Assessment of the State-of-the-Art of Remote Irrigation Control Systems

Field Guide

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NOTICE

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Ray Traynor	District 11
Tom Tuck	District 11
Kevin Tong	District 12

FIELD GUIDE

INTRODUCTION

This field guide is an abridged reference for the main report entitled "Assessment of the State-of-the-Art of Remote Irrigation Control Systems" by Ian Turnbull and Manuel Ruiz. Both the main report and the field guide are the result of research conducted by California State University, Chico for the California Department of Transportation. The field guide is intended to provide a quick way of comparing RIC systems and their Communication Link transmission methods. For a more detailed study of Remote Irrigation Control systems and related equipment the main report should be consulted. A set of contact references for RIC system manufacturers and Caltrans personnel is also included, see table 2.

RIC System Features

A table of the salient system features used to describe the RIC systems surveyed in this guide plus some additional explanations are furnished here for comparison purposes. This set of features, presented in table 1, covers the system's intended design applications, irrigation-specific programming features, data acquisition, communications and utility functions. The reader must be aware the actual implementation of these features generally differs from system to system and should refer to the system surveys (section 3.3 of the main report) for more implementation details.

Full central control indicates that the system meets the RIC model and that most controller features can be accessed from the Main Control Unit (MCU). Highway, municipality, park systems and golf course are the main application categories for RIC systems covered here. The basic requirements used to classify a RIC system for highway applications are the use of generic irrigation terminology in the software user interface and the Communication Link capability to reach widely distributed remote sites.

The irrigation programming features cover the programming paradigms supported by the RIC system. Time based programming means that water delivery is specified in terms of time units, while volume based programming means that volume units are used instead. Volume based programming requires the use of flowmeters. Sensor based programming refers to the ability of the system to allow specification of custom actions to be executed in response to selected sensor readings, e.g., cancel irrigation at this site if the wind speed exceeds 25 mph. Filter and fertilizer programming means that the system software explicitly supports programming the operation of such equipment (as opposed to using dummy stations for the same purpose). Water budgeting refers to the ability of the system to adjust water delivery by percent factors of the original irrigation program. ET driven irrigation means that evapotranspiration data are used by the system to determine water delivery requirements. Flow optimization means that the system is able to automatically rearrange the sequence of irrigation to maintain an even operating target flow, thus avoiding damaging pressure transients in the water delivery system. Soil model based adjustments include soil type, compaction, infiltration rate and other factors of a soil model provided by the system to characterize the water demands of the remote stations. Infiltration rate compensation refers to the ability of the system to automatically divide the application of the target amount of water delivery so as to avoid runoff. Moisture sensing refers to the explicit built-in support of moisture sensors to regulate

irrigation. Extensive environmental adjustment factors include exposure, slope, vegetation type, and others used to characterize the water demands of the remote stations.

Data acquisition and monitoring refers to the ability of the system to gather and monitor data from different types of sensors such as flowmeters, rain gages, etc. Integrated weather station support means that weather station data can be automatically monitored and used by the system for irrigation scheduling, as opposed to using third party software to gather the data and then entering it into the RIC system.

Alarm response definition enables the user to select predefined actions or to program custom responses to alarm conditions detected by the system. Alarm paging refers to the ability of the system to page selected operators when alarm conditions arise.

Manual operation with a hand held radio unit means users can manually operate the remote controllers on-site with a portable radio unit.

Distributed intelligence indicates that the system's remote site controllers (RSCs) are capable of autonomous execution of irrigation programs downloaded from the Main Control Unit (MCU). In this manner contact with the MCU is not necessary after program download.

Multitasking refers to the ability of the MCU to run multiple programs simultaneously. This allows the operator to perform other tasks such as word processing or data manipulation while the RIC system functions are performed in the background. Graphical user interface refers to the use of icons and pointing devices to interact with the MCU software. Extensive reporting capabilities indicates the ability of the system to report information such as water consumption, alarms, communications logs, etc. Data export support means that data gathered by the system can be ported to third party software such as spreadsheets, databases, etc. Password protection refers to the ability of the system to require passwords from users when the MCU software or the RSCs are accessed. Foreign language support means that the MCU or RSC user interfaces are available in a foreign language.

