

'AUTOLAB' - A PROGRESS REPORT

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Abstract

Further progress in the application of a computer in a cane testing laboratory is described. An important improvement to the system, a microprocessor cane massmeter controller, designed and manufactured by the Sugar Industry Central Board, is described. An industrial implementation program is briefly outlined.

Introduction

The initial stages of the Autolab project have previously been described (East *et al*¹). During almost two seasons of operation, some modification and improvement to the original suite of programs have been made, mainly with a view to making the system more foolproof and to enable easier retrieval of data for enquiries. Additional enhancements are firstly, programs which make use of the data in the computer to provide information for different mill departments, secondly, programs which enable mill laboratory data to be captured and processed and, last but not least, the use of a microprocessor controller at the cane massmeter. This unit acts as a multiplexer when the computer is operating, enabling all cane massmeter data to be passed to and fro through only a single 2 pair cable, and providing a standby system such that the cane massmeter department can continue functioning should the computer not be operational.

General Review

The previous report (East *et al*¹) covered the events up to the end of the 1978/79 season. During the ensuing off-crop periods, considerable improvements and extensions were made to the suite of programs. During the 1979/80 season, the computer ran in parallel with the manual procedures from June to August (inclusive) to enable intensive checking of the system. Virtually all errors encountered were traced to the manual system. From August 1979 the computer system operated on a stand-alone basis and the only down time was on one occasion of ± 22 hours when a ROS (see Appendix) card failed.

Once the cane testing system was fully operational, it was possible to start providing other application programs for various mill departments. As a result the installed hardware was extended from 96 K bytes to 128 K bytes of mos memory and from 4 VDU's to 9 VDU's. Early in 1980, work was begun on the design and manufacture of a microprocessor massmeter controller. The prototype unit was installed for purposes of testing and debugging towards the end of the 1980 season. An additional interface module will be required in 1981 for an analytical balance in the mill laboratory.

A continuing problem has been an intermittent and not infrequent occurrence of system hangups due to bugs in the EDX software and the vendor's inability to provide remedial support.

Modifications to Original Suite of Programs

The EDX operating system is relatively unsophisticated and additional programming was required to supplement the software package to improve security and housekeeping aspects and to support other application programs. Some enquiry programs were extended to provide easier data retrieval. The main modifications included :

- (1) An automatic logging facility to record events such as loading of programs, abnormal terminations of programs, alterations to records (e.g. addition of new vehicle information) etc.
- (2) A password system to deny access to data by unauthorised personnel. This system operates on 4 levels, permitting "view only" access at the lowest level and the ability to amend passwords at the highest level. Each person (or a group of persons) can be given their own individual password at whichever level is required for each data system.
- (3) An initiating process that involves loading the on-line programs automatically and also locking the ESC keys of certain VDU's so that only the authorised programs could be used on those VDU's.
- (4) A Sort/Merge facility to be used by various application programs for more useful presentation of data.

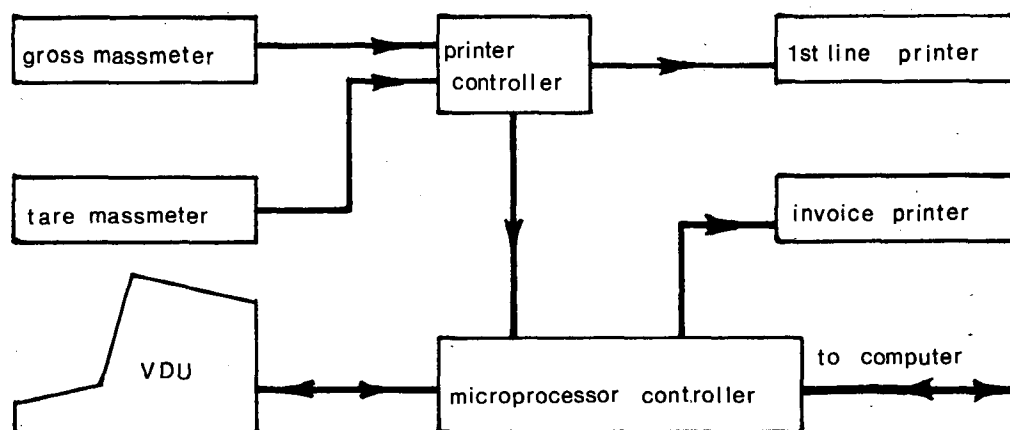


FIGURE I Block diagram showing configuration of hardware devices at the massmeters.

