ITS Traffic Data Consolidation System

Final Report 512

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March 2005

Prepared for:
Arizona Department of Transportation
206 South 17th Avenue
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in cooperation with
U.S. Department of Transportation
Federal Highway Administration

Technical Report Documentation Page

1. Report No. **FHWA-AZ-05-512**	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle **ITS Traffic Data Consolidation System**		5. Report Date **March 2005**
		6. Performing Organization Code
7. Author Tomas Guerra, Ken Satoyoshi		8. Performing Organization Report No.
9. Performing Organization Name and Address OZ Engineering LLC 3230 E. Broadway Road Suite 216 Phoenix, Arizona 85040		10. Work Unit No.
		11. Contract or Grant No. ADOT: T01-59-B0123 SPR-PL1-(59)512
12. Sponsoring Agency Name and Address ARIZONA DEPARTMENT OF TRANSPORTATION 206 S. 17th Avenue, Phoenix, Arizona 85007 ADOT Project Manager: Stephen R. Owen, P.E.		13.Type of Report & Period Covered FINAL REPORT April 2002-March 2005
		14. Sponsoring Agency Code
15. Supplementary Notes Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration		

16. Abstract –

The Arizona Department of Transportation (ADOT) maintains a variety of independent applications to monitor roadway conditions and activities across the state including traffic counts, weather data, signal timing, Variable Message Sign (VMS) advisory messages, video signals, and statewide Highway Condition Reporting System (HCRS) events. Each ITS field device has its own proprietary device driver application and output data stream format.

This report summarizes an Intelligent Transportation Systems (ITS) research program by ADOT to consolidate statewide user workstation access to a subset of the various ITS field devices via a “single-screen.” The implementation of this ability involved the development of software interfaces with device driver applications via the Internet and intranet. This resulted in the centralization and improved availability and archiving of traffic data derived from the associated ITS field devices, as well as data from the Advanced Traveler Information System (ATIS) via the HCRS. This outcome improved the real-time aspect of the operational management of the state highway system. Ultimately, the driving public will be able to plan their travel with more consistent, reliable and timely information via the Internet, and access this real-time information en route via the 511 Interactive Voice Response system (IVR).

A second project phase introduced a graphical interface to HCRS to automate location information and improve data entry accuracy for field operations staff.

17. Key Words Intelligent Transportation Systems, ITS, Advanced Traveler Information Systems, ATIS, Advanced Traveler Information Systems, Traffic Data, Data Consolidation, TDCS, Data Archiving, Highway Condition Reporting System, HCRS, Variable Message Sign, VMS, Dynamic Message Sign, DMS, National Weather Service, NWS, Road Weather Information System, RWIS, Closed Circuit Television, CCTV, 511, Interactive Voice Response System, IVR, Environmental Sensor Station, ESS.		18. Distribution Statement Document is available through: ADOT Research Center (ATRC), 206 S. 17th Avenue (MD-075R) Phoenix Arizona, 85007		23. Registrant's Seal
19. Security Classification Unclassified	20. Security Classification Unclassified	21. No. of Pages 54	22. Price	

SI (MODERN METRIC) CONVERSION FACTORS*

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: Volumes greater than 1000L shall be shown in m^3.			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000lb)	0.907	megagrams (or "metric ton")	mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE AND PRESSURE OR STRESS		
lbf	poundforce	4.45	Newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	KPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.315	cubic feet	ft^3
m^3	cubic meters	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (or "metric ton")	1.102	short tons (2000lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE AND PRESSURE OR STRESS		
N	Newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380

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TERMS, ACRONYMS AND ABBREVIATIONS

TERM	DEFINITION
ADOT	Arizona Department of Transportation
API	Application Programming Interface
Applet	A small application program especially for performing a simple specific task at a client workstation. Typically communicates with a servlet.
ArcIMS	Internet Map server software that provides a scalable framework for distributing GIS services and data over the Web (see ESRI)
ATIS	Advanced Traveler Information Systems
ATRC	Arizona Transportation Research Center – ADOT (at Phoenix)
AVL	Automatic Vehicle Location
CCTV	Closed Circuit Television
CORBA	Common Object Request Broker Architecture
CVO	Commercial Vehicle Operations
District	ADOT Maintenance & Construction Districts
DMS	Dynamic Message Sign
DOT	Department of Transportation
DPS	Department of Public Safety (Arizona Highway Patrol)
EPIC	Expedited Processing at International Crossings
ESRI	Environmental Systems Research Institute (software vendor)
ESS	Environmental Sensor Station
FDS	Fiberoptic Display Systems
FHWA	Federal Highway Administration
FMS	Freeway Management System
GIS	Geographic Information System
GPS	Global Positioning Satellite System
GUI	Graphical User Interface
HAR	Highway Advisory Radio
HCRS	Highway Condition Reporting System
ISP	Internet Service Provider
ITD	Intermodal Transportation Division
ITG	Information Technology Group
ITIS	International Traveler Information Interchange Standard
ITS	Intelligent Transportation Systems
IVR	Interactive Voice Response
j2se	Java 2 Platform, Standard Edition
JDOM	Java Document Object Model
jpeg	Joint Photographic Experts Group (graphic image format)
MP	Milepost (or Mile Marker)
MVD	Motor Vehicle Division
NAFTA	North American Free Trade Agreement

TERMS, ACRONYMS AND ABBREVIATIONS

TERM	DEFINITION
NEMA	National Electrical Manufacturers Association
NTCIP	National Transportation Communications for Intelligent Transportation Systems (ITS) Protocol
NWS	National Weather Service (of the National Oceanic & Atmospheric Administration)
Org	ADOT's Local-Level Maintenance Organization (Camp or Yard)
PAC	Proxy Auto-Configuration file tells the browser to load its proxy configuration information from a remote JavaScript file
PDA	Personal Digital Assistant
RWIS	Road Weather Information System
SAE	Society of Automotive Engineers
Servlet	An application program that resides on a computer which provides responses to requests made by applets
SPR	State Planning & Research
SSL	Secure Socket Layer
TAC	Technical Advisory Committee
TDCS	Traffic Data Consolidation System
TOC	Traffic Operations Center
TPD	Transportation Planning Division
TTG	Transportation Technology Group
VAR	Value Added Reseller
VMS	Variable Message Sign
XML	eXtensible Markup Language
XSD	XML Schema Definition

EXECUTIVE SUMMARY

The Arizona Department of Transportation (ADOT) maintains a variety of independent Intelligent Transportation Systems (ITS) applications to monitor and manage roadway conditions and events across the state, and to better inform travelers. The data includes traffic counts, weather, pavement conditions, signal timing, Variable Message Sign (VMS) text, camera images, and the statewide Highway Condition Reporting System (HCRS). Also, the public gets detailed travel information from ADOT's az511.com website, or from the 511 phone service.

Each ITS resource has its own unique user interface, security, output data format, and task initiation timetable, creating a need within ADOT for an effective Traffic Data Consolidation System. This report summarizes an ADOT research project to consolidate access on a single system for a variety of key data.

Phase One of this research provided access for HCRS users and website visitors to VMS sign messages, Closed Circuit Television (CCTV) roadway images, sensor data from Road Weather Information Systems (RWIS), and National Weather Service (NWS) forecasts and advisories. All of these functions are now integrated with the same application and user-friendly Graphical User Interface (GUI). Also, these data streams are being archived in the HCRS database.

Phase One was completed successfully ahead of schedule in August 2004, and project funds remained for a Phase Two. Based on field requests, other new HCRS enhancements were proposed by the project's Technical Advisory Committee (TAC). A new goal was defined to improve the user-friendliness of HCRS by allowing field users to enter highway mileposts graphically. This tool simplified field data entry, improved the location accuracy of road condition information, and automatically inferred the event's affected travel direction.

Ultimately, the resulting enhanced HCRS system has improved the real-time aspect of the operational management of the state highway system for ADOT, and the quality of Advanced Traveler Information Systems (ATIS) information for Arizona's highway users.

PROJECT CONCLUSIONS

Phase One integrated key data resources, making the data streams available for "big-picture" management of the state highway system. Phase Two improved the accuracy and speed of HCRS data entry with its graphical interface. Several key goals were achieved for highway operations:

- "Variable Message Sign" icons are located on the HCRS Map, with text available to both HCRS users and Internet browsers.
- Icons for CCTV still-images from RWIS stations and VMS structures appear as links on the HCRS and the az511.com website maps.
- Weather data from NWS and the ADOT RWIS system is gleaned from the Internet, linked to icons on the HCRS Map, and archived in the database.
- A Graphical User Interface (GUI) was added to more easily locate HCRS events, using the map to provide milepost information.
- Numerous redundant display layers and icons were removed or simplified.

PROJECT LESSONS LEARNED

This complex integration project succeeded due to the management and oversight techniques employed by the TAC and OZ Engineering, the system integrator, and the lessons learned can benefit future projects. One issue was integration among third-party data providers and the system integrator, including "agreed upon" requirements for documentation. Due to the limited budget and schedule, not all data providers performed sufficient unit testing, and additional OZ research project resources had to be used in the integration and system test phases.

Third-party VMS and RWIS field contracts preceded the HCRS integration work by OZ, creating sporadic schedule conflicts or delays. Had all projects been scoped with eventual integration in mind, all vendors could have better coordinated and cooperated in their roles. Also, other HCRS and 511 functional development support work for ADOT highway operations necessarily took priority over the research tasks of this project.

The amount of data archived by the HCRS became an issue for this project's database. Initially, a storage capacity analysis should have been done for each data source, and procedures implemented prior to system integration. Also, ITS data archive stakeholders should have been consulted for the design. Still, the archived ITS information will be invaluable for transportation administration, policy evaluation, safety and performance monitoring, post-analysis engineering, and short- and long-term planning.

Significant troubleshooting was needed for the HCRS and RWIS/NWS interfaces. Problems between HCRS and the RWIS server and database slowed other unrelated HCRS functions. An end-to-end communications survey should have been done to insure each component is protected from unwarranted interaction with its peer components. A "spider" tool used to poll and collect data from NWS data web pages added to the problem. Software processes and server hardware are being reconfigured for better HCRS performance, to be operational by April 2005.

The Phase Two "Easy Entry" GUI upgrade made ADOT aware of a critical dependency on up-to-date milepost GIS shape files. ADOT is in the process of addressing this issue internally.

Finally, the TAC provided crucial insight and guidance to the project, but HCRS users (field site operators) could have been better represented. "Guest experts" might also have been consulted.

PROJECT RECOMMENDATIONS

The National Transportation Communications for ITS Protocol (NTCIP) is being developed jointly by the American Association of State Highway and Transportation Officials (AASHTO); the Institute of Transportation Engineers (ITE); and the National Electrical Manufacturers Association (NEMA), with funding by the Federal Highway Administration. It is recommended that these standards continue to be used as ITS integration projects are implemented.

Extensible Markup Language (XML) and XML Schema Definition (XSD) technologies flexibly define the "mutually agreed upon" syntax of data messages. This project highly recommends that all software interface developers use XSD validators to test the XSD compliancy of their output locally, independent of parties on other side of an interface. For example, the NWS is currently working on producing its Forecasts and Advisories in XML format.

ADOT must improve its internal planning and information coordination so that HCRS data is ready when new freeway sections are opened. New procedures are required to provide updated GIS data as construction nears completion, update the 511 Interactive Voice Response system for any new roads, and perform an HCRS update for this data. The new freeway section should be available on az511.com and on 511 immediately, as of the official road opening.

The project TAC recommends two other key areas for further expansion of statewide data:

- Traveler information: rural trip travel prediction; regional weather and road conditions.
- Roadway management information: more rural and urban CCTV still-images; GIS longitude, latitude and elevation as a mouse popup on the HCRS map.

It is strongly recommended that HCRS system enhancements continue to be made incrementally, for scheduling and budgetary reasons. The incremental approach may prolong the overall system integration timeline, but it will ensure successful completion of each project along the way.

