COOPERATIVE SYSTEMS: AN INFORMATION SYSTEMS MODEL FOR INDUSTRY VALUE CHAIN MANAGEMENT

By

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Abstract

The COOPERATIVE Systems model provides an information systems framework for a value chain management approach to the sugar industry. It uses modern computer and communication technologies to integrate data and systems and provide tools across the industry value chain to assist decision making at the individual business level, and to support and implement whole of value chain management strategies. The framework consists of a central database underlying a web portal. The portal provides a common, standard interface to computer applications operating on the database that provide information and operational support for the members of the value chain. Members interact with the portal via communication networks and end-user systems appropriate to their situation. A number of computer systems and tools are being developed and trialled on this framework to demonstrate potential savings and benefits. They include paddock recording systems, variety selection tools, cane quality and analysis systems, harvester monitoring and tracking, and electronic consignment. An alternative cane payment system based on NIR analysis has also been developed. The research and its ‘spin-offs’ have generated considerable interest in the Mackay region. With the strong focus on a whole of value chain approach being adopted in the Central Region’s business plan, it is likely that the proposed new cane payment system and other elements of the Cooperative Systems model will be adopted on a broad scale in 2005 and beyond.

Introduction

In 2001, Mackay Sugar launched a web portal as part of a multi-pronged strategy to streamline communications in the supply chain (Crane and Fleming, 2003). The strategy was focused on communications between the mill and growers and harvesting contractors to manage cane supply operations more efficiently with less staff in the field. It was noted then that the web portal would also provide infrastructure to integrate data and information systems across the value chain to assist decision making and add value for its members.

In 2003, Mackay Sugar, in partnership with Canegrowers Mackay, Queensland Mechanical Cane Harvesters Association and BSES, obtained SRDC funding for a
‘Cooperative Systems’ project to develop systems and pilot value chain management concepts. The project is still in progress. This paper gives an overview of progress to date, and the preliminary results obtained.

The cooperative systems model

McNurlin and Sprague (1989) define cooperative systems as inter-organisational computer systems where two or more parties with different objectives collaborate on their development and operation.

In essence, they are systems that work together for the mutual benefit of separate organisations that share a business relationship.

The Cooperative Systems Model applies these principles to management of the sugar industry value chain. The emergence of technologies for collecting and distributing information, including the Internet, satellite imagery, NIR and mobile communications, provides the tools to integrate data and systems across the industry to support informed decision making optimised for both the individual activity and the overall value chain.

The sugar industry value chain

The Cooperative Systems Model provides an information ‘hub’ for the industry value chain, as shown in Figure 1.

![Figure 1—The sugar industry value chain.](image)

All members of the value chain make business decisions that affect other members. For example, a harvester’s costs can be affected by the way a grower sets up his paddocks; the way the harvester cuts cane affects cane quality and yield, which have impacts on the mill and the grower.
A whole of value chain approach aims to identify and manage these relationships. However, value chain management cannot be effective without:

- industry structures and agreements to facilitate cooperation between sectors;
- financial incentives to equitably share the costs and benefits of whole of value;
- chain decisions; and
- systems that provide the timely exchange of information on which to base such decisions.

The Cooperative Systems Model aims to provide systems and infrastructure, as well as the data to develop new payment systems based on commercial market signals. The organisational framework in which they can operate has to be provided by forming partnerships and alliances within regions.

In the Mackay region, such partnerships have been developing during the life of the project, and this is greatly assisting the realisation of project outcomes:

- A Cane Supply Consultative Group, formed in 2001 to review and discuss changes affecting the regional industry, has served as a high level advisory and evaluation group for the project.
- The Mackay Sugar Industry Partnership, a formal alliance between the canegrowers, harvesting and milling sectors of Mackay Sugar, has been actively developing and negotiating new systems of payment based on cooperative systems infrastructure and research.
- The Central Region Sugar Group, representing the Proserpine, Plane Creek and Mackay Sugar areas, has drafted a regional business plan based on a whole of value chain approach, and is benchmarking production yields and costs across the region using a web portal based on the Cooperative Systems Model.

