Division of Traffic Engineering

LEXINGTON'S COMPUTERIZED SIGNAL SYSTEM 1995

Introduction

Lexington is a growing city in the heart of Central Kentucky. The 1990 census showed a population in-excess of 225,060 people. The combination of closely guarded tradition and thriving development is one that requires very special attention. This is never more apparent than when dealing with the transportation related problems this can present. Among these problems is the management of congestion on the major arterials of the city.

During the 1980's, Fayette County licensed drivers increased by 14%, registered vehicles increased by 11% and vehicle miles traveled increased by 27%. The Richmond Road, Harrodsburg Road and Nicholasville Road corridors have experienced 25% - 40% increases in traffic volumes.

Project Background

The original contract to install the computerized Signal System in Lexington was begun in 1982. It evolved into a $2.5 million project and was completed in stages. The hardware, computer, communication interface and signal equipment upgrades were in place by late 1984. The final software was implemented in the spring of 1986. The major equipment malfunctions and software parameters were corrected by early fall 1986.

The original computer currently controls 294 signalized intersections in Lexington, with greater than 99% consistently on-line. There are only a few systems in the country operating at this level of sophistication and, efficiency. The signals currently run eight different timing patters on most arterials during an average weekday. These plans are designed to accommodate morning and afternoon peak periods, as well as the various off-peak traffic patters throughout the day.

Hardware Functions

The computer communicates with the signals by sending a command to and receiving a response from each location every second each day from 5:30 am to midnight over telephone lines. The computer has been programmed to recognize each of the several signal equipment designs. With this information the signal timing is controlled by pre-defined timing plans to accommodate the variable traffic patterns. The system is off-line from midnight to 5:30 am each day with the exception of a detector rest period of 3:00 am to 3:15 am. During this time all loop amps are reset by sending a command to each phase for this pre-timed period.

Central Computer

This central computer is a Perkin-Elmer 3210 mini-computer acquired at a cost of $100,000. A backup system allows for continuous system operation when the other disk drive is down. It is linked to the local intersections over more than fifty separate telephone lines. Each line can control up to six intersections. There is also a map display which provides current status information on the 292 intersections at a glance. It can also display surveillance information such as traffic volume speeds, fire routing, railroad crossing, etc.

The computer is controlled through several terminals located in the Traffic Management Center, at the Operations facility on Old Frankfort Pike and through remote access from portable terminals. This provides a network of control and information to those working with the system.

Field Equipment

Every intersection is controlled locally within a cabinet on the street corner. This cabinet contains several components totaling an average of $10,000 in value. A new installation can cost $50,000 when done by contract. The actual controller consists of a complex timer which is either actuated, responding to local traffic, or fixed-time, timing phases without regard to traffic levels (mostly in the downtown area). Each intersection has a controller with 8 specific number of phases appropriate for that location.

The Lexington-Fayette Urban County Government has an ongoing program to upgrade traffic signals form electro-mechanical to solid state controllers. Of the 292 traffic signalized intersections in Lexington-Fayette County there are a number of older, less dependable controllers in those intersections. The addition of then newer controllers will increase system safety and efficiency, thereby reducing congestion, and improving air quality. Since 1986, there have been 208 upgrades, or 72% of the total system. The remaining intersections will be upgraded during the next few years to provide for a completely downloadable system. The importance of such a system to the Lexington-Fayette County area is enormous. The efficiency of the current system is only as good as the communication link. If these upgrades are made, communication can be severed and the system will still operate as if everything is normal. Because the controllers will operate on a schedule which has been downloaded to them to address the specific traffic conditions within their area of coverage. The Division will continue the installation of type 170 controllers with downloadable WAPIII software.

A communications unit provides the interface between the other controllers and the traffic computer. Commands are received from the central computer and interpreted by the communication unit for the controller. Responses are then returned to the computer reflecting the actual phases and durations. The new 170 controllers have built in communication units. A conflict monitor is detected, the intersection will go to flashing operation in less than one-half second. The conflict monitors are tested annually.

Detectors are imbedded in the pavement at all approaches to inform actuated controllers when and for how long vehicles are present. A phase is skipped when there are no vehicles present. If vehicles are present and the phase if served, it is terminated when vehicle demand ceases. Detection is assured by pulling up to the wide, white stop bar.

