

## THE OASIS PROTOTYPE

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**ABSTRACT:** The prototype of OASIS, an advisory system for the operation of water control facilities within the South Florida Water Management District, was completed in May 1988. The prototype was developed for one of the 12 major hydrologic basins within the District and incorporated the major functional elements of the OASIS conceptual design, including the real-time display of hydrologic and meteorologic data, continuous data trend analysis for alarm conditions, and an operations advisor expert system. Over the subsequent 12 months, an extensive evaluation of the capabilities and limitations of the completion of OASIS prototype will be conducted by internal staff and external consultants. Evaluation criteria will include suitability of program to operations decisions, performance speed, appropriate use of available software and hardware, maintenance ease, acceptance by end users, accuracy, consistency and completeness of operations advice, and expansibility.

### 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. To aid in the operation of its water control structures the District is developing a comprehensive decision support system, referred to as the Operations Assistant and Simulated Intelligence System (OASIS). The advisory system will monitor and display real-time hydrologic and meteorologic data and structure status, provide multiple levels of current and projected alarm conditions, incorporate a versatile data plotting package, and feature an operations advisor expert system.

Once the decision was made to develop OASIS, a schedule of activities leading to the completion of a prototype was generated. The initial element of the schedule was a prework conference which brought the system developers together with the operations experts, control system engineers, control room radio operators and District management. Subsequent tasks included formalizing a conceptual system design, assembling a detailed scope of work, allocating development work among internal staff and external consultants, taking an

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inventory of the data and data analysis tools used by the experts, documenting the various operational rules, and testing various knowledge representation paradigms. The prototype was developed jointly by the District and Inference Corporation. District staff developed the conceptual design, conducted the knowledge acquisition interviews, formalized the knowledge representation, and established the communications links between the Symbolics and other computers. On a contract basis, Inference staff encoded the functional framework, i.e., the interfaces between the different components of OASIS, prepared the initial District maps, and designed the preliminary data storage format.

## DESCRIPTION OF THE PROTOTYPE

Consistent with other major applications of a new technology, a reduced scale prototype was designated for OASIS to evaluate the technical feasibility of the advisory concept. The prototype concentrated on the development of OASIS features for a subset of the District's water control stations and telemetry network. The Everglades Agricultural Area (EAA) is one of the 12 major hydrologic basins that compose the District's 18,000 square mile domain, and was selected as the prototypical region because of the variety and operational complexity of its component stations. The EAA is bounded by Lake Okeechobee on the north and three large water conservation areas to the south and southeast. In all, 31 stations are located within the EAA, encompassing over 80 sensors, more than 50 water control gates, and 8 major pump stations located on four primary conveyance canals.

The OASIS prototype incorporated four functional elements:

1. Operations Status - displays real-time hydrologic and meteorologic data;
2. Operations Assistant - displays current and historic time series of data for trend analysis;
3. Operations Advisor - is the control structure operations expert system; and
4. Alarm Status - provides continuous background data analysis for detecting present and anticipated alarm conditions, complete with suggestions for ameliorating the identified alarm conditions.

The prototype is executed through a highly interactive color graphics interface which utilizes a combination of the Symbolics Lisp Color system and Inference's color ARTIST capabilities. A series of maps serves as the means to locate stations of interest, and screen menus are available to select OASIS functions. Desired basins, stations and operations are accessed by moving the mouse-controlled cursor arrow to the appropriate location on the screen. Keyboard interaction is required only to enter optional station information.

The design and development of the OASIS prototype was free from constraints imposed by a specific end-product delivery system. With the implementation horizon two to three years beyond the design phase, there was no certainty what the run-time environment would be. The full flexibility of the available hardware/software development environment was utilized to create the functionality required by the OASIS conceptual design. The objective of the prototype was to

evaluate the feasibility of the concept, and this should not be limited by hardware or software constraints. To keep track of the changing possibilities, project staff monitored new developments in relevant hardware and software packages during the prototype development. After the scheduled evaluation of the prototype,

The real-time data for the OASIS prototype are accessed from the District's telemetry network host computers (Modcomp Classic series) and are converted directly into the knowledge base data storage format. In an effort to reduce the Symbolics CPU load, the data conversion is conducted on the Modcomp prior to transmission to the Symbolics.

A background process within the OASIS prototype analyzes the incoming data for current or projected alarm conditions. Present trends are extrapolated for 24 hours and 7 days to identify impending conditions which would require control operations. The presence of any level of alarm urgency is communicated to the control room operators through an alarm window which is present during all OASIS operations. The color of the alarm window reflects the urgency of the situation, flashing red represents conditions which require immediate attention, such as high water levels with a threat of economic or health damages, flashing yellow represents conditions which need attention soon to prevent alarm conditions that may arise within the next 24 hours, and flashing green signals the possibility that a problem may arise within the next 7 days. Details of the alarm conditions are obtained by selecting the alarm window with the mouse. Suggested operations for ameliorating each alarm condition are provided upon request.

The OASIS program incorporates the dual capability of providing decision-making support to the control room operators with the supplemental ability to complete the decision process by suggesting appropriate control structure operations.

## PROTOTYPE EVALUATION

During the 12 months following the completion of the OASIS prototype, the prototype will undergo extensive internal and external review. The District's operations staff will evaluate the accuracy, consistency and completeness of the expert system and other OASIS features. In addition the performance speed of the prototype will be analyzed with respect to the time requirement for the operations decisions. The data format of the knowledge base will be evaluated with regard to storage and retrieval performance, considering the interaction with the Modcomp system and the archive data storage computers. External consultants will analyze the prototype on the basis of efficient and effective utilization of hardware and software capabilities.

## FULL IMPLEMENTATION

Following the OASIS prototype evaluation, results of the technical analyses will be reviewed. If the District staff and external consultants agree that the prototype can retain its basic framework, the design revisions will be incorporated. However, if the consensus

is that the prototype structure is not appropriate for the OASIS objectives, major modifications will be implemented, up to discarding the prototype, if necessary. Regardless of the final evaluation recommendations, the prototype has satisfied the fundamental requirement of a knowledge-base prototype in that it has allowed the the District to test the concept of applying artificial intelligence techniques to the decision-making arena of water control structure operations.

#### SUMMARY AND CONCLUSIONS

The prototype of OASIS, an advisory system for the operation of water control facilities within the South Florida Water Management District, was completed in May 1988. The prototype was developed for one of the 12 major hydrologic basins within the District and incorporated the major functional elements of the OASIS conceptual design, including the real-time display of hydrologic and meteorologic data, continuous data trend analysis for alarm conditions, and an operations advisor expert system. Over the subsequent 12 months, an extensive evaluation of the capabilities and limitations of the completion of OASIS prototype will be conducted by internal staff and external consultants. Evaluation criteria will include suitability of program to operations decisions, performance speed, appropriate use of available software and hardware, maintenance ease, acceptance by end users, accuracy, consistency and completeness of operations advice, and expansibility.