CHANNEL AUTOMATION AND PEOPLE

1. ABSTRACT

The recently announced $1 billion Northern Victoria Infrastructure Renewal Project will involve large scale implementations of automated open channel control systems. Other water authorities in Australia and overseas are also implementing and planning more channel automation investments to modernise their supply systems. The investments will inevitably lead to significant impacts for staff and customers due to the fundamental change in operational environment.

Many papers in the international forum document the technical issues associated with automated control systems but less attention has been devoted to the impacts for customers and water delivery staff.

This paper will discuss some of the human issues. The evolutionary operational change leads to a shake-up of old paradigms and rules of thumb, requires cultural change, new skill sets and usually some organisational restructuring. There are many inevitable issues when transitioning from low-technology, low-performance and data-poor manual-control systems to high-technology, high performance networks and data-rich automated systems.

2. AUTHORS

Tony Oakes (Anthony.Oakes@rubicon.com.au), Rubicon Systems Australia Pty Ltd and Clive Luscombe (jebserv@bigpond.com) JEB Service Pty Ltd

3. BIOGRAPHY

Tony Oakes is a founding Director of Rubicon Systems Australia Pty Ltd and Clive Luscombe is Principal Consultant with JEB Service Pty Ltd and prior to this spent his career in management and operation at Goulburn-Murray Water and its predecessor’s. Both authors have spent a significant part of their careers utilising computing technology to improve the operation and management of open channel irrigation systems.

4. INTRODUCTION

Developments in technology over the last decade have shown that the automation of large scale open channel networks has become technically and economically feasible. More recently with the pressures of drought and climate change, irrigation authorities in Australia have been increasingly investing in channel automation technologies with intent to;

- **Improve channel distribution efficiency**. Whilst there has been much conjecture over the accuracy of reporting, manually controlled open channel systems in Australia operate with efficiencies of the order of 60% to 75%[i] - this figure is more like 50% in China and India. Given that irrigation accounts for approximately 70% of Australians water use, improving this efficiency by 15-20% through channel automation and complimentary investments makes a compelling opportunity to improve water efficiency. Improving distribution efficiency is critical for the future of irrigated agriculture as climate change reduces the amount of available water.
- **Improve customer service** – Providing water at the time required by the crop and at the constant flow rate required for optimal irrigation provides the certainty needed for farmers to invest in on farm scheduling and automation solutions, and evidence indicates that significant on-farm water and economic efficiencies from improved crop production are also generated.
- **Improve Productivity** –automated systems require less staff to operate but with a changed skill mix required for supervision, support and maintenance. Automation leads to significant reduction in vehicle travel saving money and a greenhouse benefit.
- **Mitigated Occupational Health and Safety risk** – use of automated regulators eliminate the manual handling hazards associated with placing and removing boards from regulators.

Repeated removal and insertion of wooden “drop bars” is arguably the highest cause of lost time and long term injuries in irrigation districts.

- **Reduced transport of nutrients** – eliminating outfalls reduces drainage flows and the transport of nutrients into waterways.


Figure 1- Comparison and Manual and Automated Operation

Many of the early investments in automation technology were focussed on productivity and service improvements by eliminating the need for operators to visit remote sites to reduce costs and or improve control outcomes.

5. BACKGROUND

Channel automation involves a diverse range of skills and technologies. Many of the skills required for successful implementation and operation are new to those working in the irrigation sector. The key components of an automated system can be grouped in the following categories

- Control device generally in the form of a gate, valve or pump – traditional skills in mechanical, electrical and civil engineering required.
- Instrumentation to measure levels, flows and other quantities necessary for successful control – an active market is available to support this requirement available from early adopter markets.
- Communications systems – a rapidly evolving market place with niche skills required in the low power high performance space.
- Software engineering – significant diversity required from low level microprocessor programming to enterprise class data management systems.
- Dynamic hydraulic engineering – specialist knowledge and techniques required to solve these technical challenging issues.
- Control engineering – niche control engineering knowledge, techniques and software.
- Civil construction/installation – relatively simple and standard construction practice with high focus required on project management and standardisation.
- Electrical technicians – standard skills with specialist training on unique products.
- Water System Operators – experienced and progressive operators that are supported in the challenge of continuous improvement.

Manually operated open channel systems lack performance data. In Australian systems operators usually have a reasonable estimate of demand from customer orders but in general have a poor knowledge on a system wide basis of the state on the overall system. Operators lack accurate or continuous measurements of water level and flow and have to rely on scattered spot measurements. Historically accurate assessments of flow were technically infeasible.