Table 1 Summary of RIC System Features

	Buckner COPS Universal	Griswold IDC Central	Motorola MIR 5000	Rain Bird Maxicom	Thompson Mini Mark	Toro Network 8000	Aquametrics COM-1	Buckner COPS Genesis	NSC Control	Rain Master Evolution	Solar Wind System 390-B	Thompson Mark-1	Valcon V-III	Valcon VIP
Full Central Control	O	O	O	O	O	O		O		O	O	O	O	
Highway applications	O	O	O	O	O	O	O	O	O	O			O	O
Municipality applications	O	O	O	O	O	O	O	O	O	O			O	O
Park systems applications	O	O	O	O	O	O	O	O	O	O			O	O
Golf course applications	O	O	O		O	O	O	O	O	O	O	O	O	O
Time based programming	O	O	O	O	O	O	O	O		O	O	O	O	O
Volume based programming			O											
Sensor based programming			O	O										
Filter and fertilizer programming			O											
Water budgeting	O	O	O	O	O	O		O	O	O	O	O	O	O
ET driven irrigation			O	O	O	O						O		
Flow optimization				O	O	O						O		
Soil model based adjustments				O		O								
Infiltration rate compensation				O		O	O			O				O
Moisture sensing					O		O			O		O	O	O
Extensive environmental adjustment factors						O								
Data acquisition and monitoring		O	O	O	O	O	O				O	O	O	O
Integrated weather station support			O	O	O	O		O				O		
Alarm response definition			O	O		O								
Alarm paging			O											
Hard wire interface		O	O	O	O	O		O			O	O	O	O
Radio interface	O	O	O	O	O	O	O		O	O	O	O	O	O
Trunked radio interface			O	O									O	
Cellular telephone interface		O		O	O	O	O			O		O		
Dial telephone interface		O		O	O	O	O	O		O	O	O	O	O
Private line telephone interface			O			O								
Manual operation with hand held radio unit	O	O	O	O	O					O	O	O	O	O
Distributed intelligence		O	O	O	O	O		O		O		O	O	O
Multitasking			O		O					O		O		
Graphical user interface					O	O				O		O		O
Extensive reporting capabilities			O	O	O	O								
Data export support					O							O		
Password protection		O	O	O									O	
Foreign language support		O	O	O	O	O						O		O

Table 2 RIC System Manufacturer Reference

System	Company	Contact	Phone Number
COPS Universal COPS Genesis	Buckner 4381 Brawley Avenue Fresno, CA 93722	Kurt Thompson National Sales-Golf	(209) 275-0500 Corporate office (209) 276-7829 Home office
IDC Central	Griswold Controls 2803 Barranca Road Irvine, CA 92714	Stephen W. Sawdon General Manager	(714) 559-6000 Corporate office
MIR 5000	Motorola 9912 Business Park Drive, Suite 130 Sacramento, CA 95827	Eric Scott Area Sales Engineer, Electronic Command and Control Systems	(916) 854-2800 District office (916) 854-2813 Direct line
Maxicom Maxicom Jr.	Rain Bird 145 North Grand Avenue Glendora, CA 91740-2469	Sally Prusia Maxicom Technical Specialist	(818) 963-9311 Corporate office (714) 981-1489 Home office
Mini-Mark MarK 1	Thompson Manufacturing Co. 5075 Edison Avenue P.O. Box 1500 Chino, CA 91708	Jack Kincaid District Sales Manager, Commercial Products Division	(714) 591-4851 Corporate office (510) 706-2342 Home office
Network 8000	The Toro Company, Irrigation Division 5825 Jasmine Street Riverside, CA 92504-1183	Jon Williams Product Manager, Golf Marketing & Sales	(714) 688-9221 Corporate office (714) 785-3392 Direct line
COM-1	Aquametrics Inc. 7764 Arjons Drive San Diego, CA 92126-4365	C. Michael Ruscoe Northwestern Regional Manager	(619) 693-8182 Corporate office (408) 338-7037 Home office
NSC Control	Network Services Corporation 561 Sky Ranch Drive Petaluma, CA 94954	Michael Marian Vice-President	(707) 769-9696 Corporate office
Evolution	Rain Master 5290 N. Valentine, #201 Fresno, CA 93711	Nick M. Dvorak Director, Sales/Marketing	(209) 276-8450 Corporate office
System 390-B	Solar Wind Systems, Inc. 37 Commercial Boulevard Novato, CA 94947	Michael Marian President	(415) 883-0404 Corporate office
V-III VIP	Valcon Automatic Irrigation Equipment Company 10837 Central Avenue South El Monte, CA 91733	Robert Goldman Chief Executive Officer	(818) 444-5466 Corporate office