PROJECT BENEFITS

This research has created a single user-friendly application in HCRS for ADOT, with software interfaces to the key ITS programs in Phase One via the Internet and intranet. Phase Two has improved the accuracy and speed of HCRS data entry with a graphical user interface.

The project has resulted in more statewide centralization of key ITS data. ADOT highway managers at the state and district level now have an integrated operations tool that provides dynamic traffic and roadway data for distribution, display and decision-making.

The ADOT Highway Condition Reporting System is a statewide tool that provides integrated consistency of information both for roadway management, and for travelers across the state. This research project has effectively “raised the bar” for highway agencies with its collection and dissemination of advanced traveler information.

While this project was initiated by and for the ADOT field offices, Arizona’s driving public now has access to much of the same real-time information via the Internet website and the 511 Interactive Voice Response system. Also, recent findings by others on the perceptions of older drivers as to ADOT’s use of ITS resources have been incorporated concurrently into the HCRS refinements. The results contribute greatly to enhanced public satisfaction with ADOT’s traveler information by providing more and clearer reports, advisories, and camera images.

In the near future, the public may get information through new media such as Highway Advisory Radio, Personal Digital Assistants, and cell phones, as well as third-party value-added providers. Better and more timely advisories will reduce call-in overload, improve ADOT decision-making, enhance credibility, and reduce costs for travelers and for the transportation service sector.

This development project demonstrated how national standards, such as NTCIP, promote better interfacing and cooperation between government agencies and the commercial world, and consequently, faster product development.

Finally, by enabling better ITS data archiving, this project is an excellent resource for retrospective analysis by transportation planners to improve day-to-day real-time management of state highway systems.

I. PROJECT BACKGROUND

Arizona is unique with its range of terrain and ecological zones, and being located at the crossroads of the North American Free Trade Agreement (NAFTA) and transcontinental Interstate routes. The Arizona Department of Transportation (ADOT) maintains a variety of independent applications to monitor traffic activity, and roadway and weather conditions across the state. The real-time Intelligent Transportation Systems (ITS) data streams include traffic counts, weather data, and pavement conditions from Road Weather Information Systems (RWIS), signal timing, Variable Message Sign (VMS) advisory messages, CCTV video signals, and the statewide Highway Condition Reporting System (HCRS) events.

In 1999 the ADOT Flagstaff District proposed to the Arizona Transportation Research Center (ATRC) that an integrated statewide ITS Traffic Data Master System was needed. The proposed "master system" would collect dynamic data from roadway monitors and issue multi-modal traveler advisories. In late 2000, funding was authorized and the ATRC initiated scoping of the research. Initially, this project was begun using internal ADOT information technology resources, but this approach was not completely successful. Due to organizational constraints, shifts in emphasis, personnel changes, and other commitments that arose over time, the project was finally reorganized as an ATRC research effort. As a result, the ATRC contracted OZ Engineering in early 2002 to develop an ITS Traffic Data Consolidation System (TDCS).

PROJECT SPONSORSHIP AND FIELD PARTICIPATION

The efforts of the project sponsors, Don Dorman and John Harper of the ADOT Flagstaff District, are to be acknowledged, as well as the project implementation champion, Tim Wolfe of the ADOT Transportation Technology Group, Traffic Operations Center (TTG/TOC).

The project stakeholders on the Technical Advisory Committee (TAC) bear the responsibility for a successful research project, by giving clear direction and leadership for the work, and providing generous resource support. The project TAC included personnel both from the Federal Highway Administration (FHWA) and the following key ADOT sections:

- Arizona Transportation Research Center (ATRC)
- Transportation Technology Group (TTG/TOC)
- Information Technology Group (ITG)
- Transportation Planning Division (TPD/GIS)
- Flagstaff District - Intermodal Transportation Division (ITD)
- Kingman District - ITD
- Holbrook District - ITD

II. PROJECT PHASE ONE

The call came in from the field for a “big-picture” view of the many different and independent sources of Intelligent Transportation System (ITS) information available within ADOT. Each system had a unique data format, such as for VMSs, CCTVs, RWIS, etc. That is, the field wanted to integrate the operational management of Arizona’s highway system by consolidating current dynamic traffic and roadway data for distribution and display to ADOT highway managers at state and district operations centers. What is more, if such a system could provide real-time traveler information to Arizona highway users, so much the better. Thus, the concept of an ITS traffic data “master system” was born, and with guidance from key project champions in ADOT, it was developed into this State Planning and Research (SPR) Project 512.

Funding for Project 512, the ITS Traffic Data Consolidation System research, was authorized in late 2000. The ATRC initiated scoping of the proposed work with support from Technical Advisory Committee. The project was initially assigned to staff from the internal ADOT Information Technology Group, in order to incorporate skills and develop system ownership.

Due to resource limitations, internal reorganizations, and diverse priorities, this approach ultimately was not successful. As a result, the ATRC contracted with OZ Engineering to continue the effort in early 2002. The OZ project kickoff meeting with TAC members was conducted on May 7, 2002.

PROJECT APPROACH

The TAC and OZ Engineering jointly developed the SPR 512 Statewide Data Needs Matrix, which prioritized the need level and feasibility class of various data elements. This matrix is shown in Appendix A in its latest form. From this exercise, three field devices were chosen for integration with the HCRS, as described below:

1. Rural Variable Message Sign (VMS):

   These overhead signs provide the means to advise travelers immediately about highway restrictions, closures and other critical messages. They initially were controlled by the individual ADOT districts, as well as by the ADOT Traffic Operations Center (TOC) during second and third shifts and on weekends. However, Fiberoptic Display Systems (FDS) converted all rural VMS to an FDS-supplied Mercure central control software application, which had already been implemented in the Phoenix area. This conversion provides message-reading ability to all authorized users statewide, and the password-secured ability to update messages in their own local areas. These permanent message signs may use either cellular or land-line communications.

2. Closed Circuit Television (CCTV):

   ADOT currently uses several types of video or still-frame cameras to enhance monitoring of weather conditions and traffic activities. At least three systems of still-frame cameras have been deployed at VMS and Road Weather Information System (RWIS) weather sites in rural Arizona, from Nu-Metrics, Surface Systems, and System Innovations, Inc. (SII). The SII system has evolved to become the most common application. System Innovations employs proprietary WeatherScene applications software to monitor and control the weather devices. An initial project goal for these camera installations was to allow remote pan-tilt-zoom functions.

3. Snowplow Truck Automatic Vehicle Location (AVL):
   Global positioning satellite technology (GPS) allows agencies to locate moving or stationary fleet units, track their route movements, and verify the operating status and the driver's own safety. A concurrent ADOT project evaluated two AVL units on snowplows in the Flagstaff District. These were GreyLink System 1000 units, which used commercial analog cellular communication to show real-time locations, and to store and transmit GPS position and speed data to be printed as a table or a map. The AVL software was installed at the Flagstaff District Snow Desk, but was not successful. Similar systems may be employed in the future, if an economical but more effective communication medium than analog cellular is selected for further state agency trials.

In order to develop a comprehensive user interface with these proprietary ITS field device applications, an existing statewide ADOT application with a user-friendly GUI (graphical user interface) appeared to be a good place to start. The Highway Condition Reporting System (HCRS) is a web-enabled application that already has a large user base via ADOT's own intranet. Its Geographic Information System (GIS)-based interface provides a helpful environment to 'browse' the state highway system. The public can access real-time HCRS information via its 511 telephony application and the public Internet. Operationally, the deployed HCRS application downloads to the client computer at run-time, and can be accessed through the Microsoft Internet Explorer browser. The HCRS accesses a GIS map server and performs many periodic operations to receive information from other complementary systems.

PHASE ONE DEVELOPMENT

Statewide field devices that are polled by their respective central servers were chosen to be candidates for interface development with HCRS. Various methods of providing access (read only and local control only) to these servers were explored. Among the methods investigated were opening the program using links, and developing an interface by utilizing the Application Programming Interface (API) provided by the software vendor. This approach would allow the deployment to inherit the rich features offered by each of the software systems.

One more possible way to implement an interface was to register with the proprietary system to receive some periodic status message using a well-known format such as XML or CORBA. Still another way was to access a local database, assuming that it had a standard interface. In either case, because the HCRS had been developed as a Java servlet (application program) that resides on the ADOT intranet, it was expected that the interface would be readily developed.

Once an interface mechanism was developed, the information obtained by the HCRS would be represented by an "icon" and "dropped" onto the client map. Refer to Figure 4, on Page 16, for an example of this icon implementation.

Each new Project 512 feature was posted in advance on ADOT's internal website, http://hcrs.dot.state.az.us, as a part of TTG's monthly HCRS production update schedule. This "rolling release" approach was designed to minimize catastrophic release problems and simplify user feedback during development. Appendix C lists the HCRS release cycles with their actual release dates and deployed new functionality.

The following sections describe the project's development timeline for the key HCRS features. Due to the fairly long development schedule, in part because of changing priorities and access constraints by others, this progress discussion is presented in outline form for clarity. The text includes key issues encountered, solutions developed, guidance from the TAC, changes in approach, and related milestones and achievements.

2002 SECOND QUARTER

Phase One began with the goal of interfacing with three key field device systems:

- Variable Message Signs (VMS).
- Closed Circuit Televisions (CCTV).
- Snowplow Truck Automatic Vehicle Location (AVL).

Each of the three devices was controlled by its individual proprietary application. HCRS was to support two modes:

- Read Only Client.
- Local Control Client.

The Read Only Client would only involve displaying clickable icons for the new devices on the HCRS client maps. Clicking on the icons would open an auxiliary window containing perhaps the VMS text message being displayed, or a still-frame of the current CCTV image, or the snowplow truck identification.

The Local Control Client would launch a vendor-provided executable program to control a device or system. The anticipated issues with this approach are:

- Security.
- Communication bandwidth.
- Licensing per HCRS Client.

CCTV devices are mounted on Roadway Weather Information Systems (RWIS) units supplied by System Innovations (SII) and Variable Message Signs manufactured by Fiberoptic Display Systems (FDS), as well as freestanding installations. The images are available from servers as well as individual freestanding units.

During this period, ADOT was in the process of deploying some 75 VMS displays statewide.

2002 THIRD QUARTER

During this quarter, the prototype launching of a Mercure VMS executable from an applet was demonstrated. The Local Control Client required a Digitally Signed Certificate to allow the operation to work within the applet; the certificate was eventually acquired and the functionality implemented. FDS worked with ADOT to deploy their VMS system satisfying the ADOT firewall and networking requirements. FDS agreed to develop an interface that would provide a read-only sign status to ADOT.

SII underwent ADOT network security review, continuing their statewide deployment project.

Snowplow AVL users were dissatisfied with the wireless communication range and manual intervention necessary to obtain real-time status. The vendor was characterized as unresponsive.

The TAC helped redesign the HCRS icon screen to be more user-friendly including:

- Larger window.
- Display filtering.
- Layering.
- Screen layout.

2002 FOURTH QUARTER

The TAC at this point reviewed the evolving main HCRS screen and suggested some relabeling, icon redesign and layer control.

In order to deploy an application that can launch an executable, and yet not require Digitally Signed Certification, OZ proposed deploying the HCRS as an application (versus applet) for authorized clients. In other words, there would be a "read-only" applet that all HCRS users would have access to. In addition, those select users that need to control VMS (for example) would need to use the HCRS application, in addition to having that vendor software installed on their computer.

If the Mercure software is not installed on a user's personal computer, and the user attempts to run the application version of HCRS (rather than applet version), the software will automatically detect this and redirect the user to the applet HCRS. The Mercure software licenses must be strictly controlled. Unauthorized users should not be encouraged to request the Mercure software.

