Case Study

High Occupancy Tolling and Toll Roads: A Proven Solution for HOT Lane Implementation

Problem Definition

As revenues from fuel taxation continually decrease and with ever-increasing demands on the public purse, the problem of road funding has reached crisis proportions. The interstate roadway system in the U.S. has now reached the age where the costs of repairing and maintaining the infrastructure continue to rise every year. The increase in population and urban congestion continues to put growing demands on existing infrastructure and the costs of building new roads to help with this problem are phenomenal. Traffic congestion exacerbates air quality problems, usually in areas where the air quality is already poor.

Government at all levels is looking for ways to address this crisis. Metropolitan and regional transportation authorities are performing studies and evaluations. State Departments of Transportation (DOTs) are looking for answers. The Federal Highway Administration (FHWA) is funding studies and publishing papers in an attempt to help. IBTTA sponsored a workshop in March 2004 concerning this issue. The attendance at this workshop set records for IBTTA workshops. Over 100 new attendees from regional transit authorities, state DOTs and the FHWA came to the workshop.

While "free," or government funded, roadways are experiencing this ever-increasing problem, toll roads have prospered and, with the addition of electronic tolling introduced nearly 15 years ago, have actually become more efficient and cost effective.

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Just as the innovators saw at the time, the implementation of electronic tolling has transformed the operations of toll roads dramatically and has provided for the growth of applications, services and new capabilities not previously imagined. The next technological breakthrough is occurring for efficient use of non-toll roads using this same electronic tolling technology. The U.S. now has over 15 million electronic transponders collecting tolls daily, affording the industry billions of dollars in savings. Forward-thinking regional, state and federal departments are now seeing the extension of services using this installed, proven product.

California implemented a then-radical approach to relieving congestion on their freeways by introducing the High Occupancy Vehicle (HOV) lanes in the late 1970's. Since then, state DOTs have been wrestling with the benefits of this congestion/commuting reduction compared to the negatives of reluctance to carpool and the potential efficiency of dedicating a highly valuable traffic lane to HOV traffic.

San Diego's Association of Governments (SANDAG) initiated a unique study in the late 1990's to address this critical issue. With over one million Title 21 transponders throughout the state of California, they saw a possibility of incorporating the transponder as a unique identifier for designated HOV lanes and tested the willingness of the driving public to pay for access to a high-speed HOV lane. SANDAG used focus groups, public forums, questionnaires and similar methods to gauge the potential success of the idea. The results were positive in many ways:

- Drivers saw value in paying for using an HOV lane to save time, without having the necessary multiple occupants.
- SANDAG saw an excellent opportunity for generating revenues which had not previously existed to support this service and to also help subsidize other services such as mass transit.
- The idea demonstrated a dramatic increase in the traffic on the previously underutilized HOV lane while decreasing congestion in the adjacent "free" lanes.
- A side benefit was the introduction of "fee-based" road usage that prepared the driving public for future toll or fee access to roads.

This successful test provided the concept of converting HOV lanes to High Occupancy Tolling (HOT) lanes.

The 1990's also saw another first in California. To help alleviate the enormous congestion between Orange and Riverside Counties, the Orange County Transportation Authority (OCTA) constructed toll lanes in the median of 10 miles of the most congested portion of the existing State Route 91 (SR-91). Two lanes were constructed in each direction with an additional "HOV +3" lane added at the tolling zone halfway through the 10-mile stretch of toll lanes. This toll road became the first completely electronically tolled road in the nation. All vehicles using the toll road must have a registered, prepaid electronic toll account and associated transponder. Additionally, patrons pay a variable toll for using the road based on time of day, day of week, and direction of travel. HOV +3 vehicles and motorcycles travel free of charge in the HOV +3 lanes, except for congested periods when a toll is collected. Any vehicle which does not have a transponder is considered a violator and penalties are enforced. Any vehicle violating the HOV +3 are violators and are handled under the same rules as other HOV lanes in California.

The obvious trend for funding new road construction is to build toll roads. The future of tolling is clearly open highway, nonstop tolling. This innovation in electronic tolling over barrier-based toll plazas has proven to provide the most cost-effective, efficient method of collecting tolls and also provides for maximum throughput of traffic on the toll lanes. Tolls are collected without traffic being stopped, or even slowed, to collect the toll.