one-way flow of data \longrightarrow
 two-way flow of data \longleftrightarrow

Additional Application Programs

To provide information to various mill departments, the following three main suites of programs were written :

- (1) Batch programs to provide various summaries of cane deliveries, sorted and totalled by haulage contractor, reload point, grower section, vehicle type, etc., for the purpose of delivery allocation control.
- (2) A suite of on-line programs used by the transport despatcher. This provides up to date information at all times regarding cane deliveries and crushing rates, down to details such as, for example, the average round trip time and average load hauled by a particular driver during a shift.
- (3) A suite of batch programs to provide information regarding deliveries by African growers, sorted by contractor, for purposes of allocation control and to enable corrections to grower information to be made timeously. This has contributed markedly to reducing mainframe amendments to data.

Further, a suite of programs is being developed to enable the mill laboratory analytical data to be captured automatically in the same way as the cane testing data, and to provide for all the subsequent processing required.

Additional Hardware

The above programs have required additional VDU's to be installed in the cane massmeter department, transport despatcher's office and mill laboratory. When the mill laboratory programs are operational an interface will be installed to handle data capture from the analytical balance. For the cane massmeter department a programmable micro-processor unit has been designed and developed.

Microprocessor Massmeter Controller

One of the original reasons for installing a microprocessor controller was to obviate problems in having the massmeter assized. In the original configuration, data from the massmeters went to the computer and was then returned to the 'first line' printer to provide the prime record for reference should any queries concerning vehicle mass arise. Because the computer is programmable and is placed between the massmeter and the printer, this configuration did not gain assize approval. The micro-processor controller was a first attempt to solve the problem but as it is also programmable, it was still not acceptable for assize purposes, but development of the unit was continued because of other inherent advantages.