Caltrans Personnel Reference

Following is a list of RIC-related Caltrans personnel (refer to section 3.5 of the main report for more information).

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RIC Communication Links

This section presents the RIC Communication Links (CLs). A short summary of the practical considerations covered in the communications surveys is given, followed by a tabular presentation of key design features. A more detailed analysis of the CLs outlined here is presented in the main report (section 2.10).

Hard Wire

Reliability is good. Cable burial is required. Nearby power cables, underground splicing and moisture are to be avoided. Damage may be caused by lightning, rodents, and excavation accidents.

Bus and its tree derivatives are the most commonly supported topologies. Ring topologies are cost prohibitive for long distances, but make quick recovery from cable breaks possible. Link access and release times are adequate for polling. System-wide commands are supported.

Installation into existing sites can be impractical when existing piping, cabling and plants obstruct the cable route. New sites can be hard wired more easily at the time of construction because proper routing may be planned with the total project.

Maintenance requirements consist mostly of occasional repairs of accidental cable breaks. This task can be performed with inexpensive equipment and is eased by designing the system so that it can be sectionalized expediently to isolate the fault.

There are no licensing requirements but easement agreements from the MCU to the highway right-of-way may be required.

Table 3 presents typical hard wire costs. Installation costs are very much site and RIC system specific. They include the cost of the cable, trenching and easement agreements when required. There is no charge per connection during system operation. Because the cost of the cable and trenching are proportional to distance, this type of CL is only practical for short to moderate distances or to link a local cluster of RSCs that is then linked to a distant MCU via telephone or radio CLs.

Table 3: Typical Hard Wire Costs

ITEM	COST
Direct bury cable, type as specified by RIC manufacturer	Cost is site and system specific; typical costs per 1000' range from $170 for direct burial flat cable, to $570 for direct burial shielded twisted pair cable
Trenching and installation	Cost is site specific, estimate on a case by case basis
Easement agreements	Cost is site specific, estimate on a case by case basis

Dial Telephone

Reliability is generally good but can be marginal in some areas with aging facilities and equipment. This may occur in both rural and urban areas.

Topology support is limited to star topology and its derivatives. System-wide commands are not supported because RSCs or small RSC clusters must be accessed serially. Link access and release times are long due to switching; this makes polling of large systems impractical.

Points of connection to the PSTN are available in proportion to population density. Bringing new service to remote (mostly rural) areas is often too expensive to be practical where other alternatives are available. Drop cables and an overhead drop pole may be necessary in some sites.

Maintenance is limited to the equipment at the subscriber's premises. The local telephone company is responsible for maintenance of their network up to the network interface.

There are no licensing requirements but easement agreements for routing of drop cable may be necessary.

Table 4 presents typical dial telephone costs. Installation costs include a basic service activation fee, easement agreements, and trenching or overhead drop pole. Operational costs include a monthly service fee, a monthly federal access charge, and per call charges. Some Caltrans districts have negotiated special rates with their local exchange carriers. Exact price quotations should be obtained from the Caltrans district telephone coordinator.