At this point in the project, ADOT directed FDS to move the more than two dozen Phoenix VMSs under the control of the Freeway Management System (FMS) to the Mercure application. A Mercure server was installed in each ADOT district office to communicate with the variable message signs within its jurisdiction. All Mercure servers send the status of their signs to a central Mercure server, located in the ADOT TOC. The central Mercure server periodically creates an interface file containing the status of all signs. In turn, the HCRS server retrieves the sign status from the interface file, and provides it to all HCRS clients in a read-only manner. Therefore, when an HCRS client hovers their mouse over the sign icon, a small pop-up window, called a maptip, shows the text that is displayed on that sign.

TTG tasked a consultant to create several map shape files containing the locations of the ramp meters, VMS, and RWIS devices. Issues of responsibility and maintenance of the configuration and shape files came up.

The TAC decided that there would be two icons for each RWIS device, one CCTV icon and one Weather Sensor icon. The former, when clicked, displays the two images for each direction on the roadway. When the weather sensor icon is clicked, it displays both images along with the current weather and precipitation information that is obtained from the RWIS server's database. Since the CCTV is not a constant feed, a date and time check since the last transfer was performed to reduce data traffic. Security items of firewalls, user name, and password were approved.

Icon	ITIS Category	Total Entries April 1998 - Jan 2003	Category % of Total
	Activities	69	0.12%
	Closures	6,890	11.79%
	Dangerous Vehicles	11	0.02%
	Delays/Cancellations	76	0.13%
	Environment	263	0.45%
	Exceptional Loads	75	0.13%
	Headways	2	0.00%
	Incidents/Accidents	8,150	13.95%
	Information	1,042	1.78%
	Lane Restrictions	16,032	27.44%
	Level of Service	875	1.50%
	Obstruction Hazards	4,397	7.53%
	Parking	1	0.00%
	Road Conditions	1,770	3.03%
	Road Maintenance	8,742	14.96%
	Temperature	54	0.09%
	Traffic Equipment Status	1,970	3.37%
	Traffic Regulations	76	0.13%
	Travel Times	3	0.01%
	Weather	1,905	3.26%
	Winds	744	1.27%
	Winter Storm Codes	5,276	9.03%
	Total	58,423	100.00%

Figure 1: ITIS Category Entry Summary (Apr 1998-Jan 2003)

TTG asked SII to change the text on:

- The RWIS “Weather” page from “Weather Report” to “Current Weather.”
- The RWIS “Road Conditions” page from “Salinity” to “Chemical.”

During this period the TAC decided to expand the scope of the CCTV interface to include Environmental Sensor Stations (ESS) data (precipitation, temperature, etc.) to be retrieved from the RWIS server database, which in turn, was made available to third-party clients, such as the National Weather Service (NWS), in a real-time HTML page containing camera images and ESS data. The TAC designed the page layout to be implemented. OZ stored and distributed the data in a manner that is consistent with national standards (ESS NTCIP 1204:1998 v01.13). The firewall issues were attended to by the Information Technology Group (ITG).

Because of limited data communications and the need for manual intervention, the TAC decided to replace the Snowplow Truck AVL interface task with NWS forecasts and advisories.

HCRS software development included:

- Improved icon appearance for cameras, weather stations, and other shapes.
- Added Help-About screen indicating software version.
- Installed NWS Forecasts and Advisories feed.

2003 FIRST QUARTER

As work progressed into 2003, the TAC redesigned additional icons on the main HCRS screen.

- NWS “Forecasts and Advisories” icon added.
- Used PAC (Proxy Auto-Configuration) file for configuration of Internet browser.
- Allowed Internet user to filter information displayed by icon category.
- Replaced “Thermometer” icons with “Weather Condition” icons for NWS data.
- Archived ESS data to HCRS database.
- Temporarily placed “Weather Sensor” icons on map with "Under Construction" detail page for HCRS clients and http://www.az511.com.
- Allowed HCRS clients and Internet browsers to view the RWIS data.

2003 SECOND QUARTER

In order to reduce the number of event icons that the HCRS displays, OZ generated a summary of the number of times each International Traveler Information Interchange Standard (ITIS) category was used for data entry during the period April 1998 to January 2003 (see Figure 1 on the facing page). As a result, the TAC requested that the “Headway” and “Dangerous Vehicles” icons be removed from the HCRS icon list.

The operation of the HCRS weather data-retrieval "spider," a process that was developed to periodically poll and collect data from over 40 NWS and RWIS data sources, was temporarily suspended due to poor production performance in connecting to the RWIS database. Curiously, the development environment did not exhibit this problem.

As of this report, the Tucson CCTV capture has been hampered by the lack of bandwidth to the Phoenix TOC.

HCRS software development included the following SPR 512 functionalities:

- New RWIS web page: weather and precipitation broken into two tables with dates.
- Winter storm advisory changed to winter storm alert.
- Added icons to display FMS camera images.

2003 THIRD & FOURTH QUARTERS

During the latter half of 2003, the following SPR 512 related features were implemented:

- Removed "Dangerous Vehicle" and "Headways" events and icons.
- Added additional cameras to HCRS and the Internet web page, and corrected the location of various cameras in the camera.xml property file.
- Due to problems with timely retrieval of data, removed "Weather Sensor" (RWIS) icons from HCRS and az511.com.

2004 FIRST & SECOND QUARTERS

Defined by FDS, ADOT and OZ, the VMS XML Schema Definition was finally agreed upon in 2004. It includes elements from the NTCIP 1203 v02.27. (Extensible Markup Language (XML) and XML Schema Definition (XSD) technologies can be used to flexibly define the "mutually agreed upon" syntax of data messages).

HCRS software activity included the following SPR 512 related items:

- Re-enabled RWIS.
- Updated camera names and locations.
- Installed Secure Socket Layer (SSL).

PHASE ONE ACCOMPLISHMENTS

The project challenge of interfacing disparate applications with differing data formats and access methods was met. However, the GPS-based cellular AVL application proved to be problematic since connection to the device was not automatic, requiring the Flagstaff Snow Desk dispatcher to initiate the data connection manually. Furthermore, the Interstate 40 corridor has limited wireless communications range, preventing the AVL device from being polled regularly. Given these limitations, the project TAC decided that the NWS Forecast and Advisories weather information would be a suitable replacement goal for the AVL feature.

As a result, the HCRS now places an associated NWS icon on the HCRS client map. Additionally, NWS warning and advisory information is automatically posted to the HCRS 511 telephone system.

Still-images of the roadway are obtained from the RWIS servers and the ADOT websites as jpeg files, and associated CCTV icons are “dropped” onto the HCRS client map. The TAC decided to expand this interface to include the Environmental Sensor Station (ESS) information available from the RWIS server database. An icon was associated with ESS data and placed onto the HCRS client map.

The rural and urban FDS Variable Message Sign servers are interfaced with the HCRS. A VMS icon appears on HCRS only when a text message is active on the corresponding VMS. When a user hovers the mouse over the icon, a maptip pops up displaying the sign’s text.

The overall presentation of the ITIS icons and layers was improved. Rarely-used categories were removed, and user layer selection procedures were simplified. The following Figure 2 captures these enhancements.

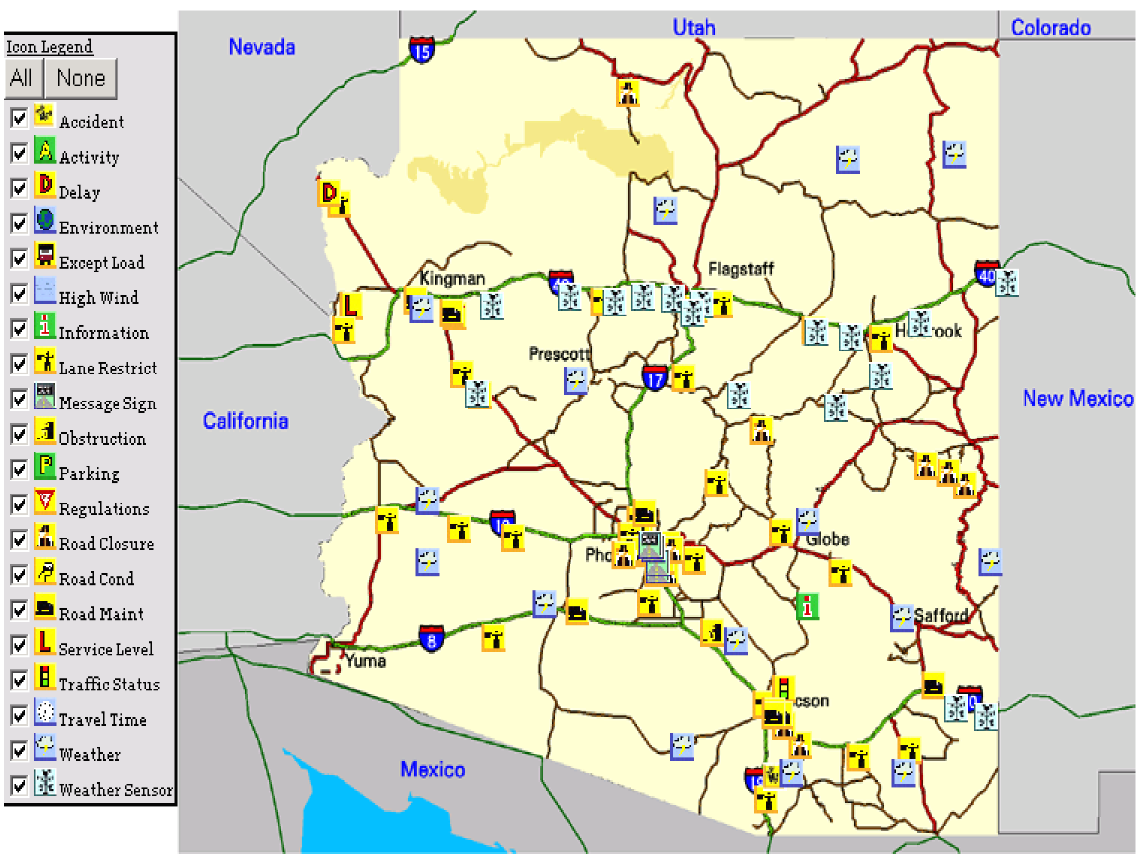

Figure 2: Current HCRS Internet Window

PHASE ONE CONCLUSIONS

As with all interface projects, getting the separate teams to work together effectively and expeditiously was sometimes a challenge. E-mail with an appropriate copy list was used as an effective tool to keep all parties informed of potential ramifications of interface changes.

Moreover, active participation by the TAC to prioritize features and oversee progress enabled work to continue in spite of the different vendor production schedules; e.g., the VMS statewide deployment and the HCRS production development schedule.

In the end, maintaining flexibility and good communications for the system design and deployment scheduling contributed to the success of the project.