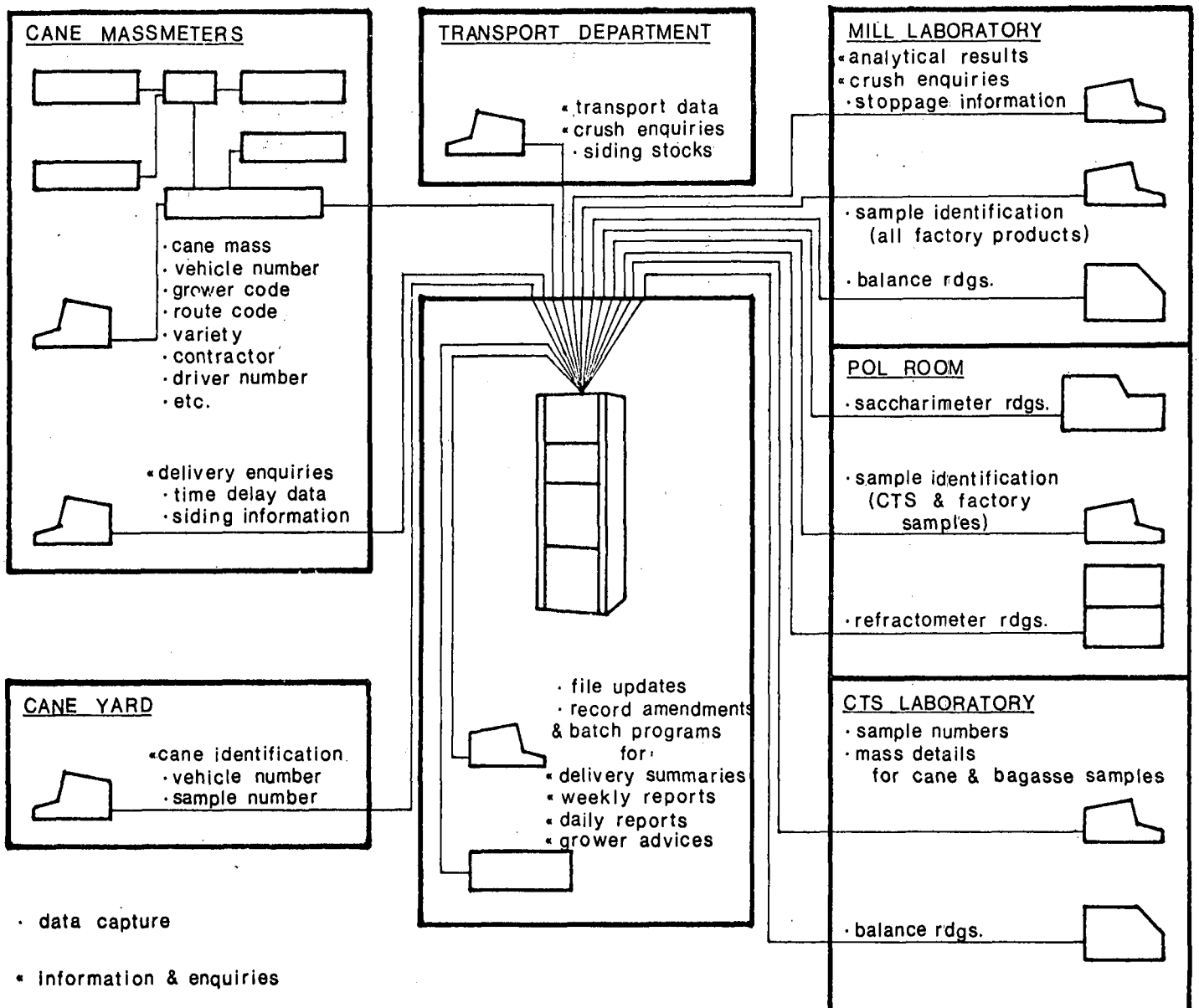


FIGURE 2 Block diagram showing principle data input and output at various hardware devices.

The final step was the design and construction of a printer controller, which includes a sequential counter, linking the massmeters to a Centronics 730 printer (the "first-line" printer) and providing a second port for output of mass and sequence numbers to the microprocessor controller. In this configuration, only the massmeters, with the printer controller and printer have to be assized.

Massmeter Hardware Configuration (See Figure 1).

The final configuration has a printer controller linking the massmeters to a Centronics 730 printer. The microprocessor unit is connected to the second port of the printer controller to receive mass and sequence number data and is in turn connected to the computer, a VDU and a further printer. The two reasons for retaining the microprocessor unit are :

- (a) To provide multiplexing facilities when the computer is in operation. Thus the 2 cane massmeters, a printer and a VDU can communicate with the computer via a 2 twisted pair cable, thereby giving a rise to a substantial saving in cable costs. The microprocessor, in handling communication with the printers, also reduces the I/O overheads on the computer.
- (b) If the computer goes down for any reason, the microprocessor is switched to a stand-by program so that cane massmeter operations can continue unabated.

Software Design

The programs were developed on a Tektronix development system using MDL programming language (a Tektronix enhanced version of BASIC).

An important portion of the software consists of tasks for multiplexing and concentrating data between the computer, VDU, printer and massmeter printer controller. Characters arriving from a source at high speed (e.g. the computer) are placed in a queue and then examined byte by byte for imbedded special characters. The special characters set software switches, indicating the destination of ensuing characters. The characters are transmitted to the destination indicated by the switches (e.g. printer) until another special character is detected. All communications are in full duplex mode. The RS 232C link level used by the controller enables it to be connected to any computer.

The controller operates either in normal mode (using the mini-computer) or in stand-alone mode when the computer is not in operation.

