SRDC Research Project
Final Report

Harvester Best Practice On-board Expert System and Monitoring

AGX001

AGTRIX
Harvest Management Systems

Robert Crossley
Agtrix P/L
PO Box 63 New Brighton, NSW, 2483
P: 02 66801309
E: robertc@agtrix.com

HARVESTING SOLUTIONS

Gary Sandell
Harvesting Solutions
1 Alexander St, Mackay Q 4740
P: (07) 4954-6385
E: hs@westnet.com.au

Sunshine Sugar

Rick Beattie
Agricultural Services Manager
NSW Sugar Milling Co-operative.
Broadwater Mill
Broadwater, NSW 2472
E: rbeattie@nswsugar.com.au

Australian Government
Sugar Research and Development Corporation

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Australian Government
Sugar Research and Development Corporation

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Executive Summary:

Cane losses through harvesters operating outside Harvest Best Practice (HBP) are a major cost to the sugar industry. Where they exist, current information systems provide feedback to the operator only after the cane has been crushed at the mill. By that time, the harvesting is finished and the losses already made.

The project was aimed at developing an on-board computer system to assist operators to interpret HBP and monitor the operation to provide feedback while harvesting. The system was also intended to be able to relay the data to a central repository that could be used to distribute objective reports on operators performance with respect to HBP. This would allow contractors and growers to use this objective information as key performance indicators when negotiating harvest contracts.

The project was to use semi-structure interviews, group discussions and other methods with project participants – harvester operators, harvester owners, growers and millers - to define reporting requirements and gauge the systems impact on not only harvest best practice in the field, but also awareness of the factors that contribute to this.

However, the project was suspended by agreement with all parties in April 2008 due to 2 main factors:

1. Long delays were experienced in 2006 and 2007 as Telstra's announcement of the CDMA mobile network closure immediately caused key hardware components to be unavailable. Considerable amounts of time were spent in this period looking for alternatives, but none were found to be really suitable to the industry requirements. Continued difficulties in this area meant that delivering a suitable platform for this project was still in doubt for the 2008 season.
2. Various collaborators had either left the industry, had moved to whole-of-crop harvesting (thus not worrying about cane loss) or had simply refocussed their attention to other areas. This meant that there simply was not the level of enthusiasm for the project in the industry to justify the intensive research effort that was required for delivering this product in the still evolving mobile technology based on Telstra's Next G network.

The key learning outcome from this project was how vulnerable projects like this are to the underlying hardware availability, and this may be influenced by factors outside the projects control. Software development projects tend to be based on the assumption that appropriate hardware will be available, and this was the case at the commencement of the project.

However, this changed very quickly when Telstra announced the cessation of the CDMA network, and hardware suppliers were very quick in their response to terminate the production of key components. It was a long time before any alternatives were available. At the time of this report, there are still no reasonably priced alternatives on the market for a harvester environment that were acceptable to the industry.

The lack of suitable hardware has created a barrier to the adoption of this technology and thus diminished the enthusiasm for solutions based on this technology.

The current interest in telemetry systems to remove the need for paper based ticketing (eg. Tablelands, NSW Sugar, Mackay Sugar, Isis Sugar) will potentially deliver the appropriate hardware into harvesters to run the types of systems proposed for this project. Once this technology becomes more readily available and accepted, we believe that the industry will again look at opportunities made available through this technology.

Background:
Cane losses through harvesters operating outside Harvest Best Practice (HBP) are a major cost to the industry. Current information systems provide feedback to the operator only after the cane has been crushed at the mill. By the time this information is conveyed back to the operator, the harvesting is finished and the losses made.

A number of data logging systems are being developed in the industry to monitor harvester performance. These data can be used to infer if an operator is working within HBP, but by the time this information is conveyed back to the operator, the harvesting is finished and the losses made.

This project set out to develop an on-board computer system integrated with developing telemetry equipment that can assist operators to interpret HBP and monitor the operation to provide feedback while harvesting. This system would warn operators if they were working outside of accepted guidelines, and would improve the operator's ability to work within those guidelines.

It was intended that the data would also provide objective reports on operator performance with respect to HBP, allowing it to be incorporated into harvesting Contracts.