PROJECT DELIVERABLES – PHASE ONE

The initial phase of the SPR 512 research project resulted in the following enhancements to the production version of the HCRS. Firstly, the redesigned HCRS client screen is shown below:

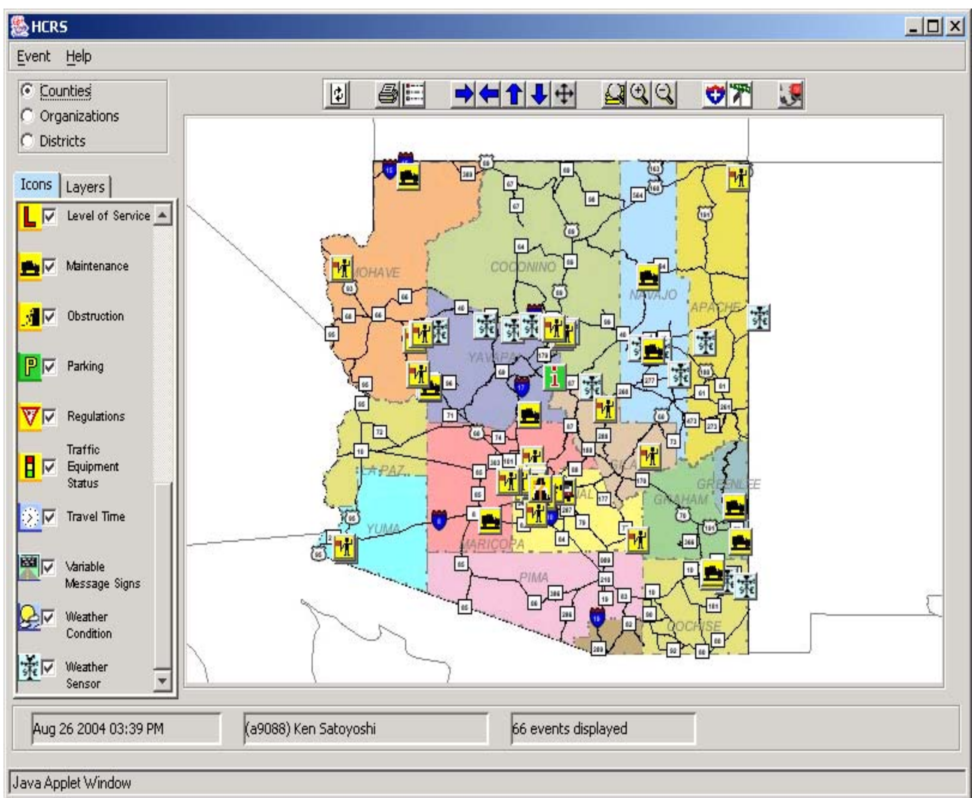

Figure 3: Redesigned HCRS Client Screen

Note the additional icons for “Variable Message Signs,” “Weather Conditions” (NWS forecasts and advisories), and “Weather Sensor” (RWIS environmental sensor system information).

A VMS icon will be displayed only when a sign contains text. When the user hovers his mouse over the icon, a maptip popup will display the text being displayed on the sign.

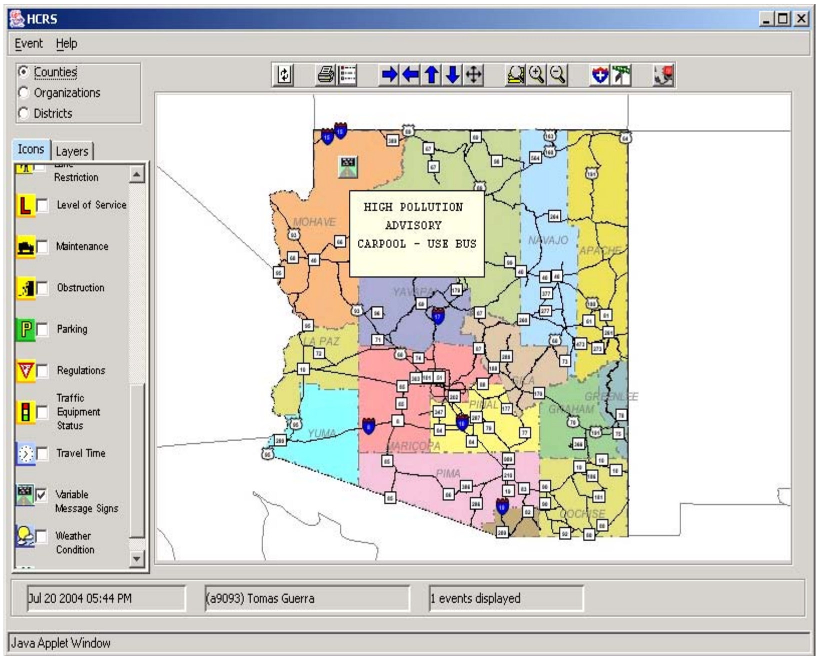

Figure 4: VMS Maptip Popup

When a user clicks on the VMS icon, the following detail screen appears:

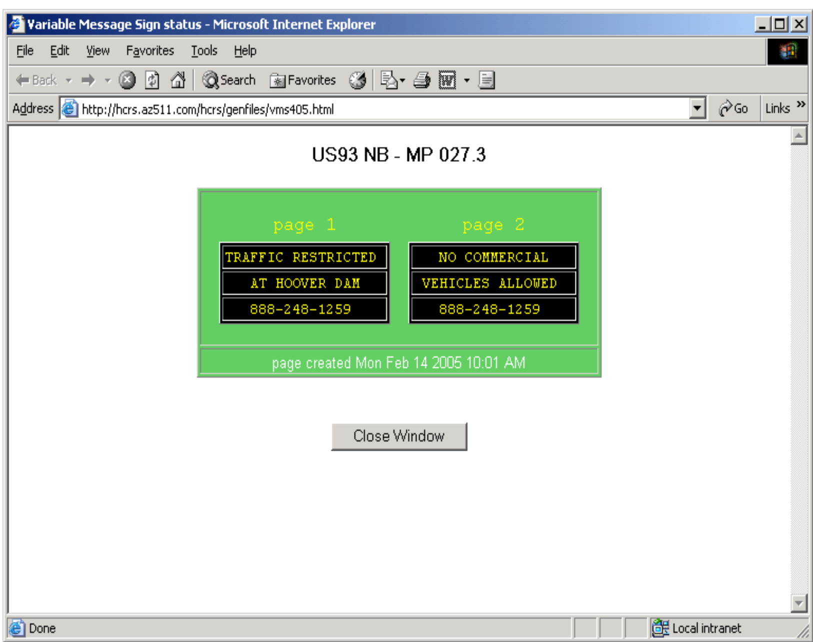

Figure 5: VMS Detail Screen

Several web "spiders" were developed to "mine" data from the various interface systems. The following Figure 6 represents the concept, showing the principal data sources and destination.

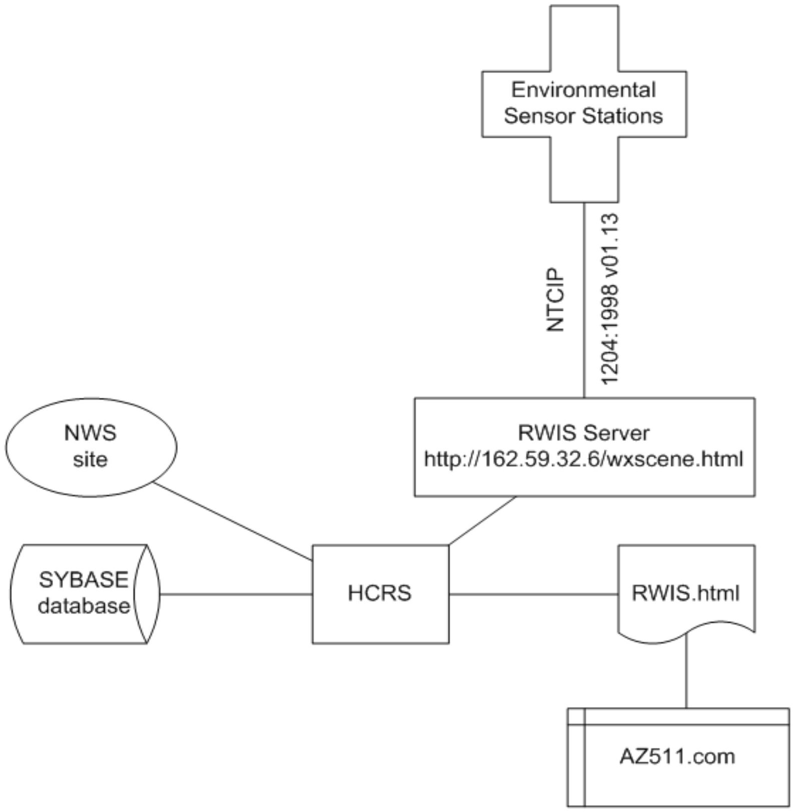

Figure 6: HCRS Weather Data Spider

The spider as illustrated retrieves data from the NWS website and converts it for display on the HCRS screen and the Internet.

This spider also retrieves environmental sensor station information from the RWIS server.

As described previously, this process was developed to periodically poll and retrieve data from over 40 NWS and RWIS sources for users of both the HCRS system and ADOT's www.az511.com website.

When the system user clicks on a "Weather Sensor" icon on the current display map (Figure 3), it will generate a screen similar to that shown in Figure 7:

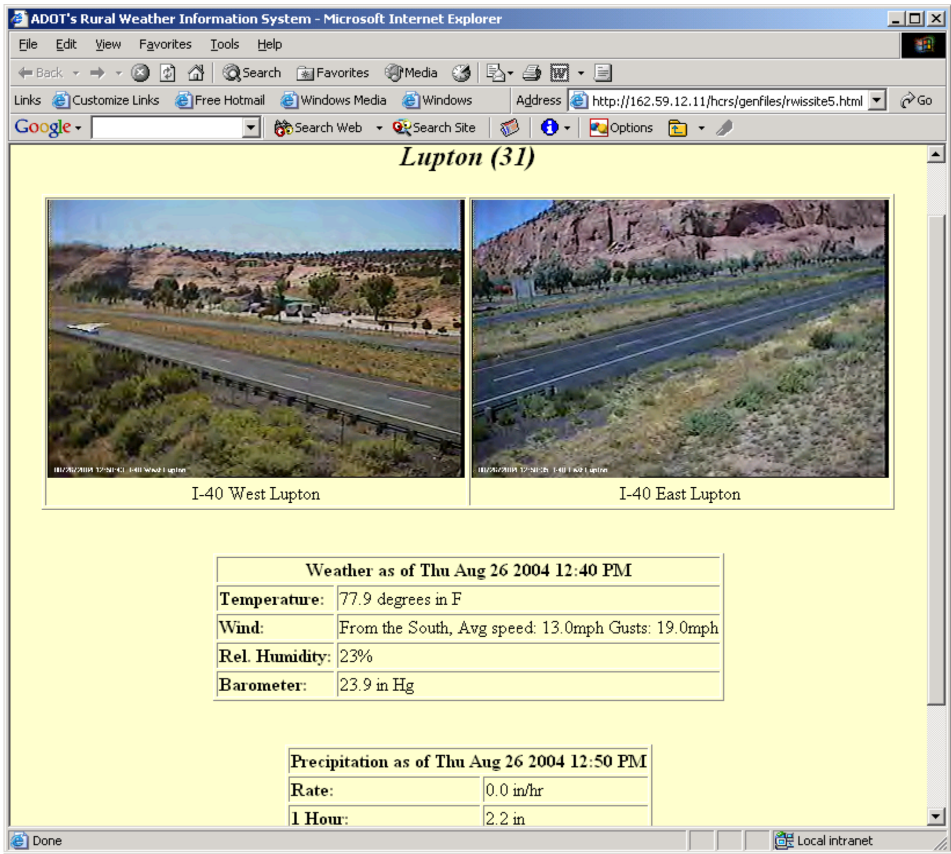

Figure 7: Road Weather Information System (RWIS) Screen

Note the CCTV images in both directions, as seen from the RWIS station or from a VMS site.

The current weather conditions (temperature, wind) and in some cases a precipitation report are given next (if for an RWIS location), along with a date and time stamp indicating when the data were last retrieved.

Clicking on the "Weather Condition" icon will produce a screen similar to the following figure. This screen displays the current NWS forecasts, and a similar screen will also display any active NWS advisories.

