An Evaluation of Philadelphia's Satellite Communications Demonstration Project – the Mobile Platform

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INTRODUCTION

The Philadelphia Satellite Communication Demonstration Project is a federally funded demonstration project to evaluate the effectiveness of using very small aperture terminal (VSAT) Ku-band satellite communications for traffic and incident management. The project was melded into PennDOT's traffic incident and management system (TIMS) program to facilitate a comparison of this technology to other communications media. The evaluation team for this nationally significant project is comprised of the Federal Highway Administration (FHWA), the Pennsylvania Department of Transportation (PennDOT), Urban Engineers, Inc. (Urban) – the prime consultant – and TransCore.

The VSAT-based closed circuit television (CCTV) system was designed to simultaneously compare it with a terrestrial-based copper and a fiber optic-based CCTV system. The VSAT system is comprised of two major elements: fixed cameras and a mobile platform. The mobile platform was designed to extend the coverage and visible area beyond the limits of the stationary CCTV cameras. Some specific uses are:

- Monitor traffic patterns and the effect of traffic control in construction zones,
- Monitor the impact of special events in the vicinity of major arena complexes, and
- Enhance PennDOT incident management ability by providing CCTV monitoring through a direct link between the incident location and the traffic control center located at the PennDOT headquarters office outside of Philadelphia.

This paper provides a description of the mobile platform, preliminary results of the evaluation, and conclusions.

PROJECT DESCRIPTION

The mobile platform is one of two main components of a communication system designed to compare applicability, reliability, and connectivity of VSAT Ku-band satellite communications with digital T-1 and fiber optic communications. The second

component includes four earth stations (camera sites) equipped with pole-mounted dish antennas twenty feet above the roadway surface and a CCTV camera. They are able to simultaneously transmit the same video image over independent terrestrial- and celestial-based communication links.

The PennDOT traffic control center (TCC) is located approximately 20 miles west of Center City and serves as the earth stations' mini-hub. It is this location where the earth stations are controlled and all traffic management activities are coordinated. The TCC is also the site where all video recorded by the mobile platform is relayed.

Mobile Platform System Design

The mobile platform consists of three major components that work together to form a system: the vehicle and its associated equipment, the TCC, and the communication link.

Vehicle and On-Board Equipment Description

The mobile platform is based on a GMC Vandura Model 3500 HD chassis. This vehicle was selected because of its commercial-type frame and, with a gross vehicle weight rating of 14,100 pounds, its ability to safely support the necessary equipment, accessories, and personnel. Other pertinent specifications and features of the vehicle and its on-board equipment include:

- an overall height (with the antenna and camera in the stowed position) of 12'-9" which allows the vehicle to maneuver under most overpasses
- collapsible dish antenna which can be automatically positioned to face the satellite
- pneumatically operated telescopic camera pole which can be adjusted to any height up to 40 feet
- an external lighting system to facilitate the process required to stabilize the vehicle, erect the antenna and camera, and acquire the satellite signal
- strategically placed amber strobe lights for safety
- dual cameras which permit viewing color images (using the color camera) during daytime conditions and black and white images (using the more light sensitive black and white camera) during low-light conditions

- local pan-tilt-zoom controller via panel mounted joystick

- receiver/driver unit housed within the electronic equipment rack allows pan, tilt, and zoom commands to be received and implemented

- 9-inch color monitors which allow the operator to view images that are being transmitted to the TCC

- a portable, hand-held VHS format camcorder used after the vehicle arrives at an incident or event scene and before the satellite link is established. The recorded images can then be remotely transmitted to the TCC or delivered to the TCC upon the vehicle return

- a time-lapse videocassette recorder (VCR) allows the operator to record camera images onto VHS format cassettes. The VCR also permits an operator to transmit images recorded by the hand-held VHS format camera described above

Traffic Control Center

The TCC is the site from which all traffic management activities in the Greater Philadelphia area are coordinated. The TCC, which also serves as a mini-hub for the satellite system, is the site that receives video images from the mobile platform. To facilitate the transmission of data and video to the TCC, the following elements were installed as part of the overall system:

- a Ku-band roof-mounted antenna equipped with a radio frequency (RF) unit and, for icy weather conditions, an electric deicer.

- a central VSAT modem to convert digital signals from the video signal encoder and the multiplexer to RF signals.

- a central multiplexer to multiplex and de-multiplex two 9.6 kbps channels and a 320 kbps channel. The 9.6 kbps channels are used for remote video encoder control and camera pan-tilt-zoom control. The 320 kbps channel is used for video image transmission only.

- a VSAT network manager which, using a dedicated PC desktop, assigns and controls the various cameras and the two leased space segments.