Channel automation addresses these issues and the balance of this paper discusses the issues that have been identified by the authors in several implementations.

6. CUSTOMER ISSUES

6.1 HIGH GROUND

Everyone knows that water won’t flow uphill by gravity but manually controlled systems have always provided farmers with the ability to drop another board in their controlling regulator to force water over high ground that is not commanded by the design of the channel system. There is some anecdotal evidence that suggests many on farm layouts have been designed on the basis of recorded high water marks and not the formal levels specified by the irrigation authorities. Whilst most irrigation system managers are well aware of the practice, the extent of this issue has not become apparent until large scale automated systems have been implemented. This problem often results in highly inefficient water use on farm and inaccurate metering. The issue creates a number of management challenges. As a result of the high ground issue many irrigation authorities run their systems above the formal design level of the channel and this of course may be further surcharged by unauthorised customer intervention.

In designing the civil works to automate channels designers need to make decisions about the gate(s) to install and in general deeper gates to check higher water level costs more money. Given that there is little published knowledge of the high ground issue and it is not cost effective to survey all farms during the design process, authorities need to make an assessment of the adopted supply level. Once set the control system configuration does not enable it to be varied by farmers. Consequently, despite the best intentions of the designers and the authorities the channels are often run at lower levels and land that may have once been commanded by gravity may no longer be. Perhaps more problematic is the reduction in flow rate and therefore increased time to irrigate with consequent lower efficiency. The resolution of these issues has proven challenging as it is resource intensive, and requires a commitment to engage meaningfully with farmers to ensure that the underlying issues are effectively communicated.

6.2 FORMAL PERFORMANCE MEASUREMENT

In Victoria the traditional measurement of customer service available to irrigators has been some simple indices that measure how much each customer’s orders are “shifted” during the scheduling process. Whilst this provides an indication of service a more valuable index measures both volumetric and flow rates relative to the order. This measure provides a far more meaningful measure of system performance. Unfortunately there is no method of comparing these outcomes with previous arrangements. Figure 2 shows the information that Southern Rural Water use to assess the performance of each irrigation delivery through an automated metering device.

Order Information						Performance								
Outlet	**Begin Date**	**End Date**	**Volume Ordered**	**Ordered Duration**	**Ordered Flow Rate**	**Volume Delivered**	**Weighted Average Flow Rate**	**Numeric Flow Rate**	**Standard Deviation**	**20% Decile Flow Rate**	**Median Flow Rate**	**80% Decile Flow Rate**	**Percentage of Time Within 95.0%**	**TCC**
MC.1000	08.03.2008 09:00:00	10.03.2008 09:00:00	24.0	48.0	12.0	21.4	10.7	11.3	1.24	11.1	11.6	11.7	95.6	N
MC.262	06.03.2008 07:00:00	06.03.2008 19:00:00	4.0	12.0	8.0	3.9	7.8	7.9	0.44	7.9	7.9	8.2	97.0	Y
MC.262	07.03.2008 07:00:00	07.03.2008 14:10:00	2.4	7.2	8.0	2.4	7.9	7.8	1.51	7.9	8.1	8.2	94.4	Y
MC.181	06.03.2008 07:00:00	06.03.2008 19:00:00	4.0	12.0	8.0	3.9	7.9	8.0	0.24	7.9	8.0	8.1	97.0	Y
MC.181	07.03.2008 07:00:00	07.03.2008 14:10:00	2.4	7.2	8.0	2.2	7.5	7.6	0.58	7.3	7.7	8.1	94.4	Y
MC.1372	06.03.2008 15:04:00	08.03.2008 03:04:00	18.0	36.0	12.0	12.0	8.0	8.0	1.71	6.6	7.9	9.3	98.6	Y
MC.184	04.03.2008 15:02:00	06.03.2008 15:02:00	30.0	48.0	15.0	26.3	13.2	13.0	2.17	11.2	13.6	15.0	99.3	Y
			84.8			**72.2**							**96.6**	

Figure 2- Extract of Standard FlumeGate™ performance report

This standard report shows a record for every water order - the order as lodged and the volume delivered and measures of the flow rate and deviation from the specified flow rate and a simple metric that indicates the percentage of time that the flow rate is within the agreed tolerance of the order.

Perhaps the most useful feature of this report is its ability to measure the consistency of flow which is so critical for efficient irrigation.