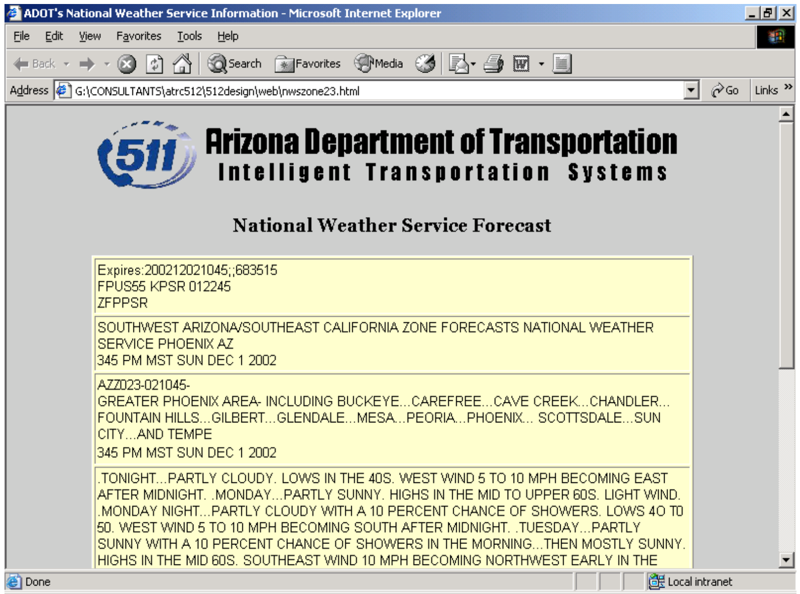

Figure 8: NWS Forecast Screen

The following screen links to an HCRS CCTV icon on Interstate 10 at 79th Avenue in Phoenix:

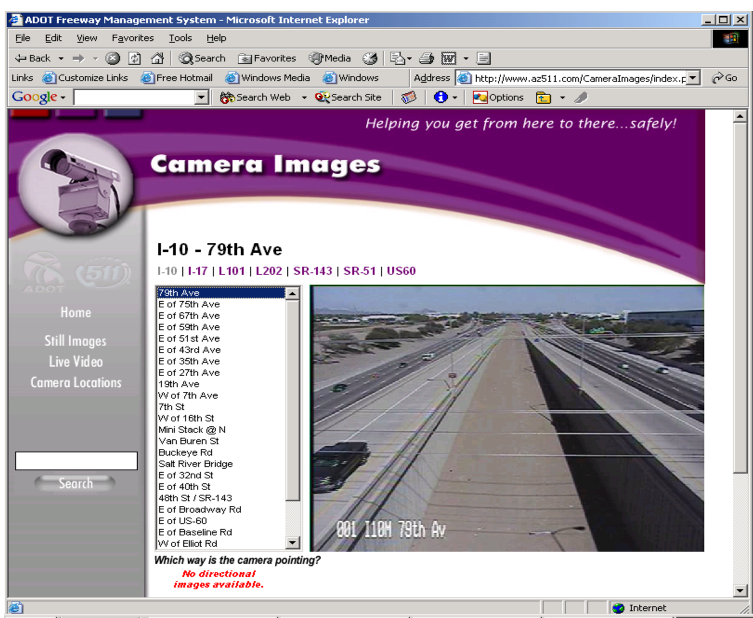

Figure 9: CCTV Screen

III. PROJECT PHASE TWO

After the early completion of the Phase One research and development of the project in the middle of 2004, limited resources remained available to perform further work on the HCRS system. Phase Two options were presented to the TAC. The tasks primarily expanded HCRS functionality and user-friendly features. The functional requirements to the different approaches were defined and presented to the TAC.

Seven options were nominated for Phase Two as useful and feasible:

1. Still images from CCTVs at Nogales Port of Entry compound for Expedited Processing at International Crossings (EPIC).
2. Rural travel times / routing information.
3. Regional weather and road conditions.
4. User-friendly HCRS data entry.
5. Pop-up GIS information for elevation contours.
6. Pop-up GIS information for latitude and longitude.
7. Tucson Freeway Management System CCTVs.

The above system enhancement tasks are detailed in Appendix B. Due to field priorities, budgetary limits and time constraints, the TAC chose the fourth option, "user-friendly HCRS data entry," to be the Phase Two goal.

Within HCRS, local organizations enter winter codes for road conditions by manually providing mileposts, routes, and direction. A key "user-friendly" refinement would give the local operators the ability to point, click, and drag their mouse from point A to point B on the HCRS map route, highlight that stretch of roadway, then assign a current road condition to it. Underlying the point-and-click process, a second key goal would be to provide the ability for the milepost-to-milepost locations, route and conditions to be automatically filled into the HCRS entry screen.

The following sections describe the Phase Two development timeline for this key enhancement.

2004 THIRD AND FOURTH QUARTER

During this period, the TAC conducted a design review of the Phase Two task, HCRS user-friendly data entry. Also during this time, the ability to view the status of VMS displays was added to HCRS and its associated Internet page. The interface for NWS forecasts and advisories was re-enabled in the fall of 2004.

2005 FIRST QUARTER

Phase Two development was completed, and functionality was released in February 2005 (see Appendix C, Version 2.38).

PHASE TWO ACCOMPLISHMENTS

The improved HCRS data entry presents a graphical input mode to more easily specify the “from...to” event locations and infer the travel direction affected by the HCRS event. The work was successfully completed and released in the first quarter of 2005.

During this time, the project’s Final Report was also developed and reviewed by the TAC. This report summarizes the project accomplishments and challenges, and provides recommendations for future enhancements.

PHASE TWO CONCLUSIONS

Successful completion of Phase Two was facilitated by the continued active participation of the TAC. The implemented changes involved significant GUI interaction, yet the timeline did not allow for extensive end-user surveys and feedback. By identifying key stakeholders and enabling them to provide valuable input during the GUI design process, the TAC ensured that the resulting product would be useful to a majority of HCRS clients.

These Phase Two enhancements marked the first time that the HCRS made use of the underlying GIS milepost data. It was discovered that this HCRS data was outdated and did not reflect the actual highway construction in all cases. Most rural highways were updated correctly, but several of the most-recent urban freeway construction projects were not represented. This has led to the establishment of a committee to improve procedures and policies within ADOT, so that as soon as a new section of roadway opens up to traffic, the GIS data is available throughout the system.

PROJECT DELIVERABLES – PHASE TWO

Phase Two of the project has improved HCRS operational ease and accuracy by adding “User-Friendly Data Entry.” The new feature was termed “Easy Entry,” although for better clarity on the screen, the icon has been labeled “EZ”

The Phase Two graphic alternative to locating an HCRS highway event begins by clicking on the “Easy Entry” button. This will cause a menu to pop up.

The menu lists two options: “At” and “From/To.” The user highlights the option that represents the type of event to be entered. The “Message Text” area then displays messages to guide the user through the necessary steps.

THE "EASY ENTRY" HCRS FEATURE

Figures 10 through 18, on the following pages, illustrate these "Easy Entry" processes.

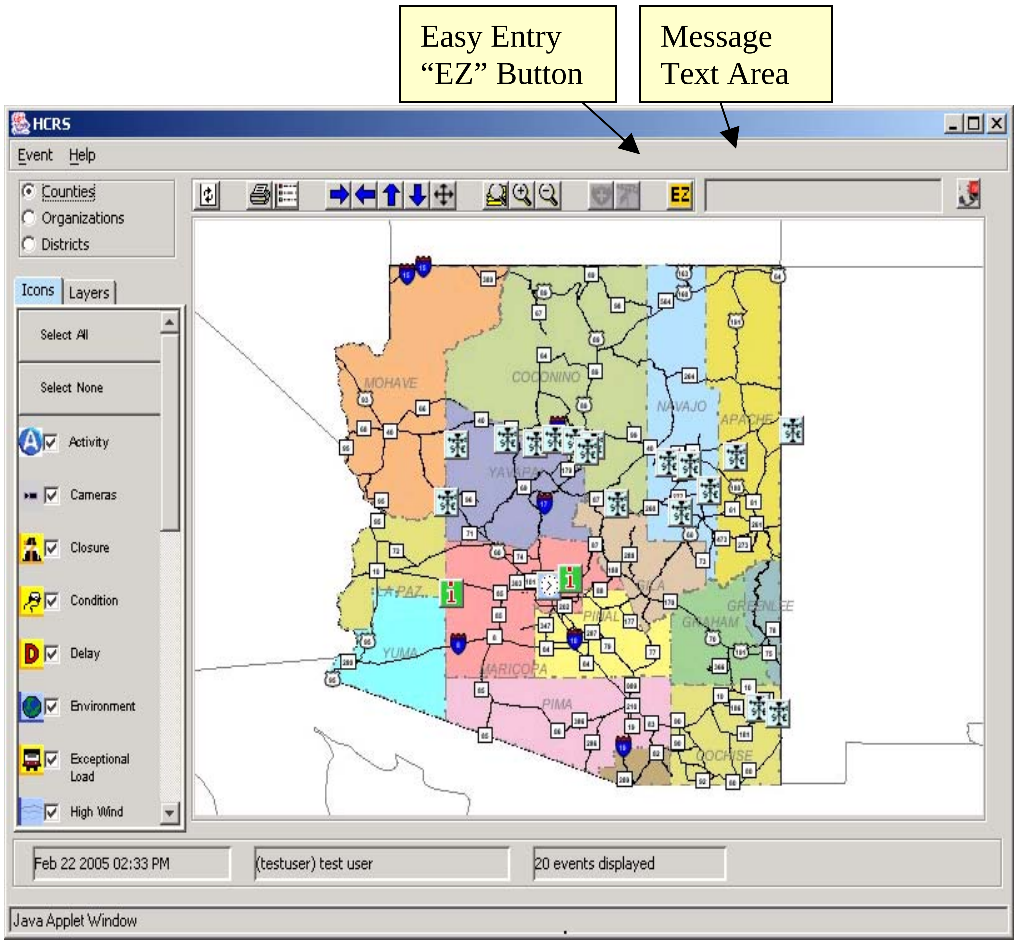

Figure 10: Easy Entry Selection

If, for example, the user selects the “At” mode, the “Option Menu” will appear as shown below:

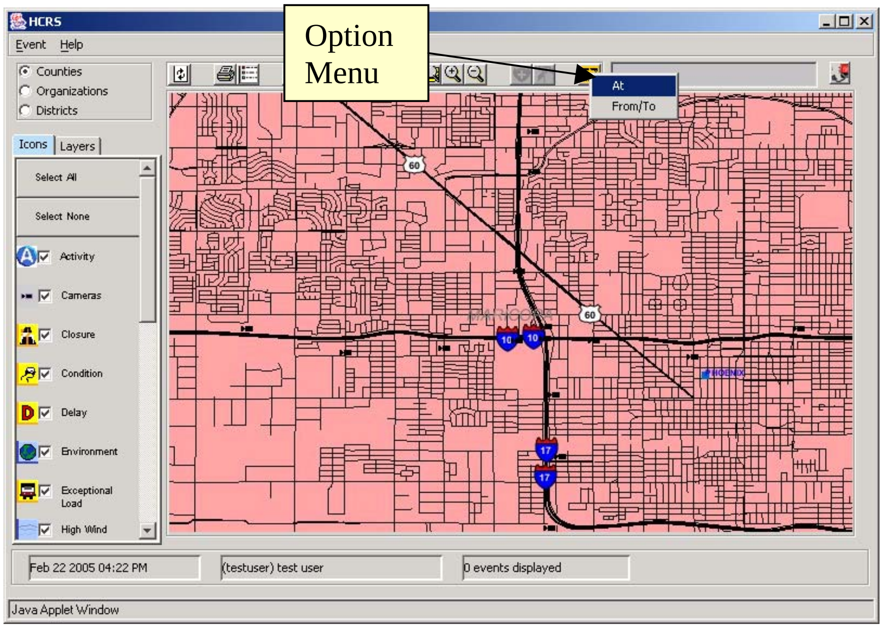

Figure 11: “At” Location Type

Then the HCRS display map will changes as follows:

- All icons disappear
- Milepost markers and labels appear on all highways
- Text area displays: **Select AT milemarker**

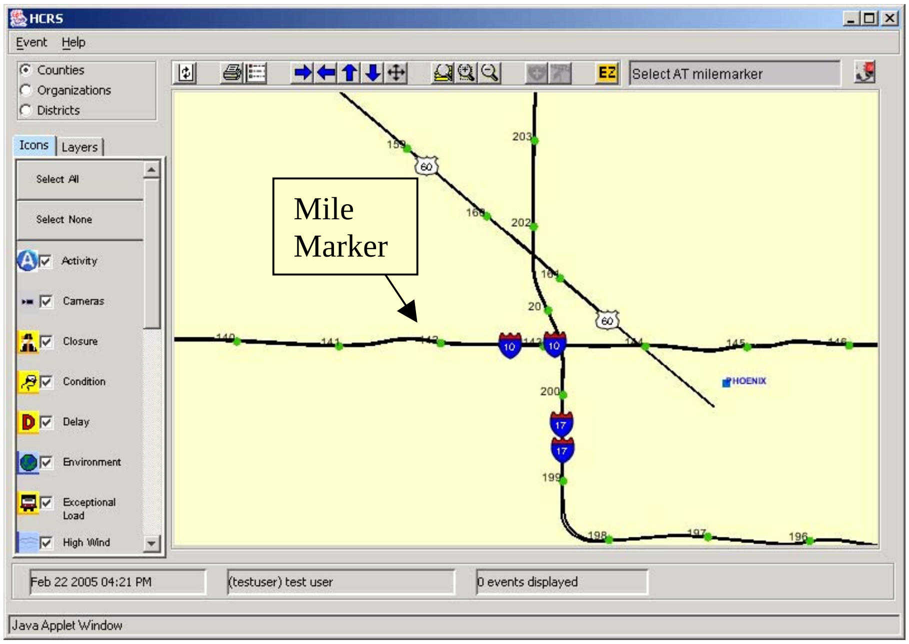

Figure 12: “At” Mile Marker Display

The user then clicks a milepost (MP) marker on the desired highway.