Within this organisational framework, the cooperative systems project has taken on a sense of urgency and purpose, and it is likely that several elements of the model will be adopted in the Mackay industry in the 2005 season.

**Cooperative systems framework**

The Cooperative Systems Model consists of operational and decision support systems for all sectors of the value chain implemented on a common infrastructure as shown in Figure 2.

Data and information relevant to the management of the value chain is stored in a central database. Computer applications (programs) capture data from end users to be stored in the database, and use it in combination with data from other value chain members to provide operational and decision support for their business via reports, enquiries, models and decision support tools.

The common ‘front end’ for all these applications is a web portal, where end users interact with the applications through a standard web browser interface. They connect to the web portal via an appropriate communications network (e.g. the Internet, a public mobile data network or a radio data network) from an end-user system appropriate to the task, such as a
home PC, a pocket PC or smart phone, or a mobile data unit mounted in a harvester or locomotive.

![Cooperative systems framework diagram]

Industry standard components are used and the model can accommodate any internal or third party systems that can be integrated into the framework.

**The systems**

The project focused on the three primary sectors of the value chain: farming, harvesting and milling. The transport sector received some consideration in the context of harvesting, but it is the subject of other research and was not directly addressed by the team.

The market sector has not been of much direct concern to the industry to date (apart from the price), but this will change as further deregulation and diversification occurs.

These two sectors were therefore excluded from the project scope, but could easily be incorporated in the model using the technologies applied to other sectors.

Project teams for the farming, harvesting and milling sectors each worked with a volunteer ‘reference group’ of four or five growers and harvester operators. These groups determined the key operational and decision areas for the sector, and the areas of investigation, i.e. system development, that should occur in each.

**Farming systems**

**Objective**

- To identify information systems that enhance key on-farm management decisions, and make them available to the farm manager.

**Areas of Investigation**

1. Integrated field record systems (inputs, irrigation etc).
2. Provision of timely milling and harvesting data for in-field corrective action.
3. Linking farm management practices to field/farm information, e.g. variety selection; fertiliser application; irrigation; pest and disease control; environmental management.
4. Benchmarking options for growers and third parties to interrogate.
5. Linkage between field/farm information and GIS, leading to precision farming options.
6. Costs.

**Harvesting systems**

**Objectives**
- To develop improved systems for harvester management using GPS tracking and logging of operating data.
- To assist the mill systems team to develop a system for electronic consignment.

**Areas of investigation**
1. Area harvested recording.
2. Harvester productivity recording (e.g. ground speed, turning time, fuel efficiency).
3. Improved in-field communication and data transmission.
4. Cane quality information available to the harvester.
5. Yield mapping.

**Mill systems**

**Objectives**
- Investigate a new system for cane payment incorporating on-line analysis, cane quality and components other than sugar.
- Develop and trial a system for electronic consignment of cane.

**Areas of investigation**
1. Trials of NIR, sucrose meter etc.
2. Payment and quality schemes.
3. Consignment – matching bins to their origins.
4. Data transmission methods.

**Systems development and pilot trials**

It is not possible to cover the detail of the systems development in this paper. The project is still in progress, so results and evaluation are incomplete. The following sections give an overview of the systems and the preliminary results obtained.

**Web portal and database**

The web portal and underlying database is built on the existing Mackay Sugar web portal architecture documented in Crane and Fleming (2003). It uses primarily Microsoft software and development tools, including the SQL Server database management system.
This platform is widely used both within and outside the sugar industry.

Security and privacy are controlled through a role-based login system that gives users different levels of access to data depending on their relationship to it. For example, a user may have grower-level access to their own farm, allowing them to view all information, but only harvester operator access to another, allowing them to view bins, tonnes and cane quality, but not payment information.

Mill systems

On-line analysis

Foss NIR systems have been installed at each of Mackay Sugar’s four mills and for most of the 2004 season analysed all cane receivals for pol, brix, fibre and ash. Sample trackers have been modified to match the NIR output stream to individual bins, giving continuous analysis at a bin level.