SOLUTION DEFINITION

The future of underutilized HOV lanes is conversion to HOT lanes. This topic has moved past the discussion phase to actual legislation in several states.
Sirit Inc., the undisputed leader in the production and provision of Title 21 readers and transponders, has helped implement future of tolling and HOT. We set a

corporate goal to become a premier leader in not only the provision of transponders and readers, but also open highway, nonstop tolling and HOT lane systems. We achieved this goal in January 2004.

The electronic tolling system on the SR-91, installed in the 1990's, had reached the end of its system life and OCTA was concerned that its revenue stream was at risk. The Authority issued an RFP to provide a replacement system in late 2002. Sirit won the bid and the contract was awarded in January 2003. Due to Authority concerns over the state of the existing system, a very aggressive replacement schedule was part of the contract.

Starting immediately, an extensive requirements gathering and interactive design effort to provide a state-of-the-art system began and was completed in April 2003. Development of the system began in mid-April 2003, and first lane deployment was completed and accepted on September 22, 2003, only five months after development was started. Full deployment of all lanes was completed on October 22, 2003, six months after development was started. This milestone began a contractual 90-day acceptance period. The system acceptance period ended on January 22, 2004, with all acceptance criteria met or exceeded. The Orange County Transportation Authority (OCTA) formally accepted the system on January 23, 2004. While the timeline for this project was full system development, deployment and acceptance in 12 months and two weeks from contract signing, full system acceptance was achieved only nine months after the start of development, a timeframe historically unmatched in the provision of tolling systems.

OCTA set critical, high system requirements that were achieved by the Sirit system, including:

- Prime Directive – "No revenue data can be lost for any reason"
- Develop a state-of-the-art nonstop, open toll road, HOT, and traffic management system
- Develop the system in a modular fashion consisting of subsystems which can work independently or be integrated together
- Develop the system to be hardware platform independent
- Develop the system to be hardware independent so the system can utilize any vendor's readers, tags, lane peripherals and devices
- Develop the system to allow for the addition for toll collection methods other than open highway, such as mixed mode and manual
- Provide multiple methods of detecting and identifying 100% of the vehicles passing through the toll zone, even motorcycles
- Correlate the multiple methods of vehicle detection and identification data and send data package to the transaction processor for account reconciliation or violation
- Develop the system to be able to interface with any transaction processor with minor modifications
- Maintain copies of all revenue data at lane and toll zone levels
- Capture Automatic Vehicle Identification (AVI) data from all transponder-equipped vehicles
- Capture vehicle license plate image and perform Automatic License Plate Recognition (ALPR) in real time in the lane for 100% of vehicles passing through the toll zone, not just violators
- Capture overview image of 100% of vehicles passing through the toll zone
- Handle vehicle speeds from 0 to 100 mph
- Handle peak traffic volumes of 2,400 vehicles per hour, per lane
- Maintain a sustained overall system accuracy of 98% (system accuracy is consistently achieving 99.6% accuracy as determined by independent audit)
- Maintain a system availability in excess of 99%, 24 hours per day, seven days per week
- Provide simplicity, scalability, flexibility, and ease of data management
- Provide auditability
- Provide redundant communication paths
- Provide redundant storage of all revenue-related data, including transactions, license plate images and overview images
- Provide that a single failure cannot completely disrupt ability to process toll collection data in one or more lanes

The development methodology successfully employed by the Sirit team was based on:

- Work interactively with the customer and their representatives throughout the design, development and testing processes

- Build a team of recognized experts in the latest Microsoft development tools but with no toll experience and team these developers with toll system experts with over 80 years' accumulated toll system and integration experience
- Develop general specifications and detail design documentation and gain customer acceptance of the design before writing the first line of computer code

The Sirit system environment provides that:

- All computer hardware utilizes Microsoft Windows 2000 operating system (this decision was made due to the longevity of Microsoft, the immense level of support available, and the vast number of tools available, as opposed to lesser supported platforms)
- The system was developed using the .NET framework and Visual Studio toolset
- The Toll Zone Computer utilizes Microsoft SQL Server 2000 relational database management system
- The Toll Zone Computer hosts the central data storage and communicates with distributed applications through multiple Windows Services utilizing a message-oriented communication methodology via Extensible Markup Language (XML) using Microsoft Message Queuing (MSMQ)
- The system is technology independent with regard to AVI readers
- The system is technology independent with regard to computer platform hosting the system
- The system can utilize any detection sensor in widespread usage in the toll industry
- The system can be configured to provide support for any toll collection methodology or configuration

The Sirit system is structured with the following attributes:

- Each subsystem is connected over a LAN
- The LAN is implemented over fiber optic links with multiple paths for redundancy and is backed up with a wireless LAN connection should the fiber optic network be completely severed and made inoperative
- LAN communication speed is 1 Gigabit
- Major subsystems include:
  - Automatic Vehicle Identification (AVI) – reads, decodes and reports all transponder identification information to Lane Controller
  - Lane Controller (LC) – captures vehicle passage data and AVI data for all vehicles equipped with transponders, correlates all data and sends to the Toll Zone Computer (TZC)
  - Video Enforcement System (VES) – captures license plate image and performs ALPR for all vehicles passing through the tolling area, captures overview image of all vehicles passing through the tolling area, sends all images to the Intermediate Storage Server (ISS) and license plate data from the ALPR process to Toll Zone Computer (TZC)
  - Intermediate Storage Server (ISS) – receives all images from VES and immediately replicates these images to the Vehicle Image Server (VImS)
  - Vehicle Image Server (VImS) – receives all images from all ISSs and provides access to Violation Processor
  - Toll Zone Computer (TZC) – receives and stores all lane data, both from the LCs and VESs, compiles and correlates all data from a single vehicle and provides all data to transaction processor
  - Real Time Enforcement Display (RTED) – provides real-ime display of all vehicle overview images, ALPR image and data, and LC data for enforcement in real time. This system provides information on the last 100 vehicles and can be scrolled and locked on a particular violator. The information is used to provide enforcement for the HOT lanes.
  - System Maintenance and Control (SMaC) – provides interface for operator to configure and maintain lane level equipment both locally and remotely and provides visual information regarding system health and any failures or degradations
  - Maintenance Online Management System (MOMS) – provides system diagnostic and failure/degradation tracking and notification of failures or

degradations
- Data Logger (DLOG) – a subsystem provided by RapidToll to monitor all lane sensors and records all lane events concurrently with toll zone overview video. This tool is used diagnose lane events down to the individual discrete level and also provides independent vehicle counts for all vehicles passing through the toll zone for audit of the revenue collection system. The Sirit system is the only system currently deployed to incorporate the DLOG as an integral component of the system. A DLOG is supplied for each toll collection zone.

Additional system capabilities include:

- Due to modular design of the system, manual, mixed mode and ACM-only lanes can easily be deployed with nonstop open highway tolling
- Though not as accurate as AVI, tolling can be provided by VES through ALPR of the vehicle license plates
- Because all data is compiled at the TZC, the system can support both open or closed tolling strategies
- The basic design relates seamlessly to HOT strategies
- The design provides all necessary lane level functions for interfacing to a transaction processor of the Authority's choice for account handling and reconciliation
- As all vehicle passage through a toll zone is captured and stored, Traffic Management System (TMS) functions can also be performed such as:
  - Determining travel habits, frequency of travel, origin and destination points, and other data necessary for state DOTs to use in preparing future construction services and desires of the traveling public
  - Determine when the real "rush hour" occurs
  - Ramp usage – are all ramps used optimally or are other entries and exits needed
  - Compare travel times and speed of the toll and HOT lanes with feeless, general purpose lanes
  - Provide information for congestion or variable rate tolling based on travel times or lane load

BENEFITS OF THE SIRIT SOLUTION

- Speed of installation
- On-time delivery of solution
- System accuracy – 99.6%
- Fault tolerance – high level of redundancy
- System cost
- System scalability
- Modular structure
- System resource availability – Microsoft programmers
- Open system architecture – Microsoft tools

Sirit has seen the future and has successfully developed and deployed what has been called the most advanced open-highway tolling and HOT system available today.

We are proud of what we have accomplished and if you would like more information, please contact:

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