The project was to develop technology to provide real-time interpretation of harvester operational parameters to the harvester operator. This technology would be made available to collaborating harvesting groups involved in a number of best practice projects.

Success of the system to improve compliance with HBP was to be assessed through a staged implementation of the system. Harvesters were being fitted with the required sensors and data loggers to record operational parameters. In the first stage, feedback would be provided back to harvesters and owners as a daily report, to demonstrate the system. The report was to contain a range of parameters known to describe HBP; fan speed and elevator pour rate.

A co-operative process was to be used to move to the final stage of development. The project planned to use semi-structure interviews, group discussions and other methods with project participants – harvester operators, harvester owners, growers and millers - to define reporting requirements. In the final phase the expert system was to be promoted to a wider audience to set the stage for a launch to the industry as a whole.

The project was to integrate with existing extension programs for improving harvester performance/ reducing costs in the northern NSW, CSR (Burdekin) and Mackay regions. These projects have established networks of collaborating harvesters and growers who are receptive to the technology, and programs to extend this type of technology to other parties.

The software was to be developed on the same operating system as the display units used for telemetry by NSW Sugar and Mackay Sugar, and the software was planned to be easily distributed through the existing and increasing on-board hardware fleet for no extra hardware cost. Other mills are currently investigating these systems for their monitoring their harvesting operations.

Objectives:

The project sought to achieve improvements in cane quality and reductions in cane loss by equipping harvester operators with a meaningful, real-time display of their performance against Harvest Best Practice (HBP) guidelines. This was to be achieved using an on-board expert system to assess, record and display HBP performance in real-time by linking to harvester tracking hardware (already in use in the industry).

Specifically, the project objectives were to:

1. Provide an objective way to monitor and report on operator compliance to HBP, and provide those reports to both the growers and harvester contractors in a timely manner so that they may be used as key performance indicators in harvester contracts.
2. Educate harvester operators about what is expected in different circumstances to comply with HBP through tailored advice delivered when required.
3. Assess the sociological aspects that will influence the general adoption of this technology, and identify strategies to address any impediments to its wide-spread adoption.

Initial surveys suggested that this project could either deliver or be used as a basis for discussion for improving HBP and the general knowledge of the factors influencing it. The lack of field trials of the final system meant that such outcomes could not be assessed.

Methodology:

The project's objectives were to develop a prototype of the concept application and involve users to guide the development throughout the process (agile development methodology). The development process undertaken was to:

1. Develop a prototype of an expert system to interpret harvester performance in terms of Harvest Best Practice (HBP) and display this to an operator in real-time. This was used to demonstrate the concept to a reference group of harvester operators, growers and contractors.
2. Undertake a baseline study of this group to provide feedback on the design of the system and knowledge of HBP.
3. Install the systems in operating harvesters for a small group of collaborators and monitor changes in their operations as a result of the system operation and reporting
4. Make changes based on feedback and extend its use to more harvesters and other regions and monitor changes in their operations as a result of the system operation and reporting.

Quantitative assessment of this technology to change behaviour was to be interpreted from data on HBP compliance at 3 stages:

1. When the logging equipment is fitted but before any feedback is given to the operator on performance.
2. After logging equipment is fitted and performance is analysed and reported back to the operator
3. After real-time feedback is given to the operator through the on-board expert system

Structured interviews at these three stages were to be used to qualitatively assess the knowledge of the operators and the educational value of the logging devices/ expert system. Structured interviews were to be done with harvester contractors and growers before and after using the system to understand expectations and their intentions. These interviews as well as focus group discussions were to be used to determine how this technology can be applied and the types of issues that may restrain this technology from being adopted widely.

The outcomes of this project were to be evaluated by:

1. How well the recommendations provided by the system mimic recommendations given by an expert in HBP
2. Improved compliance with HBP when these systems have been used, monitored and measured objectively using logging devices.
3. Improved understanding of the requirements of HBP by operators as a result of using the system.

4. An acceptance of the technology by the harvesters, operators and growers that it fulfils a need and will be used in their operations in the future.
5.

Outputs:

The projects initial milestones were aimed at the development of a knowledge survey to benchmark any change in understanding of factors relating to harvest best practice as a result of using the system. This was presented in the Milestone 2 report.