Normal Mode

In normal mode, the controller acts as a multiplexer, receiving and transmitting information between the computer, VDU, massmeters and the second printer. However, while switching data backwards and forwards, the controller keeps its own vehicle files updated so that if at any time the computer goes off line, the the massmeter operation can carry on in stand-alone mode using the information in the controller files.

The controller also reduces I/O overheads in the computer. Previously, it was necessary to send information to the printer byte by byte at timed intervals. With the controller, printer information is shunted to it at high speed by the computer, stored in a buffer, and the controller then passes the information to the printer as required. To the computer the controller appears to be a VDU. Thus, if the controller breaks down, all that is necessary is to plug the VDU into the computer instead of the controller and operations can continue, albeit without the second printer and without automatic capture of massmeter data.

Stand-Alone Mode

If the computer goes off-line, the controller is switched to stand-alone mode : The operator continues to key vehicle identification data into the VDU and to capture massmeter readings by pressing a button. The information is stored in the controller until the transaction is complete and then an invoice (massmeter voucher) is printed. When the computer comes on-line again, the operator switches back to normal mode.

Hardware Design

Various IC boards were designed and fabricated by the Sugar Industry Central Board. They are modular and plugable and conform to the CSIR SABUS specification. These boards are interchangeable between all SICB designed controllers.

Processor Board

This uses an Intel 8085, 6 MHz cycle time processor, capable of 800 000 machine code instructions/second. The board also contains the control logic, bus driver circuitry and memory address latch.

UVEPROM Board

This card can hold up to 16K bytes of memory, held in 8 x 2716 type IC's. The erased circuits are placed onto the card and a 5 to 26 volt inverter section attached. The information is thus pulsed into the memories on the card. After removing the inverter, the UVEPROMS can no longer be written to. The address block is set up by switches.

RAM Board

This card uses 2114 IC's with one 1K x 4 bit static cell. Thus 16 memory IC's are needed to fully populate the card to 8 K bytes maximum. Its address block is set up by switches.

Peripheral Interface Board

This board can address :

- 1 x Centronics compatible printer.
- 1 x 6 BCD digital input (from massmeter printer controller).
- 1 x 64 character ASCII standard keyboard.

Most small printers have a Centronics compatible input, which is a 7 bit, parallel ASCII, character data structure, with associated strobe and acknowledge signals, as well as fault condition signals.

The 6 BCD digit input can be connected up to most instruments, including load cells, servo encoders, etc.

The 64 way ASCII keyboard interface is not used, but it can be combined with a CRT controller (a standard SICB board as used in the cane tracker) to form a terminal if a commercial VDU is not available.

Dual RS 232C/ V 24 + 20 mA Current Loop Control Board

This controller interfaces the massmeter controller with the main computer in the laboratory (up to 1,6 km away) on one port, and with a VDU on the other port. This allows the massmeter controller to act as a multiplexer, eliminating high cable costs between the massmeter and computer.

The controller can operate at speeds from 110 to 9 600 baud, the selection of which may be programmed or preset by switch, using either EIA or TTY 20 mA link levels.

The interface allows the program to select interrupts and switch them on or off, on any or all of 4 levels (viz. two

receive levels and two transmit levels). These are hardware memory vectors which allow high throughput of information.

Clock/Timer Board

This module enables the controller to record date and time and permits timed computer interrupts when required. The module incorporates a digital display.

Benefits Attained by Autolab

The proto-type system has operated for two seasons and has fulfilled, and in some ways exceeded, all expectations. The only real problem was the persistent occurrence of system hangup stemming from inherent flaws in the operating system software.