7 WATER SYSTEM OPERATORS

Perhaps the most challenging issue for water distribution operators is the complete reversal of the traditional operating paradigm associated with manually controlled systems. Systems like Rubicon's Total Channel Control® (TCC®) use a demand or "downstream" based control paradigm - where all upstream regulating devices are operated to meet downstream needs. The implication is that only enough water to meet consumptive and non consumptive needs is diverted from the source of supply to replenish downstream. This contrasts with traditional operation based on the "upstream" control paradigm where operators have to add a significant margin of safety to flows to overcome control limitations relating to measurement accuracy and only being able to be in one place at a time, to provide flexibility to respond to demand changes and to ensure channel levels stay above the levels that avoid service issues.

Automatic systems effectively replace field operators with automatic gates and planners with automatic scheduling software. The typical implementation approach has been to implement automation on a gradual basis and to transition the planning role into a supervising or system controller role and the field operator into a plant/equipment supervisor and also undertaking 1st level equipment maintenance. Managing this transition is not easy and there are critical human issues to address.

Change and fear of a new regime is clearly a critical management issue and this can be expressed in many different ways. Automated systems result in a loss of operator control and provide greater accountability. There is a requirement to learn new skills involving a diverse range of technologies and this creates new career opportunities. Automation also provides a greater insight into how systems operate and provides the capability to identify, understand and address long term infrastructure bottlenecks.

Even with training it takes some time for operators to understand the behaviour of automated regulators and to predict future regulator changes. Like all automated systems, operators have to intervene from time to time to respond to such situations as control equipment malfunction or inappropriate farmer behaviour, weed growth or channel leaks or bursts. A typical example is a pool with a low water level where the traditional "intuitive" response is to reduce the flow downstream to fill the pool, whereas the required response to put more flow on the system to sustain downstream demand and fill the pool.

7.1 ALARMS

With modern communications and software systems there is a sound rationale to transmit and record a diverse range of measurements from the water system and control the plant and this kind of technology has been traditionally known as SCADA. Modern enterprise class SCADA systems provide the ability for operators to pre-define conditions that they would like to know about and to have these conditions brought to their attention by means such a flashing icons on screens, ringing computer bells, sending Email's, pager, SMS or synthetic voice messages. This capability is typically know as alarming. Alarms provide a wonderful capability for operators and managers to be kept informed of all kinds of activities. However, the definition of alarm conditions and the actions taken when these alarm conditions are encountered need very careful design and ongoing management. Managers often interpret "excessive" alarms as indicators of poor system performance which may or may not relate to equipment performance, water system condition (weeds, capacity constraints), algorithm tuning etc.

Some examples.

- A common issue with alarm configuration is to set the alarm limits of water levels within a constant band of the supply level irrespective of the pool length or volume. Sudden changes in demand will be expressed as water level deviations. There needs to be clear management delineation between an “alert” and an “alarm” and appropriate bounds set based on the underlying dynamics of the system.

- Defining an SMS alarm action on an outfall at the end of a manually controlled system that wakes a duty officer at night. In most cases there is little that can be done to mitigate the alarm condition without making a manual regulation.

7.2 WATER LEVEL VARITAIONS

Many water system operators have a perception that flows and water levels in manually regulated channel systems vary little except at the time of regulation. The computation and presentation methods in the planning and scheduling systems typically present demand changes as step functions and this presentation supports this perception. Throughout the 2007/2008 irrigation season a significant part of Southern Rural Water’s Nambrok Denison Irrigation Area at Maffra in South Eastern Victoria was manually operated with automated FlumeGate™’s that measure both upstream and downstream water levels and accurately compute flows. This manual operation was necessary as a transitional arrangement until the linking carrier channel from Glenmaggie Weir to the start of the irrigation area becomes automated.

The method of operation was to set automated flows at the top of the channel system and have these “top” gates automatically adjust to pass the required flow. The inline regulating gates were manually set to position as the flow changes were routed through the system in a traditional manually controlled “top down” operation. The off takes to small channels were set in flow mode. The system involved a total of 194 gates at a total of 156 sites. To the authors knowledge this is the largest measured and audited system of manual control ever conducted and the time series of water level measurements shows how challenging it is to operate a large well instrumented system with operators making all of the decisions as to when and how much to change the position of a gate.