Table 4: Typical Dial Telephone Costs

ITEM	COST
Basic activation fee (per line for installation at MCU and each RSC)	$70.75
Pole installation for overhead drop (per site)	Incurred only if overhead drop is used, cost is site specific, estimate on a case by case basis
Trenching and covering for underground drop installation (per site)	Incurred only if underground drop is used, cost is site specific, estimate on a case by case basis
Easement agreements	Cost is site specific, estimate on a case by case basis
Basic monthly rate (per line, at business rate)	$8.35
Federal access charge (per line, per month)	$4.14
Per outgoing call charge (day rate, toll charges extra)	$0.04 for first minute, $0.01 for each additional minute

Private Line Telephone

Reliability is generally good but can be marginal in some areas with aging facilities and equipment. This may occur in both rural and urban areas. Blocking problems like those of switched telephone services or trunked radio do not occur.

Topology support is limited to star topology and its derivatives. Two point and multipoint configurations are available. System-wide commands are supported by multipoint connections (because there is no switching involved). Link access and release times are short and make polling of large systems possible.

Points of connection to the telephone network are available in proportion to population density. Bringing new service to remote (mostly rural) areas is often too expensive to be practical if other alternatives are available. This service may not be available in many areas. Drop cables and an overhead drop pole may be necessary in some sites. For some types of private line circuits the network interface equipment requires 120-VAC power.

Maintenance is limited to the equipment at the subscriber's premises. The local telephone company is responsible for maintenance of their network up to the demarcation point.

There are no licensing requirements but easement agreements for routing of drop cable may be necessary.

Tables 5 and 6 present typical private line telephone costs for data transmission channel and local area data channel. Installation costs include a service installation fee, easement agreements, and trenching or overhead drop pole. Operational costs include a monthly service fee and monthly mileage charge between COs, but no per call charges. Monthly charges are based on distance. Some Caltrans districts have negotiated special rates with their local exchange carriers. Exact price quotations should be obtained from the Caltrans district telephone coordinator.

Table 5: Typical Private Line Telephone Costs, Data Transmission Channel Service

ITEM	COST
Installation fee for two sites from the same CO (include MCU)	$716.00
Installation fee for additional sites from the same CO (per site)	$357.00
Pole installation for overhead drop (per site)	Incurred only if overhead drop is used, cost is site specific, estimate on a case by case basis
Trenching and covering for underground drop installation (per site)	Incurred only if underground drop is used, cost is site specific, estimate on a case by case basis
Easement agreements	Cost is site specific, estimate on a case by case basis
Monthly charge for two sites from the same CO (include MCU)	$55.88
Monthly charge for additional sites from the same CO (per site)	$27.94
Monthly mileage charge between COs 01 to 10 miles 11 to 15 miles 16 to 20 miles 21 to 60 miles	 $5.23 per mile $3.16 per mile $3.01 per mile $2.64 per mile

Table 6: Typical Private Line Telephone Costs, Local Area Data Channel Service

ITEM	COST
Installation fee	$716.00
Pole installation for overhead drop (per site)	Incurred only if overhead drop is used, cost is site specific, estimate on a case by case basis
Trenching and covering for underground drop installation (per site)	Incurred only if underground drop is used, cost is site specific, estimate on a case by case basis
Easement agreements	Cost is site specific, estimate on a case by case basis
Monthly charge	
Four-wire circuit	$55.88
Two-wire circuit	$37.58

Cellular Telephone

Reliability is good. Blocking may occur at peak travel times along major commuting arteries. Good quality coverage is available in major metropolitan areas, most medium sized towns, many small sized towns and along most major highways.

Topology support is limited to star topology and its derivatives. System-wide commands are not supported because RSCs or small RSC clusters must be accessed serially. Link access and release times are long and make polling of large systems impractical.

An unobstructed line of sight path is necessary from each RSC location to the nearest cell site.