Subsequent to this phase, the project focussed on solving the technical issues facing it to deliver an on-board system as was proposed. This work was in two areas, the architecture of on-board systems that can overlay various logging hardware installed on harvesters, and the communications between the on-board systems and a central server, and the requirements for hardware.

The concept adopted was to provide a programming environment that the expert system would:

- provide feedback on a number of different sensors to the operator
- be one of a number of applications that use the communications link
- be able to operate alongside telemetry for consignment and other applications (eg. Shirt)
- be able to sending performance data back to a central base so reports can be generated for harvester managers and growers

Figure 1 shows the adopted architecture that allowed for the option of using different loggers and communications channels.

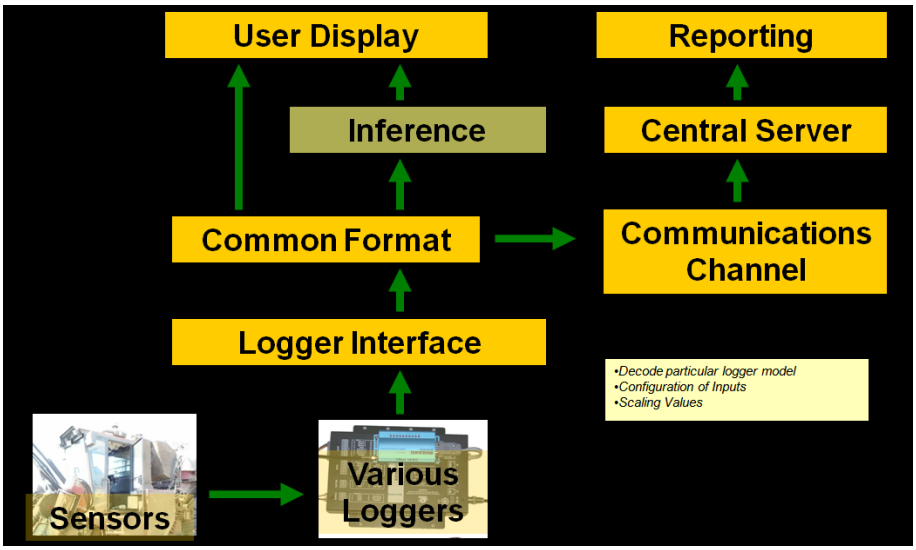

Figure 1 Overview of the architecture of the Expert System

Considerable work was undertaken in trying to source appropriate hardware to run in harvesters that could communicate back to mill over mobile network. This system needed to be able to work on hardware that

- Was suited to the harsh conditions in a harvester,
- Had a large Touch Screen display
- Was programmable,
- Had serial connections to be able to transfer data from other devices.
- Was able to communicate using mobile technology

The project initially identified the Advantech MPC-100e as a likely contender for the hardware platform, with its main limitation being its operating system (WinCE 4.2). However, this hardware was phased out in 2006. We had bought the last 7 units in Australia for telemetry in the Tablelands Mill. We also sourced the last CDMA modems that were available for these units (they had only one serial port and we needed to use PCMIA for the Modem).

The project then spent a lot of effort in searching for other appropriate hardware. Telstra's announcement that CDMA was to be phased out and replaced by Next G in country areas caused an immediate stop to hardware production that supported the CDMA network. When they finally became available, modems that could operate on the Next G network only had serial port connections – which then imposed restrictions on the computer hardware as they needed 2 serial port connections (one was used to connect to the loggers). Further issues were encountered when we tried to continue to use the CDMA network, as the second-in-charge of Telstra had to personally sign off on any new connections.

All of these issues necessarily diverted resources away from what should have been a straight forward task of implementing the expert system in harvesters for a pilot study.