- The "Event" entry screen opens with the highway system, the highway number, and the milepost filled out.
- The user fills out the rest of the event information.

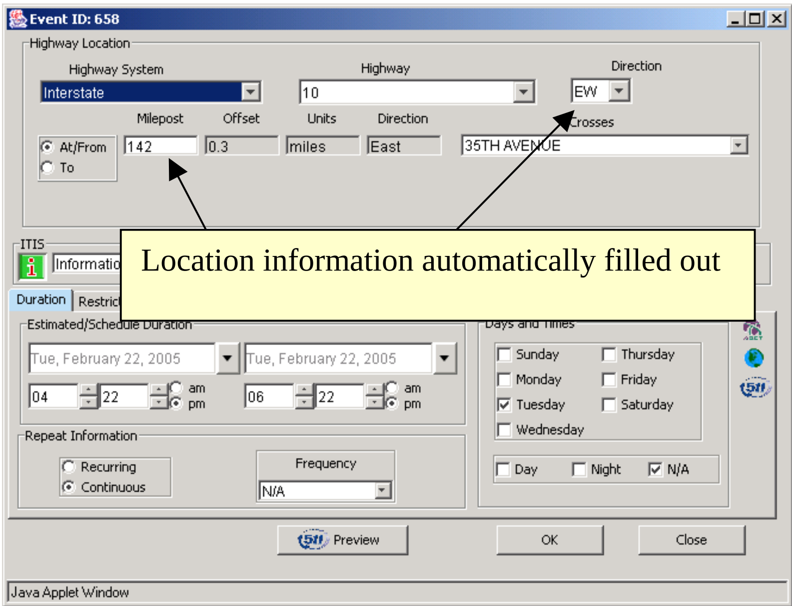

Figure 13: "At" Mile Marker Selection

The user fills out the entry screen and presses "OK," "Submit," or "Terminate."

- The map display changes back to normal mode.
- All icons return.
- Text area cleared.

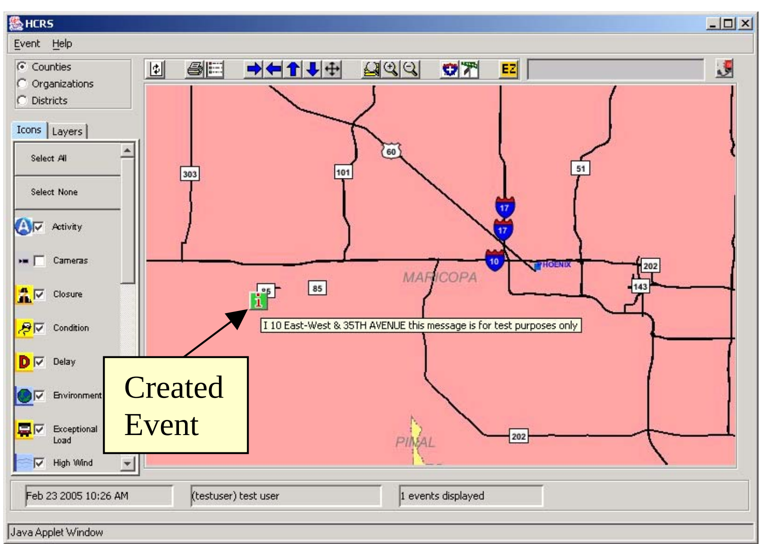

Figure 14: "At" Resultant Icon

If the user selects the “EZ Entry From/To” option, the displayed map changes:

- All icons disappear.
- Milepost markers and labels appear on all highways.
- Text area displays: **Select FROM milemarker.**

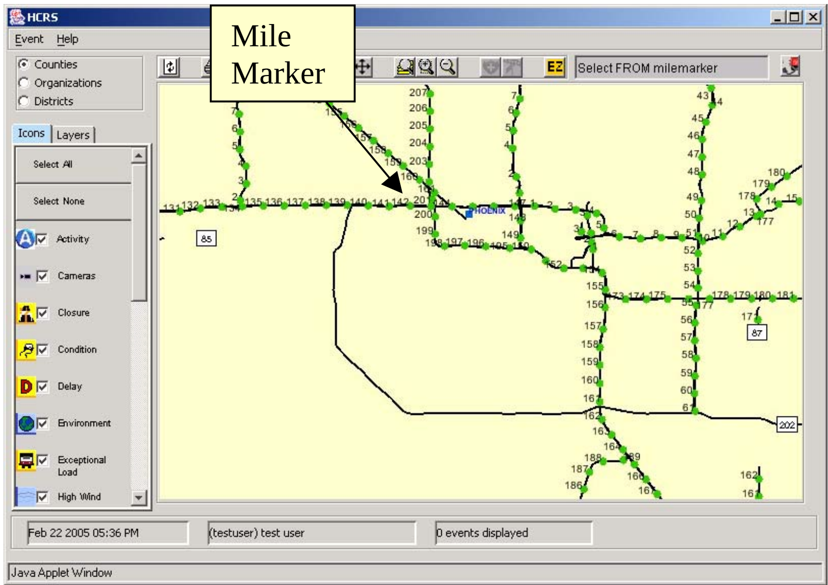

Figure 15: “From” Mile Marker Display

The user clicks a milepost marker to indicate the “From” mile marker:

- The map changes to display milepost markers only along the selected highway.
- The selected FROM milepost marker will be marked blue.
- The text area displays **Select TO milemarker.**

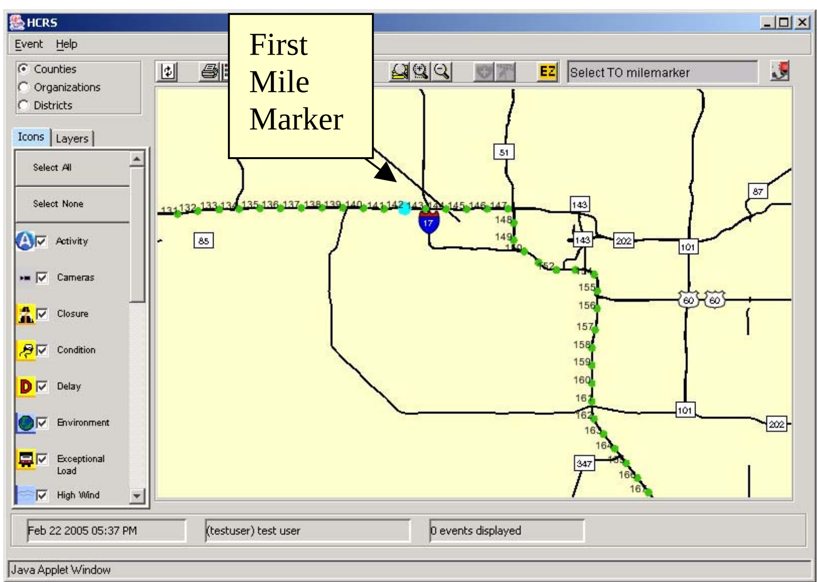

Figure 16: “To” Mile Marker Selection

The user clicks a second milepost marker on the desired highway:

- The "Event" entry screen opens with the highway system, highway, the At/From and the To milepost fields filled out.
- The user fills out the rest of the event information.

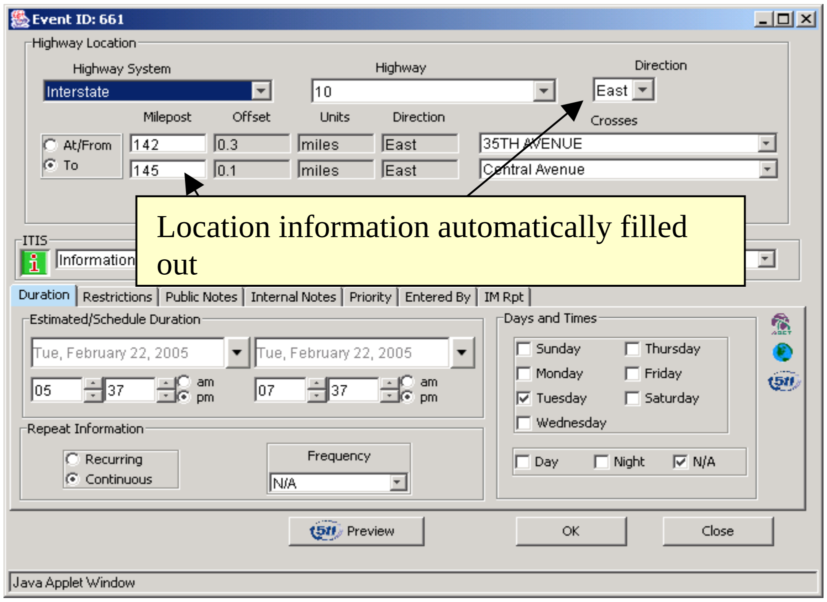

Figure 17: "From/To" Mile Marker Selection

The user fills out the entry screen and presses "OK", "Submit" or Terminate"

- The map display changes back to normal mode.
- All icons return.
- Text area is cleared.

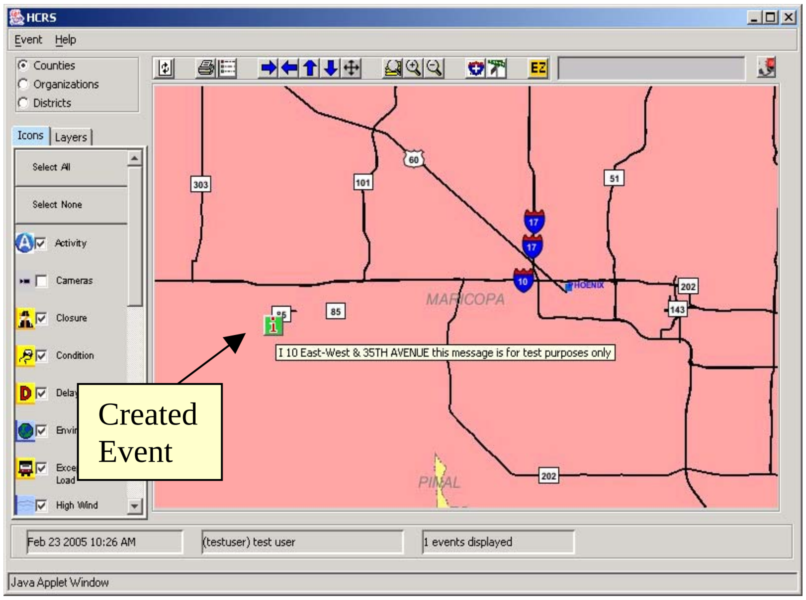

Figure 18: "From/To" Resultant Icon

IV. PROJECT CONCLUSIONS AND RECOMMENDATIONS

Phase One succeeded in consolidating the selected data resources and making those data streams available for better "big-picture" management of the state highway system by ADOT. This success carries over to the public website and 511 telephone services, greatly enhancing the information available to travelers and Commercial Vehicle Operations (CVO).