Figure 3 shows the flow changes at the top of the system (top most trace) and the corresponding upstream water level changes at the next downstream regulator (lowest trace) and the water level 22 “pools” down the system (middle trace). Over the one month period from 1 March to 1 April 2008 the flow at the top of the channel, that has a capacity of 535 ML/Day, varied from 90 to 425 ML/Day and the maximum water level deviation at the next structure downstream was of the order of 100 mm. It should be noted that the large flow change from 150 to 340 ML/Day on 4th March resulted in only a minor deviation at the next structure downstream. This is illustrative of very well managed manual regulation. However, for smaller changes in flow there are significantly bigger variations in water level and this is illustrative of the difficulties of perfectly timing manual regulation. Note that the water levels towards the bottom of the system show deviations of approximately 200 mm. This is symptomatic of the challenges of maintaining water levels further down the system and combined with reducing demand and less emphasis on tighter management.

Figure 3- Flow at top regulator and water levels at downstream regulator

Figure 4 shows the same flow trace as Figure 3 but also shows the water level deviation upstream of the automated gate. These 300 mm water level deviations result from a mismatch between the arrival of flow changes from Lake Glenmaggie that are manually routed through the 25km of channel to the offtake structure. The automation of this top section of channel during the 2008/2009 irrigation season will seek to reduce these water level variations and enable more frequent changes in flow to be made at the offtake structure.

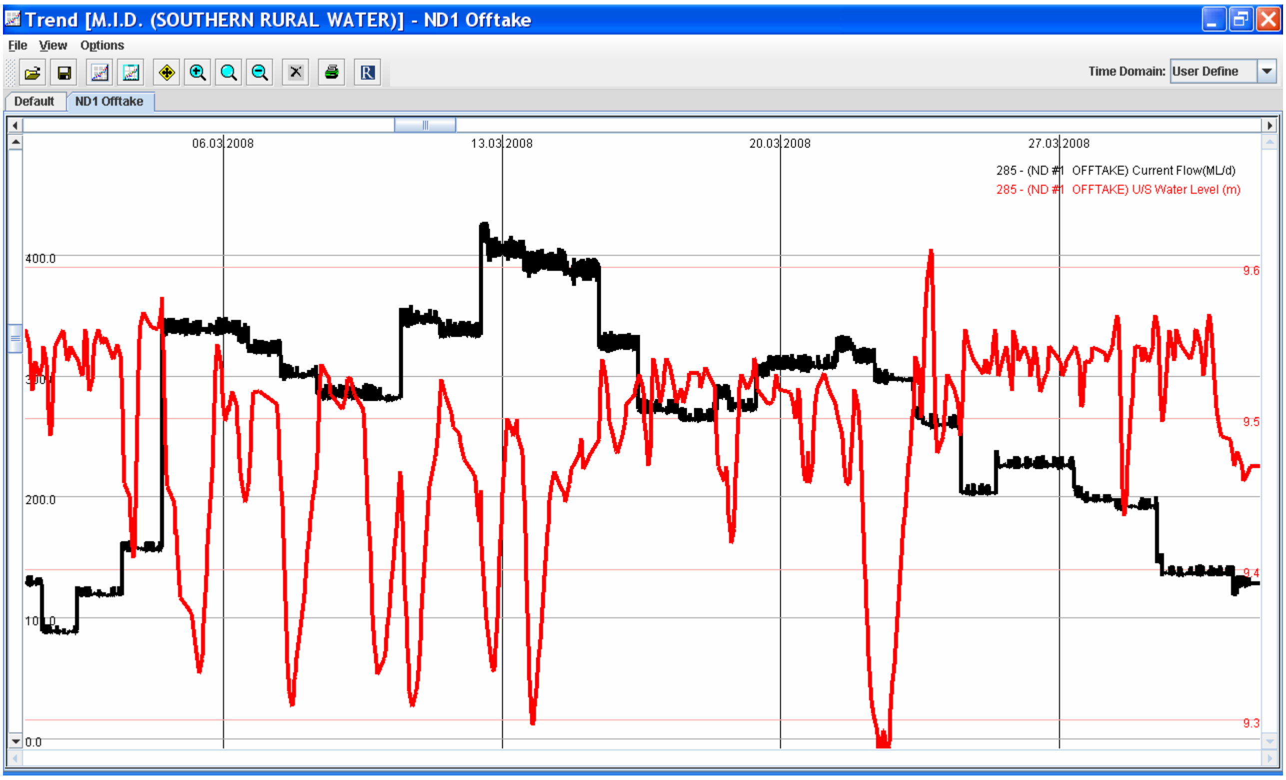

Figure 4- Flow at Top of ND1 system with Upstream Water level form manual control

Figure 5 illustrates the automated flow being released from the Northern channel from Lake Glenmaggie to maintain a “constant” water level at the next downstream regulating structure. Note that the significant changes in flow from the dam are made to maintain a near constant water level downstream, despite varying demand. Note that the water level deviations vary no more than 50 mm, albeit that the changes are much more frequent than would be seen in a manually regulated system.

