AN OPERATIONS ADVISOR FOR REGIONAL WATER MANAGEMENT

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ABSTRACT: The application of artificial intelligence techniques was evaluated for implementation for water control structure operations at the South Florida Water Management District (District). After an analysis of operational needs within the District, and an evaluation of available hardware and software packages, the decision was reached to develop a comprehensive real-time operations advisory system. The prototype is currently scheduled for completion in April 1988, with full-scale implementation scheduled for late 1989.

INTRODUCTION

The South Florida Water Management District (District) operates more than 200 water control structures along 2000 miles of primary canals within its 18,000-square mile domain. Seasonal demand for agricultural and municipal water supply, year-round flood protection and protection of coastal well fields from salt water intrusion, environmental quality enhancement, as well as site-specific legal and other constraints, combine to create a very complex decision making arena for the Operations staff at the District.

The District is developing a comprehensive decision support system to aid in the operation of its water control structures. The Operations Assistant and Simulated Intelligence System (OASIS) program will monitor and display real-time hydrologic and meteorologic data and structure status, provide multiple levels of current and projected high and low water alarm detections, incorporate a versatile current and historic data plotting package, and features an operations advisor expert system. The prototype includes 31 stations and is scheduled for completion by summer 1988; full implementation of the OASIS program is scheduled for December 1989.

BACKGROUND

The general operational strategy of the District's physical system is to provide adequate flood protection during the wet season (June through October) by placing water into storage and discharging excesses to the ocean; and to draw from the storage areas for water supply during the dry season (November through May). This strategy also incorporates protection of the environmental and water quality values of the lakes, wetlands and estuaries in South Florida. As part of the design of the C&SF Project, the COE developed general operating guidelines for

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each of the project's water control structures. These guidelines suggest appropriate gate levels and pumping conditions for specific objectives, including safely passing the design flood, supplying water demands during the dry season,preventing saltwater intrusion, providing discharge to the Everglades National Park, and facilitating water movement and conditions during normal operations. Concurrent with the normal operating guidelines are various local operating policies which have been derived from environmental considerations, development pressures, agricultural demands and other socio-economic concerns.

An additional set of operating guidelines has arisen from communication with the local users of the water supply/flood control system. For example, during the semiannual growing seasons in the Everglades Agricultural Area (EAA), the District diverts water from appropriate storage reservoirs to the local agricultural areas in anticipation of and in response to agricultural- related water supply demands. However, the stormwater pumping capacity of the secondary canal system within the EAA greatly exceeds the conveyance capability of the District-operated primary canals and it is necessary to anticipate the pumping events in order to avert local flooding.

Data Acquisition.- Water level gages located throughout the District's canals and reservoirs provide the primary measure of hydrologic conditions in the system. Current hydrologic and meterologic data are collected by field personnel, telephone-based units and through the District's microwave telemetry network, consisting of an expansive network of over 650 electronic sensors located at 44 of the major water control stations south of Lake Okeechobee. Sensors at each station are automatically interrogated between 1 and 4 times per hour during normal operations, generating approximately 65,000 records of information each day during. In addition to scheduled acquisitions, Control Room personnel can interrogate sensors as frequently as once per minute during inclement weather or to monitor maintenance operations; during severe weather conditions requiring frequent data scans, up to 250,000 records per day of information are processed by the telemetry network.

Decision Factors.-Control structure operation decisions are based on the analysis of many related hydrologic and meteorologic factors; rarely are decisions based on a value of a single parameter. In addition to the instantaneous water level in the canal, factors which enter the decision process include trends in the canal stage, the local precipitation forecast, antecedent rainfall conditions, the present capabilities of the canal's water control structures, notices from District constituents which are affected by canal water levels, and other site specific operating constraints. The extensive data acquisition program maintained at the District provides the Operations decision makers with sufficiently detailed information to evaluate these factors.

DEVELOPMENT OF OASIS

In the spring of 1985, the District formalized a committment to develop an AI application within one area of its daily operations. District staff attended various national conferences and conventions to gain enough background information to evaluate the possible applications as well as to evaluate the available hardware and software products. In the fall of 1985 the District selected the Operations project as the application. The resident domain expert was within a few years of retiring, the operating rules had developed from single-objective hydraulic constraints to encompass multiple objectives, a high proportion of the operating rules were not well-documented (private knowledge as opposed to public

knowledge contained in the manuals), and the efficiency of the Control and Communication System created an information overload situation, with the experts unable to process each of the data generated. Mr. Richard Slyfield, Director of the Operations Division and Mr. George Hwa, Assistant Director, are the experts whose operations expertise will be embodied in the OASIS program. Together, they have over 20 years of experience with the District's operations.

An extensive search process culminated in formal presentations by three combinations of hardware and software firms. The District selected a Symbolics 3640 computer and the Automated Reasoning Tool (ART) from Inference Corp. for the development of OASIS.

The SFWMD opted to designate a water resources engineer to design and develop the OASIS program as opposed to someone with formal training in computer science; this decision was based on the assumption that the knowledge acquisition and functional design processes would be easier for an engineer familiar with the fundamental physical principles and operational aspects of the District's operations. In August of 1986, Gary Goforth, an engineer with over 15 years of computer experience, initiated the formal development of the OASIS program.

DEVELOPMENT SCHEDULE

The origrinal schedule called for a prototype to be developed within 12 months, with approximately 2 man-years of effort. The prototype will then be evaluated during an additional 6-12 months for proof of concept, performance, and expansion capability. If the prototype is evaluated to be adequate, expansion will include the remaing water control structures in the District over a 12-24 month period. OASIS will be used in an advisory capacity in the Operations Control Room environment. It will be a dynamic advisor, incorporating new operating procedures as they are implemented. Anticipated benefits of OASIS fall into two categories, daily operations and operations support. Benefits expected to accrue during daily operational activities include

1. Routine system-wide monitoring will be provided on a consistent and comprehensive basis.
2. Decision makers will be fully informed of changing conditions at all times.
3. Continuous analyses of data trends will identify impending alarm conditions.
4. The operations expertise of multiple experts are combined.
5. Operations advice during crisis conditions will not be influenced by emotions.
6. Consistency of operations should provide more defensibility of actions, as well as enable better coordination with local water management districts.

Benefits expected to accrue in support of operations include

1. The knowledge extraction process has provided documentation of previously undocumented operating rules.
2. The rules have been further evaluated as they are organized.
3. Using the advisor to accurately and quickly determine the influence of proposed operating strategies on existing operations.
4. The advisor can act as a training tool for operations staff.

SUMMARY

The application of artificial intelligence techniques was evaluated for implementation for water control structure operations at the South Florida Water Management District (District). After an analysis of operational needs within the District, and an evaluation of available hardware and software packages, the decision was reached to develop a comprehensive real-time operations advisory system. The prototype is currently scheduled for completion in April 1988, with full-scale implementation scheduled for late 1989.