Maintenance of the cellular equipment is the responsibility of the user. Maintenance service contracts are available.

There are no direct licensing requirements.

Table 7 presents typical cellular telephone costs. Installation costs include a service establishment fee, the cost of the cellular telephone equipment, and possibly the installation of a pole for the cellular transceiver antenna. Operational costs include a monthly access charge and per call charges. Caltrans has contracted with Cellular One for cellular telephone service. A special liaison at the Division of Maintenance, Office of Telecommunications, has been

authorized to assist with the purchase, installation, and activation of cellular telephone service. For assistance contact Mr. Dayle Goldsberry, (916) 324-1964.

Table 7: Typical Cellular Telephone Costs

ITEM	COST
Service establishment (per access number, per site)	$15.00 to $20.00
Cellular telephone equipment (Motorola cellular connection transceiver, antenna and power supply, per RSC)	$605.00 to $710.00
Cellular telephone equipment installation (per RSC)	$150.00 (Cellular One price)
Pole installation for antenna	Incurred only if additional antenna height is desired, cost is site specific, estimate on a case by case basis
Access charge (per month, per RSC)	$10.00 to $35.00
Usage rates (per minute, toll charges extra)	$0.20 to $0.39 for peak period, $0.12 to $0.23 for off-peak period
Equipment maintenance contract (per RSC)	$4.95 per month with a $50.00 deductible, plus an on site repair fee of $60.00 per hour and $0.30 per mile for each call out (Cellular One price)

Conventional Radio

Reliability is often difficult to guarantee due primarily to path uncertainties and radio spectrum congestion. An engineering analysis is necessary to assure reliability. Urban areas are typically more prone to unexpected interference problems that rural areas.

The star topology and its derivatives are the most popular. Because an unobstructed line of sight (LOS) path is required to every device in the network, a repeater at a mountain top location is sometimes the hub of the star. System-wide commands are supported because RSCs or small RSC clusters can be accessed simultaneously. Link access and release times are short and make polling of large systems practical.

The Department of General Services, Telecommunications Division, is responsible for the maintenance of all conventional radio systems used by Caltrans. This department establishes maintenance schedules and provides technicians to perform the necessary work.

FCC licensing is required and must be obtained through the Department of General Services, Telecommunications Division Request for licensing should be directed to Mr. Dan Johnson, Division of Maintenance, Office of Telecommunications at (916) 445-5090. Data communications are secondary to voice communications in Private Land Mobile Radio Services, the service used by most RIC conventional radio links. The Office of Telecommunications handles the frequency coordination process to obtain Highway Maintenance service frequencies The Department of General Services, Telecommunications Division, requires an initial engineering study to determine the feasibility of using conventional radio.

Table 8 presents typical conventional radio costs. The installation costs include the initial engineering study, and the radio equipment and its installation. The FCC license fee is included in the initial engineering study. There are no usage fees or charges per connection.

Table 8: Typical Conventional Radio Costs

ITEM	COST
Initial engineering study required by Communications Division (per system)	$3500.00 to $5500.00 (price is based on an hourly rate, cost will vary on a case by case basis)
Frequency coordination fee	Included in initial engineering study
License fee	Included in initial engineering study
Transceiver, modem, power supply, cables and antenna	$1000.00 to $2600.00 (per RSC), $1100.00 to $4200.00 (for MCU), radio equipment is specified by the RIC system manufacturer
Radio equipment installation	$100.00 to $225.00 (per RSC), $100.00 to $475.00 (for MCU), installation is usually included in RIC system price
Maintenance fee required by Communications Division	Price is based on an hourly rate until a system history is established, a fixed rate is then calculated, cost will vary on a case by case basis

Trunked Radio

Reliability is adequate for RIC applications. Good quality coverage is available in all major metropolitan areas and most medium sized cities. Blocking may occur in SMR systems during heavy traffic periods, especially if low priority service is used.