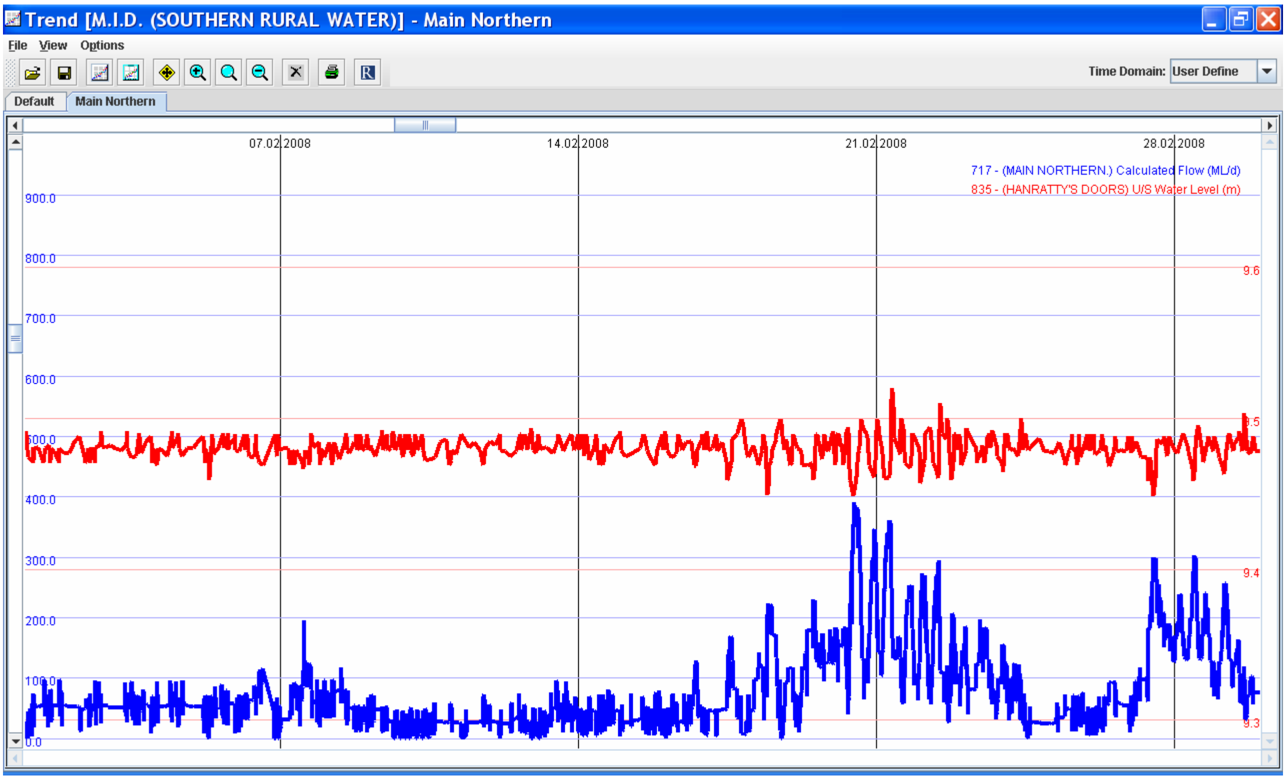

Figure 5- Flow from Northern Outlet of Glenmaggie and water level at downstream regulator

8. CONCLUSIONS

This paper seeks to outline the key human issues associated with the large scale automation of open channel systems. Management of the human aspects of the change process is clearly a critical success factor in the automation of channel systems. The authors experience is that too much "upfront" attention has been focussed on the technology infrastructure and less attention has been paid to staff and customer concerns regarding the change process. Issues with the technology implementation undermine staff and customer confidence. For successful implementations it is critical for management to acknowledge and plan for the staff and customer changes in parallel with the equipment installation.

Engagement with people is clearly a critical aspect of project delivery. The additional knowledge made available by the channel automation technology provides considerable insight into the operation and management of irrigation systems and provides managers with the tools required to formally quantify performance. This information is critical to improving management.

9. ACKNOWLEDEMENTS

The authors wish to gratefully acknowledge Southern Rural Water for this use of information from its implementation of channel automation technology in the Macalister Irrigation District in South Eastern Victoria and Clinton Rodda in particular for his desire to develop meaningful measures of system performance and customer service.

---

[i] ANCID Benchmark Report 2006