ITS Deployment and Improvements in Smaller Cities: Minnesota Case Studies

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ABSTRACT

Minnesota is widely known for not only its great lakes, but also for its metropolitan area including the cities of Minneapolis and St. Paul. With combined populations of more than 2 million residents, much focus is given to the rising congestion in these areas and transportation management.

Yet there is another significant transportation story in Minnesota – that of the needs of the rural areas and smaller urban areas. Minnesota has a great deal of weather-related traffic issues, special events throughout the state, seasonal tourism, and challenges affecting roadways without traditional communications or power infrastructure.

Minnesota has addressed these issues through a concept known as Transportation Operations and Communications Centers, or TOCCs, using co-location of state patrol and DOT personnel and a variety of technologies to manage traffic outside of the major metropolitan area of the Twin Cities. There are currently 9 TOCCs located in smaller Minnesotan cities. Five of these TOCCs have been upgraded to include a variety of cost-effective intelligent transportation system technologies which facilitate traffic challenges. The TOCCs also complement the Twin Cities Regional Transportation Operations Center (RTMC), which includes several workstations accessing TOCC and related transportation information from the corresponding cities.

This paper will focus on several of these cities and surrounding rural areas including Duluth, St. Cloud, and Rochester Minnesota. It will look at the transportation tools used to effectively manage unique challenges. This paper will also discuss the foundational public-private partnership model, recent operations and system enhancements, related ITS planning for additional implementations, linkage with the Twin Cities transportation operations, and lessons learned.

Introduction

The Minnesota Department of Transportation (Mn/DOT) and the Minnesota State Patrol (MSP) have implemented a network of Transportation Operation and Communication Centers (TOCCs). The goal of these centers is to establish an integrated statewide communication and transportation operations network serving rural and the smaller urban areas outside the Twin Cities metro area.

The individual TOCCs act as regional centers for 24-hour incident and emergency response, multi-agency dispatching and fleet management, interagency communications, collection and dissemination of road conditions and closures, traffic management, and in some cases, integrated transit operations. At the core of the TOCC concept is interagency cooperation, with updated facilities, innovative use of ITS technologies, enhanced, flexible communications networks, and leveraging of the Internet, with the overall goal to improve Mn/DOT's and MSP's operational effectiveness and to improve the overall safety and efficiency of the transportation system in Minnesota.

Five of these TOCCs have recently been enhanced with a new, flexible operations software developed in public/private partnership with ADDCO, Inc. known as Virtual Transportation Operations Center (VTOC) software. In 2003, VTOC was upgraded to include enhanced capabilities, and is now fully operational in the Duluth, St. Cloud, Rochester, Marshall and Mankato TOCCs. VTOC, coupled with other significant advances in these TOCCs, have made these smaller TOCCs truly unique and revolutionary.

Mn/DOT's first ITS implementations at TOCCs began with a public/private partnership initiated in 1998 and completed in 2003. This was a cooperative design/build effort using many new approaches to achieve transportation solutions. The partnership project was the first implementation in a statewide goal to ultimately have nine Transportation Operations and Communications Centers (TOCCs) in outstate Minnesota that would utilize unique and innovative ITS technologies and optimize resources through co-location of personnel and shared assets. The project was also intended to demonstrate rapid deployment using both existing and non-traditional communications infrastructure. While the design/build public/private partnership was formed by ADDCO and Mn/DOT, more than 25 different public agencies, 10 private companies, and 100 individuals were extensively involved in all aspects of the project.

Minnesota's unique TOCC concept holds that TOCCs will act as regional centers for gathering and disseminating transportation information. Each center incorporates multiple agencies in an expandable traffic management system and in deploying real-time traveler and weather information systems. By establishing a framework for interagency cooperation for incident response, operations, maintenance, traveler information systems and integrated transit operation, the TOCCs will increase the efficiency of Mn/DOT and its other partners. Since the inception of the partnership work with Duluth and St. Cloud, other ITS projects have been completed at three additional TOCCs in Rochester, Marshall and Mankato Minnesota.