The system returns results for sugar, extraneous matter (as pol/fibre ratio) and dirt (from ash) in cane. These are displayed on a rake by rake level on the web portal, in tabular and graphical form. Figure 3 shows an example of the output.

![Fig. 3—NIR cane analysis results.](image-url)
The results have been available to all growers and harvester operators on the web portal since early September. An extensive program of evaluation and discussion is in progress as a prelude to agreement on a new system of payment based on these results.

**Electronic consignment**

A system to consign cane electronically was developed and deployed for trials on three harvesting groups. The system is designed to replace paper consignment notes and improve consignment accuracy at a paddock level.

The harvesting groups were equipped with a mobile data and tracking system incorporating a GPS and a communications module that uses the public mobile data network (GPRS or CDMA1X), and a processor with touch screen running the Windows CE operating system.

Deliveries of bins were read as they left the mill yard (all Mackay Sugar bins carry Radio Frequency Identification (RFID) tags that reference the bin number).

At the commencement of the day’s harvesting the operator would enter basic consignment data, and then request the system to download the bins delivered. The operator would then check off the bins as they were filled, and when ready, upload the consignment to the web portal. Figure 4 shows an example of the screen used by the operator.

![Electronic consignment screen.](image)
Because the time that the bins are filled is recorded together with the location of the harvester at that time, the system can associate each bin with reasonable certainty not only to the paddock but also the part of the paddock that it came from and, with NIR analysis of individual bins, this gives a picture of variations across a paddock, or with changes in harvesting parameters.

There were some problems with the installation of the equipment and some deficiencies in the communications software that restricted the extent of the trials. However, the system was shown to work and will be practical when reliability issues are addressed.

A fallback in the event of system or communications failure (apart from reverting to paper) is to enter consignment details via the web site after harvesting has been completed. An interface is being provided for two other groups to trial.

**Alternative cane payment scheme**

The project team’s investigation of alternative methods of cane payment evolved into a full proposal for a new payment system for Mackay Sugar. The proposed system shares the proceeds from sugar, cogeneration and molasses, and provides for revenue sharing from any future alternative products between the miller and the grower in a fixed ratio. This shares the risks and benefits of CCS variation with season length, and recovery efficiencies in the mill. It removes many of the commercial barriers to a whole of value chain approach.

Under the proposed new payment system, grower-grower relativity will be determined from a new measure of sugar content based on NIR analysis. This is called Percent Recoverable Sugar (PRS), and while its value is similar to CCS, it is calculated from direct NIR measurement of sugar in cane less average losses to bagasse, mud and molasses.

Results using this system have been displayed on the web portal during the 2004 season (see Figure 3), and the system will be incorporated in proposed supply contracts for 2005.

**Farm management systems**

**Paddock recording system**

Mackay Sugar’s web portal includes a ‘web mapping’ interface that allows growers to interact with a MapInfo GIS system to display their farm maps overlaid on satellite imagery, aerial photographs, soil maps and any other spatial layer. This interface is being further developed for growers to record field inputs and operations by indicating the treated area on their farm map and entering data via a pop-up window.

MapInfo Spatialware is also being trialled. This is a product which allows the spatial data in the GIS to be integrated with the traditional ‘lineal’ data in the SQL Server database. This significantly simplifies the paddock recording system and opens up several possibilities for productivity reporting.

Development and testing of the system is still in progress, but the technology is working well. It may be possible to automate some recording using mobile tracking and data recording systems on mud and dunder trucks and precision applicators.

**Variety selection**

The same technology is being used to develop a variety selection tool. A grower can indicate the paddock he wishes to plant, and using queries with filters such as soil type,
district, irrigated or dry etc. and applying rules provided by BSES, the model will show recommended varieties for the paddock’s geography and report the performance of the best-yielding varieties in the district.