Additional equipment at the TCC includes eight video monitors, a time-lapse VCR, two control panels, etc. The video encoder-decoder (codec) units for this project matched the existing equipment to facilitate an accurate comparison. Doing so ruled out the codecs as being a reason for dissimilar video images.

Communication Link

The project specifications required that the contractor lease two space segments for a period of two years. Each space segment was specified at a total rate of 384 kbps for simplex video transmissions from the five camera locations, including the mobile platform, to the TCC and for duplex data communications for camera control and network management functions.

EVALUATION FINDINGS TO DATE

The evaluation period began in April 1996 and is now nearly complete. Midway through the evaluation a new satellite lease was arranged with a different provider to reduce operating costs. Changes to procedures for satellite acquisition required re-training of PennDOT personnel. So far, the evaluation team has deployed the mobile platform more than two dozen times during day and evening hours and to locations with varying traffic volumes and roadway conditions.

Evaluation of the mobile platform is being performed to determine its effectiveness under various incident management and traffic monitoring situations. Such issues as image clarity, driver reaction to the vehicle, vandalism, and security of the vehicle as well as the ability to establish a satellite link in various weather and physical environmental conditions are key subjects of the evaluation and will be assessed based upon the data collection during the evaluation period. The types of data collected and evaluated to date are described below.

Set Up Time

The time beginning when the mobile platform arrives at the scene to when data is first received from the unit at the TCC is known as the set-up time. The accessibility of the vehicle to an incident location can prolong set-up time by requiring additional time to find a location from which an incident can be observed. Surface type and slope can impact duration of platform leveling or even make deployment impossible. Since the mobile platform dish antenna has to be directed toward the satellite, certain adjustments to the vehicle angle are sometimes required. This could become a critical factor in urban areas with tall buildings and limited set-up space. Set up time has been observed to be approximately 30 to 40 minutes. While the platform is being set up, the camcorder can be used to record incident management activities for later viewing and debriefing of incident management personnel.

System Security

PennDOT personnel maintain a log of unusual occurrences related to the mobile platform. The log is used to record all breaches of security to the mobile platform. This log is reviewed by the project team on a regular basis to determine what effect, if any, the security breaches have on the operability of the vehicle and how such incidents can be prevented in the future. Security issues discovered early in the project have been resolved.

Frequency of Use and Applicability

The mobile platform has been deployed to incident sites where camera surveillance is not available. Once at these sites, the vehicle has served as an observation post from which the TCC personnel can assess the impact of the incident on traffic and implement any necessary mitigating steps. The mobile platform is deployed on the basis of a schedule and in response to incidents. The schedule is established monthly and typically includes two planned deployments per week to a variety of sites. The purpose for such a large number of deployments is to collect as much data as possible before the satellite lease period expires. Other mobile platform deployments, both conducted and planned, include construction sites (to view traffic maintenance and protection), special events, and traffic data collection.

System Reliability

System reliability is the ability of the mobile platform to operate successfully and without any downtime. Downtime includes mechanical and/or software failures and any transmission losses once a communication link has been established. To date the only significant mechanical failure with the mobile platform was associated with an auxiliary battery. This battery, which powers the on-board satellite equipment, was being prematurely drained while the vehicle was idle because the telescopic camera pole switch was being left in the "hold" position. This situation has been remedied no more significant recorded mechanical failures have occurred. Transmission losses are defined as a break or interruption in the communication link between the mobile platform and the TCC. Such interruptions would cause the blanking out of any video images at the TCC. To date, with no recorded failures, satellite transmissions have proven to be a reliable communication link.

Operating and Maintenance Cost

Cost data is being collected for the mobile platform. This information includes costs associated with staffing, routine maintenance, leasing, service calls (labor and material), fuel and training. This information will be included as part of the final report. To date the only readily available costs are those associated with the purchase of the fully equipped vehicle, the cost to retrofit the TCC with the satellite communication

equipment, and the monthly cost to lease each space segment. These costs are $470,000, $290,000 and $2,200 respectively.

CONCLUSIONS

To date, the mobile platform has proven to be a reliable vehicle that can support and enhance incident management efforts. The benefit of the mobile platform was demonstrated upon its deployment to the first incident location. Engineers at the TCC were able to visibly inspect the accident scene, have a "birds eye view" of the traffic back up and merge movements. The engineers noted that this information, which was videotaped, would be of use to the incident responders to better enable them to establish incident management procedures that would reduce the traffic impact.

The mobile platform is a highly complicated piece of equipment that requires significant training prior to use. The operator should have some background in physics, electrical engineering, and/or telecommunications to attain the optimal benefit of the vehicle.

The project team will continue to gather data on the mobile platform through the end of August 1998 after which time a final report will be prepared. This report will include a more detailed analysis of all the data collected, events encountered, and conclusions. Until then, this paper may be used as a discussion of the early findings of Philadelphia's mobile platform.

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