Duluth and St. Cloud TOCC Example

Duluth, Minnesota is a vibrant city nestled on the shores of Lake Superior in Minnesota with a population of 100,000. While not overly large, Duluth has faced significant traffic challenges due to adverse and varying weather conditions including heavy snow and fog, seasonal tourism greatly impacting traffic volumes, and a proliferation of accident-prone bridges and tunnels. As with most smaller urban areas, Duluth's size and lacking infrastructure had initially prohibited them from using ITS to address their traffic challenges.

St. Cloud is approximately 60 miles from the Twin Cities area. A growing urban center, St. Cloud is now beginning to face issues similar to its larger urban counterparts. Interstate 94 connects St. Cloud directly to the cities of Minneapolis and St. Paul, and faces significant traffic volumes.

Project Background

Facing limited funding to significantly address these challenges, Mn/DOT decided to pursue a public/private partnership, by which the private partnership would financially contribute to the project goals through goods, services, development etc. Mn/DOT issued an RFPP for the project and ultimately entered into a contract with ADDCO in September, 1998.

Scoping studies for each Duluth and St. Cloud were performed in 1997-98, as a result of the Minnesota Intelligent Transportation Systems (ITS) Strategic Plan, and identified and prioritized each area's top transportation needs. The following top transportation needs were identified in the Duluth and St. Cloud Areas. (See Figure I for a more in-depth sample of needs identified in Duluth).

Duluth

- Reduction of incidents in the Interstate 35 tunnels, improvements in handling tunnel incidents, selecting of diversion routes, and informing the public of tunnel incidents and alternate routes.
- Improvement in handling congestion due to seasonal/special events.
- Reduction in number of and improvement in response for the high crash rate area at Interstate 35 bridge interchanges.

St. Cloud

- Improved arterial traffic management within the St. Cloud metro area.
- Ability to operate and maintain remote signals at key highway intersections in the District.
- Provide an opportunity to conduct a transit priority test.

- Implement a specialized demand-responsive system that provides transit scheduling for, monitoring of, and communicating to transit vehicles in the field.

Technical Overview

The core of the systems implemented in Duluth, St. Cloud and other TOCCs, and ADDCO's contribution to the public-private partnership, was the development of an innovative traffic management software solution known as the Virtual Transportation Operations Center, or VTOC®. A key enabling technology to this solution is the Internet. Internet-based software allows full networking capabilities of all desired ITS devices and systems. Most devices networked through this software have an Internet protocol (IP) address. A "virtual" transportation operations center – or VTOC – is then created. Operators with security access can operate all system devices (changeable message signs, variable speed limit signs, surveillance cameras, detection devices, etc.) from any computer, allowing control even in the absence of traditional TOC facilities and manpower.

Another key factor in the software system development is incorporating flexibility to talk to any number of devices with any given protocol (including, but not limited to, NTCIP). This is done by separating the device drivers from the core Advanced Transportation System Server (ATSS), and then creating individual device drivers that act as a liaison between the individual devices and the ATSS. The ATSS is the business logic layer of the system. The device drivers act as servers that provide services to the ATSS, and send commands back to the devices. By doing this, one can create an extremely robust ATSS while allowing full modularity and flexibility with the individual devices needed. The ATSS also requires no significant additional space and can be located in the existing facilities. If resources are limited, one ATSS can drive the system for multiple cities. (See Figure 2 for overview of VTOC system architecture).

In addition to the software implementation at the related TOCCs, the project included design and deployment of a variety of ITS devices to collect and disseminate real-time information, including the following example of devices in Duluth:

- 9 dynamic message signs using ADDCO's BRICK® Modular Message Sign System
- Three variable speed limit BRICK signs.
- Five retrofit overhead drum signs using the BRICK
- 18 surveillance cameras
- 7 Autoscope machine vision systems
- One ice detection system.