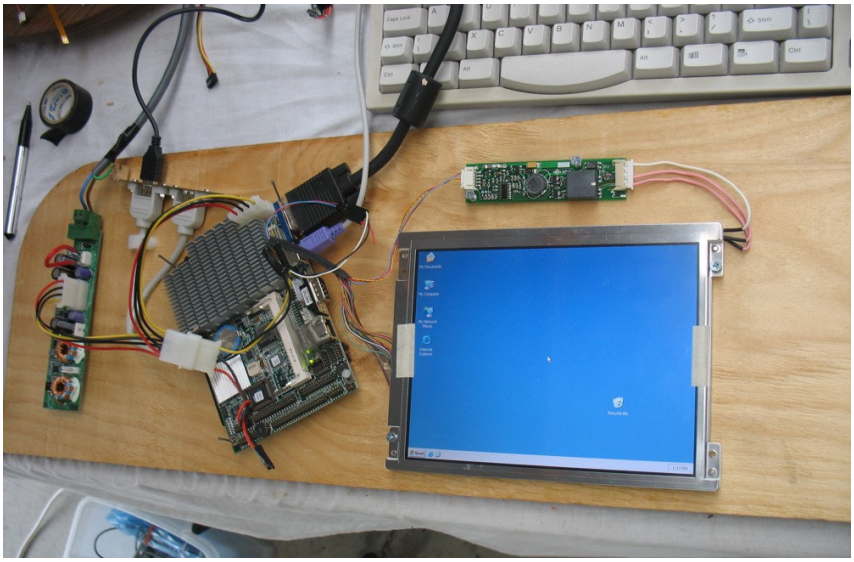

Figure 2 Work bench used to test hardware/ software options.

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The lack of any readily available options for this solution that were available to the industry meant that the project could not confidently deliver a solution for the 2008 season. Over the period of lack of progress with the project due to the hardware issues, various collaborators had either left the industry, had moved to whole cane harvesting (thus not worrying about cane loss) or had simply refocussed their attention to other areas.

This meant that there simply was not the level of enthusiasm for the project in the industry to justify the intensive research effort that was required for delivering this product in the still evolving mobile technology based on Telstra's Next G network.

Intellectual Property and Confidentiality:
No patents were taken. Interpretation of harvest losses were to be based on published material. Some of the modules for communicating with hardware are owned by commercial organisations supplying hardware or software, and were to be supplied under licence. There was no software developed past prototype phase in the project.

Environmental and Social Impacts:
It was expected that the successful implementation of this project would help operators be more aware of the factors involved in HBP, particularly during the harvest operation.

The development of an objective measure of HBP may provide a opportunity that HBP could have been incorporated as a key performance indicator in harvest contracts.

Expected Outcomes:

The lack of available hardware platforms that could meet the requirements for this system using the Next G mobile technology meant that no field trials were undertaken. However, the original objectives for the project still are valid.

We expect that appropriate hardware for this sort of system will become available in the next year (2008), and this or similar projects may be revisited once this technology is more available. The original objectives were to:

1. Provide a critical measurement and feedback component to help harvester operators achieve HBP. Adoption of HBP was conservatively expected to increase yields in the industry 2-5%, (27 to 70 million dollars based on 2002 values).
2. Provide an objective measure that could enable HBP performance to be monitored and incorporated into harvesting contracts, and be used to negotiate more performance based harvesting contracts. This would facilitate adoption of more efficient paddock layouts to further reduce harvesting costs.
3. Educate harvester operators in HBP parameters under different field conditions.
4. Enhance knowledge of programming for on-board computers that are capable of communicating with the mills, and open up a number of possible applications of this technology.

This project was terminated before any field trials were conducted, thus the impacts of this project could not be determined.

Future Research Needs:

It is almost certain that hardware that would satisfy the needs of this project will be developed due to commercial motives in the near future. Adoption of this technology will require some critical applications to be developed using such hardware rather than “nice-to-have”. Examples of such applications are the paperless consignment systems that are in trial at Tablelands Mill and in development at NSW, Mackay and Isis Mills, or information systems such as SHIRT (Clarence River Harvesting Co-Op), which use these types of field devices for production applications, yet have spare capacity for other applications.

Recommendations:
The concept (that this project was based on) of real-time performance monitoring and feedback, should be revisited when the hardware required to support such systems is more available and less subject to current changes in communication technology.

List of Publications:

No publications were produced, although the Cane Officers and Transport and Supply Officers who attended the Agtrix FarmMap conferences (and who represent 85% of the industry), were informed of the project and its objectives each year of the conference.