Cost Benefits

Cost benefit arises mainly by the reduction of clerical staff. At Tongaat, the Cane Testing Service labour complement has been reduced by three units and in the cane massmeter department by one unit. Further benefits have been realised through the reduction of data capture costs at the mainframe and the reduction in amendment costs. Projected over 16 mills, and at current wage levels, this saving becomes:

CTS Staff (40 persons)	....	....	....	R215 000
Cane Massmeter staff (34 persons)	....	....	....	R182 000
Elimination of data capture	....	....	....	R65 000
Reduction of amendment costs	....	....	....	R10 000
			TOTAL	R472 000

The cost of implementing the system at 16 mills would be R1 344 000 with an annual maintenance cost of R60 000. Thus an annual saving of R412 000 would result and the pay-back period of implementation is 3 years.

Further benefits could be attained in other departments through the use of the Autolab System, e.g. the elimination of data capture costs for SASA Harvest to Crush Time Delay Scheme and the reduction of clerical work in the mill laboratory.

Other Benefits

Apart from the saving of labour, the computer has significantly speeded up massmeter and analytical procedures and has virtually eliminated clerical and analytical errors. The time taken to mass a consignment of cane has been more than halved, e.g. for a hilo, the previous time of 1,6 minutes has been reduced to 0,4 minutes. In the laboratory, previously existing bottlenecks have been ironed out allowing the staff to process a consistently high turnover of samples. The incidence of wild results (exceeding stipulated tolerances) has been reduced from the industry average of 0,2% to 0,02%.

Industrial Implementation

Approval has been obtained to implement the SICB Autolab system at all mills in the Industry. It is intended that two systems will be installed in 1981 (Amatikulu and Illovo mills). Thereafter two or three system are to be imple-

mented each year until the industrial implementation is complete.

Data General Eclipse S 140 minicomputers are to be used in future installations. The Data General Advanced Operating System (AOS) will obviate the shortcomings experienced with the present system and enable the use of PL/I programming language which will speed up program development. It is intended to use a pseudo data base type of file structure (under Data General INFOS) to enable easy access to any data. It is planned that with time the Central Board will establish its own in-house maintenance capabilities, initially at board-replacement level and ultimately to board repair level.

Communications with the mainframe computer in Durban (IBM 4341) will be implemented as soon as is practicable. This facility will really come into its own if Autolab is installed at all mills.

Acknowledgement

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REFERENCES

1. King, S., East, E. and Evans, A. D. (1979). Cane Testing Service looks at Laboratory Computerisation. *SASTA Proc* 53: 73-75.

APPENDIX 1

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ASCII	American Standard Code for Information Interchange.
BATCH PROGRAMS	Programs queued and executed sequentially.
BAUD	Binary Digits per second.
BCD	Binary Coded Decimal.
BUFFER	Temporary storage for information received or to be transmitted.
BUG	A mistake or malfunction.
BYTE	A sequence of adjacent binary digits (typically 8) operated upon as a unit.
CRT	Cathode ray tube.
DEBUGGING	Detection of mistakes or malfunctions.
EDX	An IBM operating system and associated language.
EIA	Electronic Industries Association.
ESC KEY	A key to interrupt the operation of a currently running program.
FULL DUPLEX	Simultaneous transfer of information in both directions on transmission lines.
HARDWARE	Physical equipment, e.g. electronic, magnetic and mechanical devices.
IC BOARD	Integrated circuit board.
INTERFACE	Hardware link between two devices.
INTERRUPTS	Signal to interrupt the sequential execution of a program.
I/O	Pertaining to input or output of data at the computer.
K BYTES	1024 bytes.
MAINFRAME	Central Data Processing System.
MICROPROCESSOR	Miniaturised processor (typically on a single chip).
MOSMEMORY	Metal Oxide Semiconductor Memory.
MULTIPLEXER	Device for channelling two or more inputs into a single output.
ON-LINE PROGRAM	Program continuously present in the computer.
RAM	Random Access Memory.
ROS	Read only storage.
RS 232 C	An International Standard for Asynchronous data transfer.
SOFTWARE	Set of computer programs or procedures.
SYSTEM HANGUP	Abnormal stoppage of the computer operating system software.
TTY	Teletype corporation trade mark.
UVEPROM	Ultra-violet erasable, programmable read only memory.
VDU	Visual display unit: A CRT with a keyboard.