The system is communications-agnostic, working with any communication medium available as long as bandwidth needs are satisfied. Communication to and from these devices is variable. Fiber is used where it is available. In the absence of fiber, initial communications have been enabled via the telephone company's digital communications facilities. In Duluth, T-1 communications will be used for tunnel areas, with either T-1 or ISDN lines available for other freeway areas. Remote devices integrated with the system that do not require video bandwidth can use cellular CDPD where available. In some cases, regular POTS lines were available and utilized. DSL cabling was another medium that was tapped into for several of the devices. For others, the team deployed a spread spectrum network with repeaters to the final destination at the District 3 headquarters. It is important to note that the Internet IP protocol allowing networking is the key to the VTOC concept, rather than the actual communications medium used to transmit and receive data.

In St. Cloud, the project also included signal timing plans, transit dispatch, transit bus priority testing, an enhanced Traveler Information Network, signal improvements, and incident management plans. The systems in both Duluth and St. Cloud were designed with the flexibility to expand as new technologies evolve as well as changing needs of the areas. All products and services are scaleable for statewide implementation and transferable to other cities. The systems were designed to minimize future operations and maintenance costs, and can be operated by current employees at existing facilities.

Work Approach

As a design/build contract blazing new ground, the partnership formed work teams for all aspects of the project, including both public and private stakeholders for each area. A total of 13 work teams and two advisory boards were formed. ADDCO acted as the project manager and was responsible for the administration of the teams, meeting scheduling, and related documentation. The teams met as often as needed to define requirements and develop action plans, but at least monthly. All stakeholders in the team, including more than 25 public agencies and 10 private firms (Alliant Engineering, BRW (now URS), SRF, Castle Rock Consultants, SSI, Westwood Professional, Trapeze, Econolite, and Warning Lites (now URI)), were extensively involved in work planning efforts, requirements definition, compliance tracking, and testing.

The software working team defined the requirements and later detailed design documents for the VTOC software from scratch, based on Mn/DOT's specific needs. This is also true for the communications subsystems, DMS, and all other aspects of the project.

Training and testing were also highly considered, with one day test requirements for all initial field device installations, followed by more extensive 30-day tests, and finally a 30-day system test. For further assurance regarding system quality, Mn/DOT also hired a private evaluation firm that worked with the teams to openly address any issues.

Rochester TOCC Example

In the past 12 months, one of the TOCCs to come fully online was in Rochester, Minnesota, coinciding with a major four-year $232 million design-build (Roc52) reconstruction project at the intersection of two major trunk highways, USTH 14 and 52. The TOCC has been effectively monitoring and controlling traffic 24/7 during this reconstruction. Mn/DOT required an Advanced Traveler Management System that would effectively, efficiently, and reliably monitor and manage traffic on and near the

USTH52 corridor and related arterial system before, during and after the reconstruction. Mn/DOT also required that the TOCC and supporting ITS devices would integrate seamlessly into the existing State Patrol Dispatch center. The reconstruction project began in May of 2003 and will be completed by August of 2006. The corresponding TOCC in Rochester was made fully operational in time for groundbreaking, with ongoing enhancements to meet the project's traffic control and monitoring needs and manage day-to-day operations.

In preparation for the project, and in response to a Mn/DOT RFP, a team led by ADDCO, Inc. established the TOCC capabilities in the existing dispatch center.

The team equipped the center with three workstations in a local area network, with Windows NT and the ADDCO VTOC client installed on each, and a video server to disseminate digital video to each of the workstations, including the primary Advanced Transportation System Server (ATSS). This enabled immediate control and monitoring of team-installed field devices, including eight CCTV cameras and five dynamic message signs. The VTOC software was enhanced to include video recording, data archiving, and NTCIP compliance. The TOCC and VTOC also enabled additional device integration required by the design build contract, including integration of an additional seven CCTV and seven DMS, addition of in-ground loop detectors, conversion of the communication mode from wireless (spread spectrum radio and cellular) to fiber optic, and relocation and permanent installation of some devices.