Based on this level of success, additional HCRS data interfaces are being considered, including rural CCTV, "live" video, traffic signal timing plans, trip travel time, and traffic equipment status. Phase Two of this project has improved the accuracy and speed of HCRS data entry with its graphical interface.

This project achieved several key goals for highway operations:

- "Variable Message Sign" icons were located on the HCRS map and their text made available to both HCRS clients and Internet browsers. The text messages displayed on VMS are archived within HCRS.
- Icons for CCTVs on RWIS stations, VMS structures and free-standing installations were placed on the HCRS map and their still images displayed as links.
- Weather data from NWS and the ADOT RWIS system were gleaned from the Internet, linked to icons on the HCRS map, and archived into the HCRS database.
- A graphical interface was added to locate HCRS events using the map to provide milepost information.
- Presentation layers and icons were removed and simplified.

PROJECT LESSONS LEARNED

This complex integration project was successful due to the application of proper management and oversight techniques by the TAC and system integrator. Although the overall response given by HCRS users and management has been positive, lessons can always be derived for the benefit of subsequent projects.

One of the more complex issues surmounted was the integration among the various third-party data providers and OZ Engineering, the system integrator. Interfacing between disparate systems must have "agreed upon" requirements documentation including unit and integration test plans. Due to the limited budget and schedule, insufficient unit testing was performed by the various other data providers. This resulted in additional resources being used during the integration and system testing phases of this project.

Additionally, the VMS and RWIS field projects were contracted previous to, and independent of the HCRS integration project. This caused several schedule conflicts and delays over the course of the implementation. For example, the statewide upgrade of VMSs occurred over the course of one year, which essentially delayed this interfacing project for that same duration. Had all projects been scoped with the eventual integration results in mind, then all vendors might have been more cooperative and timely in their participation. Furthermore, other HCRS and 511 functional development efforts with respect to highway management necessarily took priority over the research tasks of this SPR 512 project.

Due to the amount of external system data now being archived by the HCRS, the size of this project's ITS database has become a concern. Additional storage capacity was not accounted for in the project's original hardware budget. In retrospect, a storage capacity analysis should have been conducted for each data source, and procedures including backup cycles should have been implemented prior to system integration.

For example, while the CCTV still-images were not archived, the text data from VMS signs and NWS forecasts and advisories could have been compressed before archiving to the HCRS database. Furthermore, ITS data archive stakeholders should have been consulted to better design the backend infrastructure. In spite of this, it is expected that the archived ITS information will be invaluable for transportation administration, policy evaluation, safety and performance monitoring, post-analysis engineering, and short- and long-term planning.

While the Technical Advisory Committee provided invaluable insight and guidance, the TAC demographics could have been improved. HCRS users (operators) could have been better represented, or guest experts called in for consultation. It is believed that the teleconferencing and pre-meeting distributions of presentation slides and meeting notes worked well.

A longer than expected troubleshooting effort was required when interfacing between HCRS and RWIS/NWS. HCRS difficulties in connecting to the RWIS server and its database resulted in noticeable slowdown of other, unrelated, HCRS functions. A "spider" process, which was developed to periodically poll and collect data from over 40 NWS weather data web pages, exacerbated this situation. ADOT is reconfiguring the HCRS complex, and OZ Engineering is redistributing the software processes among the additional server hardware to provide better performance. An end-to-end communications survey should have been conducted to insure each component is protected from unwarranted interaction with its peer components. The new HCRS hardware configuration is being implemented and will be operational by April 2005.

Finally, the "Easy Entry" GUI upgrade has made ADOT aware of a critical dependency on up-to-date milepost GIS shape files. ADOT is in the process of addressing this issue.

PROJECT RECOMMENDATIONS

NTCIP is a family of communication protocols for traffic management devices. Since 1996, this protocol is being developed jointly by the American Association of State Highway and Transportation Officials (AASHTO); the Institute of Transportation Engineers (ITE); and the National Electrical Manufacturers Association (NEMA), with funding from the Federal Highway Administration. It is recommended that these standards continue to be used as ITS integration projects are implemented.

Extensible Markup Language (XML) and XML Schema Definition (XSD) technologies can be used to flexibly define the "mutually agreed upon" syntax of data messages. The project highly recommends to any software interface developers that XSD validators be used to allow developers to test the XSD compliancy of their output locally, independent of parties on the other side of an interface. For example, the NWS is currently working on producing the forecasts and advisories in XML format.

Along the lines of consistent and up-to-date public information, the project recommends improved processes that permit seamless openings of new freeways such that, at the time of the official opening, HCRS is ready to respond. This would require that ADOT create procedures for updating its GIS data as a construction project approaches completion, as well as recording additional 511 Interactive Voice Response voice files for any new road names, and creating an HCRS maintenance release. The ultimate goal would be to have the new freeway section available on az511.com and 511 immediately following the official roadway opening.

There are many more ITS data elements that might be helpful and useful to Arizona roadway travelers, whether Arizona is their destination or "on the way". These might include interstate and international border crossing information, roadway and weather conditions, incident management and traffic reports, roadway construction and maintenance schedules, law enforcement emergencies, and so on. The TAC decided that the two key areas of statewide data needs (see Appendix A) are:

- More traveler information, e.g., rural trip travel prediction, and regional weather and road conditions.
- Additional roadway management information, e.g., Tucson and Nogales CCTV still-images, and a GIS longitude, latitude and elevation maptip that appears when the client's mouse hovers over the HCRS map.

It is strongly recommended that system enhancements continue to be made incrementally for scheduling and budgetary reasons. Although this incremental approach may prolong the overall system integration timeline, it will ensure successful completion of each project along the way.

PROJECT BENEFITS

The phased implementation of this research involved the development of a single user-friendly application (HCRS) with consistent software interfaces to numerous ITS proprietary applications via the Internet and intranet. As each new feature passed testing, it was inserted into the HCRS production update schedule. This field-tested development resulted in statewide centralization of ITS data. This gave ADOT highway managers at state and district operations centers, and in the field, an integrated operations tool to receive current dynamic traffic and roadway data for distribution, display and decision-making. Generally speaking, this project has "raised the bar" in collection and dissemination of advanced traveler information.

Unlike most traffic management systems that cover metropolitan urban centers, the HCRS is statewide, and it provides integrated consistency for ADOT's roadway management and for the state traveler. While this project was initiated by and for the ADOT field offices, Arizona's driving public can now access some of the same real-time information via the Internet and the 511 Interactive Voice Response system. Also, recent findings by others on the perceptions of older drivers as to ADOT's use of ITS resources have been incorporated concurrently into the HCRS refinements. The results contribute greatly to enhanced public satisfaction with ADOT's traveler information by providing more and clearer reports, advisories, and camera images.

It is envisioned that the motoring public would access this information via Highway Advisory Radio, information kiosks at rest stops, Personal Digital Assistant cell phones, third party media companies, and other future data Value Added Resellers. It is expected that better dissemination of traveler advisory information during major storms and other incidents will reduce call-in overload, improve ADOT district core staff decision-making efficiency, enhance the credibility of the Department, and decrease costs for travelers, as well as the transportation service sector.

This development project demonstrated how national standards, for example, the National Transportation Communications for Intelligent Transportation System Protocol (NTCIP), promote better interfacing and cooperation between government agencies and the commercial world, and consequently, faster product development.

Finally, because of the ITS data archiving, this project is an example of how retrospective analysis by transportation planners can improve the day-to-day real-time management of state highway systems.

APPENDIX A: STATEWIDE DATA NEEDS

OVERVIEW: APPENDIX A

The following memorandum and tables were developed collaboratively by the project TAC, ATRC and OZ Engineering in late 2002 and early 2003. It refers to an early (2000) matrix of needs that was a tool of the original project scoping process.

The goal was to determine the feasibility and status of the principal original (2000) Project 512 concepts as follows, which, in the project team's opinion:

- Had been successfully completed.
- Were already programmed to be addressed by others.
- Were seen to be unachievable in the near future.
- Might yet be achievable in a second phase of the project.

It should be noted that the ultimate decisions about what might be scoped in Phase Two were further refined by the project team by mid-2003, at which point OZ Engineering proposed to ADOT the user-friendly HCRS data entry based on the remaining project funds and the viability of the goals (refer to Appendix B).

SPR 512

Data Integration / Traveler Information Project

Statewide Data Needs

Update to TAC on Work by Others – February 2003

TAC: 22 January, 2003
Rev: 12 February, 2003

Introduction:

The statewide Data Needs Matrix was created by the ATRC Technical Advisory Committee and dated 21 August 2000. Based on the TAC meeting of 22 January 2003, further reviews of planned HCRS upgrades, and the current state and types of ITS data available, OZ Engineering has revised the project's original SPR 512 statewide Data Needs matrix. The goal is to scope a second phase of the project, with additional types of data to be consolidated with HCRS, if possible.

This new matrix is organized as follows:

- Section A – HCRS Upgrades completed by February 2003.
- Section B – HCRS Upgrades in scope now, after February 2003.
- Section C – Items that are to be scoped as part of Phase 2 of this project.
- Section D – Items that are deemed not achievable as of February 2003.

In the TAC's original project goals matrix, four Status Classes of items were defined:

- Class S – In scope – HCRS upgrades by OZ Engineering.
- Class F1 – Achievable / commitments exist to complete.
- Class F2 – Achievable easily / commitments & funds needed.
- Class F3 – Proof of concept / may be achievable / commitments & funds needed.

<u>Status: Old Code</u>	**<u>No.</u>**	**<u>ITS DATA CLASS / SOURCE</u>**	**First or Second Priority**		**Existing or Future Resource**	
Section A – HCRS Upgrades Completed by February 2003						
S	**1**	HCRS - Access to and Local Updates of: Information Types, Functions, Graphics, Map Use Tools	**1**		**E**	
F2 - *Read*	**4a**	RWIS real-time data – Design 1 <u>(new third party)</u> *Read-only*	**1**		**E**	
F2 - *Read*	**4b**	RWIS real-time data – Design 2 <u>(new third party)</u> *Read-only*	**1**		**E**	
S	**5**	Real-time Weather: Local, Regional, Nat'l / NWS radio;<u> text, website</u> are in-scope	**1**		**E**	
F2	**5**	Real-time Weather: Local, Regional, Nat'l	**1**		**E**	
S	**9a**	Real-Time Route Restrictions: **<u>Static</u>**: Height, Weight, (from ABIS data) are in-scope	**1**		**E**	
S	**9b**	Real-Time Route Restrictions: HCRS **-** <u>Dynamic</u> Incidents, Construction, Special Events	**1**		**E**	

