafing tributaries that feed the upper Senegal in Guinea and Mali. Phases II and III concern the other tributaries of the Senegal such as the Falémé and those that, in the west and south-west, feed the coastal rivers that drain Gambia, Guinea-Bissau, Sierra Leone, Guinea and Liberia. We shall limit the discussion to Phase I, and therefore to the upper basins of the Niger and Senegal in Mali and in particular in Guinea, since that is where the most serious onchocerciasis and hydrological problems are posed.

The previous political régime left Guinea underdeveloped, particularly when one considers the country's resources. In 1985, the hydrological network of the Niger basin was still generally recognized as being under-equipped. The HydroNiger project did, of course, provide the upper Niger basin with six CEIS-Espace data transmission stations in Guinea, each with a SEBA limnigraph, Précis-Mécanique raingauge and Argos PTT. However, the stations were only established on the Niger itself (at Kouroussa and Faranah) or on major tributaries such as the Milo (Kankan and Kerouane), Niandan (Baro), Tinkisso and Sankarani (Mandiana still at project stage). The OCP needs a much denser network of stations, since the flow must be known both along the main rivers and along their tributaries, up to the tributary basins, some of which cover less than 1000 sq. km.

Although rich in untamed beauty, this part of Guinea is either sparsely populated or totally uninhabited. This is due to past and recent political upheavals and the near-permanent presence of breeding sites for onchocerciasis vectors along the rapids that break up the waters coming down from Fouta D'jalon. In many places, the road system has totally disappeared or is in a critical condition, and 75% of the OCP sites, i.e. locations to be equipped with limnigraphs and calibration devices, are totally inaccessible by road, at least during the rainy season.

The OCP researchers accordingly decided to install and calibrate the equipment using helicopters. However, given the inaccessibility of the sites during the high-water season and the fact that limnigraph readings would have to be gathered by helicopter, which is prohibitively expensive, the OCP researchers decided to install limnigraphs and associated remote readout equipment at the main sites and those that are the least accessible. The Argos data collection system was chosen for the transmission function, since it was already in use for the HydroNiger program and because it was available immediately. The OCP could also expect to draw from the experience of a pilot network using Argos, developed by ORSTOM (*Institut Français de Recherche Scientifique pour le développement en coopération*) for the WHO/OCP in the Oti basin (Kara, Keran and Koumougou rivers in northern Togo).

3 - CHOICE AND PERFORMANCE OF EQUIPMENT IN WESTERN EXTENSION

Experience in northern Togo had demonstrated the effectiveness of realtime data transmission and the greater economy and efficiency that could be achieved. However, the limits of the system had also become clear: in its present state, it could only transmit water depth data during satellite passes. At such low latitudes, there can be a seven-hour gap between passes, making it impossible to know the readings, even after the event, unless they are stored before transmission. This, in turn, means that hydrograms cannot be compiled, and is a particular problem for making predictions based on correlative transposition of readings made at stations upstream or even correlative analysis at the station itself. In northern Togo, to make matters worse, the existing float-type limnigraphs had simply been fitted with digital encoders. This method was difficult to transpose to Guinea where there were no limnigraphs and where it was already clear that helicopters would be needed for installation.

To meet these constraints it was decided that a modified Chloe limnigraph, built by the Elsyde company, would be used. The limnigraph uses a SPI-2 sensor, comprising a semiconductor pressure gauge and a printed circuit board (PCB) inside an immersible cylindrical case, which in turn connects to the Chloe-C limnigraph by a PVC-clad, shielded, flexible cable. The Chloe-C is fully automatic, and both records and transmits; its functions can be broken down as follows:

- recording of water depth as measured by the SPI-2 sensor, in a CE64 cartridge comprising eight 8-Kbyte EPROMs
- measurement of internal housekeeping parameters (battery and solar panel voltage, EPROM programming voltage, internal temperatures of Chloe cased and SPI sensor);
- transmission of messages containing the values of fifteen water depth values recorded at half-hourly intervals preceding the transmission, the housekeeping parameters mentioned above, and the data input to the EPROMs;
- user dialog through an interactive terminal with keypad and screen, connectable to the case, for system initialization, programming of sensitivity thresholds and polling frequency, and adjustment of readings.

The first five Chloe-C limnigraphs were developed by Elsyde and CEIS-Espace early in 1986, and were exhaustively tested at the prototype stage in spring 1986 by the ORSTOM hydrological laboratory in Montpellier. They were scheduled for installation in Guinea in August 1986, and will be joined by a second series of fifteen in November, also to go to Guinea and Mali.

In the final phase, the WHO/OCP network should comprise around 50 limnigraphs of this type in the western extension, and an expected thirty or so in the central area and eastern extension.

4 - DIRECT READOUT STATION AND DATA TRANSMISSION

The pilot network in northern Togo clearly demonstrated the advantages of remote data transmission. It was therefore decided to further refine the approach and adapt it for the management of a much larger network that already included three types of limnigraphs: HydroNiger, WHO/northern Togo-type and WHO/Guinea-type. Such tasks can be performed, largely automatically, by a direct readout station developed by CEIS-Espace and designed around a 10-Mbyte IBM PC XT microcomputer. The station can handle around 50 Argos PTTs on a fully automatic basis, and is programmable in dialog mode. The station creates and manages an indexed water-depth file which receives fresh input each time the satellite passes over. It uses an error correcting code (ECC) to validate the PTT data received during the pass and correct any transmission errors. The files are stored and classified and can be printed out, automatically for certain parameters or in response to an operator command for others. The station also monitors internal PTT operating parameters or minimum or maximum water depth thresholds prescribed by the operator, and displays appropriate warning messages .

The station can also dump all files to diskette, whether they be work files (raw and corrected data from the satellite) or semi-processed (results and processed PTT files). Such disquettes are particularly convenient for exchanging data between the OCP and other groups such as national hydrological departments.

A second microcomputer connected to the readout station will process the water depth files transmitted over a RS 232 link or supplied on diskette. The HYDROM software, written at the ORSTOM hydrological laboratory, performs depth/flow conversion and predicts flood flow levels, and will be updated in the light of experience in northern Togo. ORSTOM is sending a team of hydrologists to Odienné to work on the problem alongside the OCP in 1987.

5 - CONCLUSION

The use of mdern technology, both in the design of new-generation limnigraphs featuring piezoelectric sensors and EPROM memory and in transmission via the Argos satellite system, has produced a fast response to the requirements of the WHO program to combat river blindness. Quite clearly, the basic idea (which is in no way original) and, even more so, the dedicated hardware open up a large range of possible uses. Equally clearly, the demonstration during the OCP of the ruggedness and reliability of this type of equipment should lead to its more widespread adoption and an increasing number of applications.