Linking the TOCCs and the Twin Cities Transportation Management

The TOCCs also integrate well with the state's urban transportation system managed from the Regional Transportation Management Center serving the urban area of the Twin Cities. The TOCCs are also linked to the RTMC to provide a statewide capability in traffic management and traveler information.

RTMC operators with security access can operate all system devices (changeable message signs, variable speed limit signs, surveillance cameras, detection devices, etc.) from the center allowing control even in the absence of traditional TOC facilities and manpower. Through its two TOCC/VTOC workstations, the RTMC currently has access to each region's traffic conditions, with full center-to-center communications in the planning stages

Lessons Learned

Many new technological and institutional approaches were used on these projects. Stakeholders with different interests needed to work together to resolve problems for the common good. The design/build aspect of the projects was challenging at times, particularly with the VTOC software development. Creeping elegance, changing requirements, non-performance of subcontractors, and new technologies ultimately delayed the software significantly and cost ADDCO four times the original amount budgeted for their project contribution.

PR was an ongoing issue with the public as well, managing expectations for any installation disruptions, temporary system glitches, and education on what the new technologies meant to their travel. One new ITS device, the ice detector, ultimately didn't work as planned, forcing the team to pursue other technology avenues. Integration of the devices with the VTOC software also posed unforeseen technical challenges due to protocol issues and proprietary device software.

While the working teams wrestled with these and other issues, one of the key successes of the project was that ultimately the teams came through to resolve all obstacles. Communication was strong throughout the project, and absolutely vital to the project's success.

Current Status

The ITS deployments in the Duluth, St. Cloud, and Rochester TOCCs were a success in virtually every aspect. The revolutionary ITS technologies deployed have been seen by national and international visitors. These visitors recognize, as Mn/DOT, that rural and smaller urban areas face transportation challenges that require innovative and flexible solutions. As the volume of traffic serving these areas continue to increase, the transportation challenges continually change. The optimal solution to address current and future issues is a system that is flexible as well as expandable. In the case of Duluth and St. Cloud, the systems have been fully operational for more than a year with true benefits to the traveling public. In the case of Rochester, the system has greatly facilitated the mobility of travelers and incident response rates during a major reconstruction project.

Based on stakeholder requirements, the TOCCs' system is now being enhanced to include additional capabilities such as video recording. Additionally, based on the initial success of the system, Duluth's "sister city," Superior, Wisconsin, is now slated to begin a similar ITS deployment. Mn/DOT District 1 in Duluth is participating in the development of an ITS deployment plan for Wisconsin DOT District 8, which will include Superior. As Duluth-Superior is one urban area, stakeholders from both states appreciate the importance of an integrated transportation management solution across state and jurisdictional borders.

Future Implementations

Mn/DOT has expanded its ITS implementations to two more TOCCs in Marshall and Mankato, using VTOC for system software, a variety of communications media, with ITS devices tailored to their individual needs. More TOCC ITS implementations are planned to begin in 2005, bringing Mn/DOT closer to its statewide goal and Minnesota citizens faster, safer, and more informed travel.

Figure I: Duluth Problem Identification

Identified Problem Area	**Brief Description**
Weather	Diversity and rapid changes in weather including fog, icing, and high winds causing accidents and congestion.
Traveler Information	Need to improve traveler information collection and dissemination methods, as well as improve the timeliness of data, especially for road closures.
Variable Speed Limits/Traffic Control, Special Events and Enforcement	Need to vary speed limits based on weather and traffic conditions.
Communications/Integration	Lack of common communications and systems integration among agencies sometimes inhibits the flow of important information.
Incident Management/Emergency Response	Need to improve interagency response to incidents and allow for traffic diversion when required.
High Accident Rates	Need to enhance safety at high accident locations through improved information.
Tunnels and Bridges	Weather and lighting conditions in tunnels and along bridges causes traffic incidents.

Figure II: VTOC Architecture