The star topology and its derivatives are the most popular. An unobstructed line of sight (LOS) path from the repeater site to every device in the network is required. System-wide commands are supported because RSCs and RSC clusters can be accessed simultaneously. Link access and release times are adequate to make polling of large systems practical on a sporadic basis only.

Maintenance is limited to user owned equipment, i.e., transceivers, cables and antennas. SMR service providers offer maintenance contacts.

End user FCC licenses are required and are granted immediately to SMR users. Operational fixed stations (e.g., RSCs) are licensed to transmit data on a secondary basis to voice communications.

Table 9 presents typical trunked radio costs. Installation costs include the cost of the trunked radio equipment, a service activation fee and the FCC end user license fee. Operational costs include a monthly repeater rental fee and, possibly, per connection charges (see note in table 9). Special liaisons at the Division of Maintenance, Office of Telecommunications, Special Projects Branch, have been authorized to oversee the purchase, installation, and activation of trunked radio service. They are Mr. John Schmidt, (916) 327-6210, and Mr. Ron De Leon, (916) 324-8954.

Table 9: Typical Trunked Radio Costs

ITEM	COST
Service activation (per system)	$100.00 to $150.00
End user license fee	$35.00
Trunked radio equipment (Transceiver, antenna, and power supply, per RSC and for MCU)	$970.00 to $2850.00
Trunked radio equipment installation	$140.00 to $225.00 (per RSC) $250.00 to $475.00 (for MCU)
Repeater rental (per RSC and for MCU)	$13.00 to $20.00 (per month), 75 minutes per month usage, $0.30 for each additional minute *
Equipment maintenance contract	4.5% of radio equipment purchase price, per month

* For purchases of the Motorola MIR 5000 system, Motorola will provide SMR service as well as the RIC system. The cost of SMR service in this situation is substantially lower. The repeater rental is from $3.00 to $5.00 per RSC and for the MCU. Also, there is no per minute usage fee.

Table 10 presents a summary comparison of RIC system CL features. For more information on how to select the proper CL for RIC implementation refer to section 2.11 of the main report.

Table 10 Summary of RIC System CL Features

	Hard Wire	Dial Telephone	Private Line Telephone	Cellular Telephone	Conventional Radio	Trunked Radio
All Call Support	Yes	No	Yes	No	Yes	Yes
Polling Support	Yes	Yes, but can be impractical for large systems	Yes	Yes, but can be impractical for large systems	Yes	Yes
Multiple Access Support	Yes	Yes	Yes	Yes	Yes	Yes
Licensing Required	No	No	No	No	Yes	Yes, instant approval for SMR users
Installation Cost(s)	Trenching, cable, possible easement agreements	Service activation, trenching or overhead pole, possible easement agreements	Service installation, trenching or overhead pole, possible easement agreements	Service activation, cellular equipment, installation, antenna pole	Engineering and licensing study, radio equipment, installation	Service activation,FCC end user license, trunked radio equipment, installation
Ongoing Cost(s)	None	Monthly service and federal access fees	Monthly service and monthly milage charge between COs	Monthly access charge, maintenance contract	Maintenance fee	Monthly repeater rental, maintenance contract
Charge per Connection	No	Yes	No	Yes	No	Yes*
Reliability	Good	Good generally, but marginal in some areas	Good	Good	Good in rural areas, marginal to poor in urban areas	Good
Line of Sight Required	No	No	No	Yes, to cell site	Yes	Yes, to repeater site
Trenching Required	Yes	Possibly, for drop only	Possibly, for drop only	No	No	No
Urban Area Coverage	Yes, for new construction	Yes	Yes	Yes	Marginal, usually congested	Yes
Rural Area Coverage	Usually impractical	Yes	Yes, but service not available in some areas	Yes	Yes	Yes

* For purchases of the Motorola MIR 5000 system, Motorola will provide SMR service as well as the RIC system. The cost of SMR service in this situation is substantially lower. The repeater rental is from $3.00 to $5.00 per RSC and for the MCU. Also, there is no per minute usage fee.