Table A: HCRS Upgrades Completed by February 2003

Status: Old Code	**No.**	**ITS DATA CLASS / SOURCE**	**First or Second Priority**		**Existing or Future Resource**	
Section B - HCRS Upgrades In Scope Now - After February 2003						
S	**2a**	Rural VMS Facilities – Physical location, directionality (from ATIS data)	**1**		**E**	
F1	**2b**	Rural VMS Status - Active messages, user ID, message time/date log: Provide statewide views to all users.	**1**			**F**
F3 – *2-way*	**3**	Rural VMS Operation *(Two-way communication / real-time update / continuous polling)*		**2**		**F**
F1 – *urban*	**6a**	*Urban* "Live" Video / CCTV – Planned deployments at TI's, etc, use of 3rd-party feeds. *(Images can be polled at intervals)*	**1**			**F**
F2 – *rural*	**6a**	Rural "Live" Video / CCTV – Planned rural deployments at TI's, etc, use of 3rd-party feeds. *(Images can be polled at intervals)*	**1**			**F**
F3 – *2-way*	**6a**	Rural "Live" Video / CCTV – Planned rural deployments at TI's, etc, use of 3rd-party feeds. *(Requires commitment from CCTV software owner)*	**1**			**F**
F1 – *urban*	**6b**	*Urban* "Still-frame" Video / CCTV – Planned deployments at VMS sites *(Images can be polled at intervals)*	**1**			**F**
F2 – *rural*	**6b**	Rural "Still-frame" Video / CCTV – Planned deployments at rural VMS sites *(Images can be polled at intervals)*	**1**			**F**
F3 – *2-way*	**6b**	Rural "Still-frame" Video / CCTV – Planned deployments at rural VMS sites *(Requires commitment from CCTV software owner)*	**1**			**F**
S	**12**	Real-Time Traffic Monitored Data – Volume, Speeds Primary Sources – ADOT-FMS	**1**		**E**	
S	**13**	Incident Management database: Response Resources, Contacts and Guidelines *(Word / Excel by TOC)*		**2**	**E**	
S - *Read*	**14**	Feature Inventory: Speed Limits, ADTs, Passing Lanes, Structures etc. ***Primary Sources – HPMS, ATIS, ABIS, Traffic Engr. Speed Regs. File*** **(*S – basic read-only*) (SPR 513 project shapefile only)**		**2**	**E**	

Table B: HCRS Upgrades in Scope After February 2003

Status: Old Code	Old/ New No.	ITS DATA CLASS / SOURCE	First / Second Priority		Existing / Future Resource	
Section C – Data Types to be Scoped in Phase 2 of This Project						
F2 – *Urban*	6a **(C-1)**	Rural/Urban "Live" Video / CCTV – Planned rural deployments at TI's, etc, use of 3rd-party feeds. *(Images can be polled at intervals)* **(Retrieve Tucson FMS camera stills, same as Phoenix FMS)**	**1**			**F**
F2	16 **(C-2)**	EPIC - International Port-of-Entry Clearance Data *(Can be read if proprietary data is accessible)* **(Retrieval of border crossing congestion camera(s) only)**		**2**	**E**	
NEW	**(C-3)**	Kingman District Escape Ramp Prototypes: • Escape-ramp cameras. • Intrusion sensor information. • Other.	**1**		**E**	

Table C: Data Types to be Scoped in Phase Two

Status: Old Code	**No.**	**ITS DATA CLASS / SOURCE**	**First / Second Priority**		**Existing / Future Resource**	
		Section D – Data Types Not Achievable as of February 2003				
F2	**3**	Rural VMS Operational Strategy & Guidelines to indicate which VM signs should be utilized, and to recommend messages advising of situation and action. **(do not currently exist)**		**2**		**F**
F2	**7**	AVL – Monitoring of snowplows and DPS and Maintenance units for safety and operational efficiency. *(Requires cooperation from software owner* as to polling interval and process; communications constraints exist) **(Not Feasible with ADOT's current AVL technology)**		**2**		**F**
F3	**7**	AVL – **Real-time** tracking of snowplows and DPS and Maintenance units for safety and operational efficiency. *(Real-time issue – requires commitment from software owner)* (*Dependent on AVL communication – cell, satellite, radio)* **(Not Feasible with ADOT's current AVL technology)**		**2**		**F**
F2	**8**	Alternate Route Database *(Current ARIS Project 513 – when implemented after field test, via central server w/ district updates)* **(Separate project)**		**2**		**F**
F1	**9a**	Real-Time Route Restrictions: *Grades, Radii – future ATIS data from GPS, Video Van, GIS Section **(Future Data - not available)**	**1** **1**		**E**	 **F**
S	**10**	Traveler Roadway Information – New System Concepts *(*Open protocol will accommodate future devices / systems)* **DELETED**	**1**			**F**
F2	**11**	Traveler Tourism Information – New System Concepts *(Restaurants, motels, travel times)* *(*Open protocol will accommodate future devices / systems)* – Can access Trip USA / Northern Arizona (?) *DELETED*		**2**		**F**
F2	**14**	Feature Inventory: Speed Limits, ADTs, Passing Lanes, Structures etc. ***Primary Sources – HPMS, ATIS, ABIS, Traffic Engr. Speed Regs. File*** *(**F2 – to query & work with data**)* **(Out of scope)**		**2**	**E**	
F2	**15**	Weigh-In-Motion Data – Remote / Rural at state border POEs *(Can be read if proprietary data is accessible)* **(Data not available)**		**2**	**E**	
F2	**17**	Traffic Signal Timing Plans – District / Local Workbooks & Traffic Engr./Traffic Operations paper & DB files **(Out of scope)**	**1**		**E**	
F2	**18**	Traffic Signals: Rural / Remote Dynamic Timing & Status (& future control) Based on AZTech control concepts in rural applications **(Out of scope)**		**2**		**F**

Table D: Data Types Not Achievable as of February 2003

APPENDIX B: PHASE TWO OPTIONS

Phase Two Options

Proposal to ADOT Project 512 TAC

STILL IMAGES FROM CCTVS AT NOGALES PORT OF ENTRY COMPOUND FOR EXPEDITED PROCESSING AT INTERNATIONAL CROSSINGS (EPIC)

The EPIC system has several cameras at the international border crossing at Nogales, Arizona port-of-entry. This option would display CCTV still images of border traffic congestion via HCRS Map icons.

RURAL TRAVEL TIMES / ROUTING INFORMATION

The original vision included such possibilities as average travel speeds, trip time estimates, status of destination (construction, congestion etc), weather and road conditions, and other information of value to the motorist. If, for example, a trip to Phoenix is +/- two hours but "complications" arise, then travelers can alter their timing or routing plans. Much of this information about potential delays is available or can be transferred from, or developed from, the current HCRS data.

The original concept was to have everything in a visual format (as with HCRS). Routes could be color-coded for travel times or speeds to indicate capacity or delay. That feature could be similar to the FMS maps for the Phoenix metro area. However, currently there is no way to reasonably determine real-time travel conditions with the technology deployed in the rural portions of the State.

REGIONAL WEATHER AND ROAD CONDITIONS

Based on HCRS data, users could toggle the display to color-code the highway system for road surface conditions, for example, with blue for ice, green or black for dry, etc. At a glance everyone would know what the road conditions are for that route without reading text or manually referencing to mileposts or landmarks. This feature would be based on RWIS sensor information and on real-time field inspection reports called in to the District with road surface classification codes.. Detailed application functionalities include:

- Work with ADOT to establish road weather condition classification themes.
- Create a process that will monitor RWIS data and update the road layer to reflect road conditions.
- Modify HCRS so that weather events update the appropriate road layer to reflect road conditions.
- Update HCRS GUI to allow the user to display the regional weather and road condition layer.

USER-FRIENDLY HCRS DATA ENTRY

At present in HCRS, local Orgs enter winter codes for road conditions manually with mileposts, routes, etc. A key refinement would give the local operators the ability to point, click, and drag their mouse from point A to point B on the HCRS map route, highlight that stretch, then assign a color to it for the current road condition.

Underlying the point and click process, a second key goal would be to provide the ability for the milepost to milepost locations, route and conditions to be automatically recorded in text and archived. This would be very easy for the local operators to keep current using these concepts.

OZ Engineering will provide the services necessary to implement a user friendly data entry screen. Detailed application functionalities include:

A. Task management.
B. Work with ADOT to establish milepost layer and add shape file to the HCRS map file. Determine the zoom level at which mileposts appear on map.
C. Update HCRS GUI to allow the user to select an “entry-by-milepost” option that becomes active at a given zoom level only.
D. Modify HCRS to monitor user mouse click on milepost points “A” and “B”. These clicks will be translated to latitude and longitude and sent to the ArcIMS map server to determine the nearest highway and milepost that user clicked. The background map will be redrawn with the beginning and ending mileposts highlighted, as well as the mileposts in between.
E. Initialize the HCRS event entry GUI to receive on-road, beginning and ending milepost as initialization parameters.
F. Update User manual and documentation.

POP-UP GIS ELEVATION CONTOUR INFORMATION

Another user-friendly concept would be to provide a layer of elevation contours so that areas above a certain elevation could be shown, for example, when the snow line drops to 6,000’. Zone elevations are also significant for elevation-constrained travelers or cargoes. Color-coding may be useful in this case. Detailed application functionalities include:

- Obtain an elevation contour shape file from ADOT’s GIS department.
- Work with ADOT to establish contour colors and add shape file to the HCRS map file.
- Update HCRS GUI to allow the user to display the elevation layer as a background layer option.

POP-UP GIS LATITUDE AND LONGITUDE INFORMATION

Enhance HCRS to display the latitude-longitude of the mouse pointer, for example, to dispatch Medevac, public safety, or fire control aircraft to specific point locations such as road junctions. Detailed application functionalities include:

- Capture cursor events as mouse is moved over map display.
- Convert mouse position to latitude and longitude.
- Display latitude and longitude on the GUI.

TUCSON CAMERAS

Augment HCRS to display Tucson camera images onto the Internet. Detailed application functionalities include:

- Review camera image capture options with ADOT and implement in Tucson.
- Investigate Tucson’s Internet publishing infrastructure.
- Obtain latitude and longitude of camera positions.
- Create camera image retrieval spider that obtains the image data already published on the Internet web.
- Add Tucson cameras as an HCRS startup event and display on Internet.

APPENDIX C: HCRS PRODUCTION RELEASE SCHEDULE

HCRS PRODUCTION SCHEDULE

VERSION	DATE	SPR 512 RELATED FUNCTIONALITY
2.7	11 Dec 2002	• Added “Help About” window indicating software version. • Improved icon appearance, viz., cameras, weather stations. • NWS “Forecasts and Advisories” feed in place.
2.8	8 Jan 2003	• NWS “Forecasts and Advisories” icon added. • Used PAC file for configuration of Internet browser. • Allowed Internet user to filter information displayed by icon category.
2.9	12 Feb 2003	• Replaced “Thermometer” icons with “Weather Condition” icons for NWS. • Archived ESS data to HCRS database. • Temporarily placed “Weather Sensor “icons on map with "Under Construction" detail page for HCRS clients and http://www.az511.com.
2.10	12 Mar 2003	Allowed HCRS Clients and Internet browsers to view the RWIS data
2.11	9 Apr 2003	• New RWIS html page: weather and precipitation broken into two tables with dates. • Winter storm advisory changed to winter storm alert.
2.12	14 May 2003	Added icons to display FMS camera images.
2.13	11 Jun 2003	• Installed new JDOM.jar file. • Updated ArcIMS java to use j2se. • Removed “Dangerous Vehicle” and “Headways” events. • Path correction for camera.xml.
2.16	10 Sep 2003	Removed “Weather Sensor” (RWIS) icons from HCRS and az511.com.
2.17	8 Oct 2003	Additional Cameras added.
2.18	12 Nov 2003	• New Cameras added to webpage. • Updated legend display.
2.19	10 Dec 2003	Updated weather text page.
2.20	7 Jan 2004	RWIS re-enabled.
2.26	13 May 2004	• Updated camera names and locations. • Installed ssl. • Installed RWIS.

VERSION	DATE	SPR 512 RELATED FUNCTIONALITY
2.30	22 Sep 2004	• Enabled Roadway Weather Information System (RWIS) interface • Enabled NWS forecast & advisory interface
2.31	30 Sep 2004	• Displayed VMS status on HCRS & Internet
2.33	18 Nov 2004	• Added VMS message information • Changed CCTV icon
2.35	13 Dec 2004	• Added troubleshooting code to capture VMS data feed when the VMS status does not update. • Trimmed the field string retrieved from RWIS tables.
2.38	24 Feb 2005	• Added “Easy Entry” functionality. • Fixed maptip on az511 that was truncating large VMS messages. • Changed watchdog in xsd file to match incoming VMS xml data. This should improve the notification process of VMS changes made on the FDS system reaching HCRS • Enhanced pre- and post-activation QA/QC procedures
2.39	10 Mar 2005	• Added az511 maps for Pima County outside of Tucson. • Added labels for surrounding states to az511 maps.

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