**Pests and diseases**

The web mapping tool can also be used to map the incidence of pests and diseases, recorded as either another spatial layer or as an attribute attached to paddocks. Some investigation has also been done into the use of remote sensing (from satellite imagery) to detect cane grub damage. If successful, this could be used as an early warning system to help control the spread of such pests.

**Harvest scheduling**

CSIRO have developed two models, VarietyMax and SugarMax, that recommend geographical harvesting schedules on a farm and within a group respectively. We are cooperating with them to deploy these tools on the web portal to guide growers in scheduling their harvest to maximise sugar content.

**Costs and benchmarking**

In a related development to Cooperative Systems, the Central Region Sugar Group has developed a web site to record and benchmark the costs of production between farming entities. Production data are obtained from the mill systems that underlie Cooperative Systems, and costs are entered by the growers’ financial advisors. Growers and/or their financial advisors can then compare their historical performance against similar farms, and can also perform ‘what if’ analyses to predict performance at different prices, yields and cost structures.

**Harvest management systems**

**Harvester monitoring**

The mobile data units fitted to harvesters for electronic consignment included interfaces to monitor a broad array of operating parameters, for example: engine on/off, engine revs, oil temperature, fuel usage, fan speed, chopper pressure. The associated GPS adds position and time, and hence speed.

The data are transmitted to the web portal where they can be processed to display operating profiles by time and location, allowing analysis of turning and idle time, conformance to harvesting best practice etc.

When combined with cane quality data also recorded by position and time, one can start to look at the costs of achieving cane quality targets, facilitating new methods of payment based on these results.

Some research is also being conducted on correlating tonnage throughput to operating parameters, which would make it possible to directly measure yield variation across a paddock without needing consignment data.

This system is also being used to measure area harvested, for the calculation of actual versus estimated yields during the season. The harvester ‘tracks’ are converted to polygons and overlaid on farm maps by CHOMP software from Agtrix Pty Ltd. CHOMP can also be used to display any other measured parameter as a map layer.
Cane quality

As noted under the On-Line Analysis system, NIR technology can measure dirt and extraneous matter as well as pol, brix and fibre.

Extraneous matter, dirt and bin weight (from weighbridge systems) are indicators of cane quality and harvesting efficiency.

Results for these measures have been published on the web portal on a rake by rake basis, as well as for harvesting groups. Figure 5 is an example of the output.

A number of mills have introduced incentive schemes based on these measurements. The risk of such schemes is that good results can be achieved by adopting practices that increase cane loss in the field.

We are hopeful that research on cane quality measurements in conjunction with harvester monitoring will lead to contract-based payment schemes that encourage best practice harvesting for high quality cane with reduced losses.

Harvesting costs

Measurement of financial performance for harvesters is also to be piloted by making the BSES Harvest Haul model available via the web portal. The model is not currently in a
form suitable for interactive use on the web site, so data captured from harvest management systems will be processed off line and the results made available to users through the portal for their evaluation.

**Conclusions**

The work to date has shown that there are no significant technical barriers to the Cooperative Systems model. We have been able to capture and integrate data from the farm, the harvester, the mill and external sources, and demonstrate its use for information systems, decision support tools and operational aids across the value chain.

The Cooperative Systems framework is an ‘enabling technology’. Once it is established, people will find an increasing number of uses for it. We are already working with staff from CSIRO and BSES to integrate previously stand-alone models into the model.

These promising developments demonstrate some of the opportunities available for the sugar industry to rise to the economic challenges that confront it. This paper has described various new mechanisms that can lead to improved productivity, reduced costs and a generally more co-operative approach to growing the industry cake. They all contribute to a rising confidence level amongst project participants that the Australian sugar industry does have a sustainable future providing we are able to promote the process of change better than we have in the past.

The research will now focus on a high level of adoption of the principles of Cooperative Systems. Adoption is already occurring in Mackay through the proposed new cane payment system and the benchmarking program being undertaken by the Central Region Sugar Group. We also hope that the pilot and reference groups who are trialling and evaluating the new systems will become ‘champions’ on the ground who will play an important role in this most important stage of the project.

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