Surveillance System

The surveillance system is comprised of over 1,400 vehicle detector loops located on major and minor arterial roadways, providing detailed data on traffic volumes and speeds. This information is used to determine when signal timing patters should be changed, assist in clearing ramp or railroad activity congestion, and for collecting roadway data. In addition, there are 150 locations where system loops bring back occupancy, traffic volumes and speeds.

There are 29 television cameras which currently provide color video feedback of real time traffic conditions at strategic locations in Lexington. The Division of Traffic Engineering remotely controls the cameras for pan/tilt/zoom operations from the traffic control room. The cameras provide real-time traffic information to the Division's Traffic Management Center. The controller allow other government divisions to access the cameras from remote locations for maintenance, snow and ice removal activities, public safety needs, etc. The local state District Highway Office, Lexington-Fayette Urban county Government Police and Fire Dispatch Centers are also capable of monitoring Fayette County traffic. Two cameras are placed at either end of the Clays Ferry Bridge, one inFayette County and the others in Madison County. Video is transmitted from Madison County toFayette County using wireless technology where both video signals are converted to data and transmitted via telephone lines to the Lexington Traffic Management Center. The Center receives the data and converts it to video. The video is transmitted via cable link to Lexington Police and Fire Communication Centers and the Kentucky Department of Highways, district 7 Office. Vehicle detection software called MOBILIZER TM is used to analyze the video data to determine possible incidents and notify emergency response personnel (Poke and Fii) for dispatch. MOBILIZER TM wide area fusion TM system processes traffic data obtained from multiple sensors using propriety third generation tracking technology to obtain dynamic wide area traffic information like flow, densities, merging and turning motions, queue formations, and travel of link times in real time over a large geographical area. Vehicle classification is another output of the system. "View Image Processing/Motion Detection" equipment is being tested for video vehicle detection and traffic counting. The Division is researching several lowest home security devices to improve the reliability of detection, and to move to more advanced testing for the detection of vehicles for system input data to the computerized traffic signal computer.

Traffic Information Network

In November, 1990, the Lexington-Fayette Urban County Government initiated a motorist information network called Traffic Information Network (TIN). This provides traffic information via

radio, television and newspaper to the Lexington-Fayette County area and surrounding counties. The TIN operates as a public service to the community.

Currently, this Network operates Monday through Friday, from 6:00 to 9:00 am. and from 4:00 to 6:00 pm. (peak travel times). Traffic information is gathered from various divisions within government and other agencies, then provided to the media. The flow of traffic information is described by the TIN and Lexington Traffic information System graphics.

There are sixteen radio stations and four television stations providing traffic information on road construction, lane blockages, accidents, fire emergency runs, traffic signal malfunctions, weather related emergencies and other activities affecting traffic flow. This information can also be accessed via telephone to a digital announce unit and on a local government cable station. Media agencies review this information and provide it to their listening and viewing audiences which cover forty-three counties in central Kentucky.

The TIN resources include cameras, color monitors, computer system map and terminals, TIN work station, a national weather service data downlink and read only access to the Police and Fire communication centers.

The Division of Traffic Engineering produces a two hour daily traffic program in video format on a local government cable television channel each weekday morning from 6:30 to 8:30 am. This program presents congestion-related traffic information such as accidents, lane blockages, construction activities, traffic volumes, safe-driving tips, traffic safety tips, general Division information and live cameras. This gives would be motorist up-to-date information so that they can plan their work commute or errands wore getting into their vehicle.

Maintenance

The Division's Operation's staff has maintained the field equipment of the system, as it progressed toward becoming operational until the present. This includes a multitude of electronic functions and troubleshooting required by this very complex system. The staff has several technicians who have become proficient in the operations of the control equipment and its interface with the computer. This has meant that they have learned to use state-of-the-art technology in order to analyze problem situations effectively.

The computer and peripheral equipment is under maintenance agreement with the manufacturer. We rely on an outside contractor to replace damaged detector loops. New signal construction is also done by outside contract so that the Division's staff can concentrate on providing a high standard of system maintenance. The technicians use laptop computers linked to intersection controllers for much troubleshooting in the field.

Software Functions

Every intersection must be defined as to its signal configuration and detection capabilities for the computer to interact properly with the field equipment. This intricate database has been established detailing the myriad of variables on equipment and related data throughout the signal system.

High Resolution Colorgraphics

The High-Resolution Colorgraphics software provides a graphic representation of all 292 intersections in the traffic control system. This information can be viewed on a city-wide basis, section basis or an individual intersection basis.

The city-wide display presents a city map of the entire traffic system where each signalized intersection is depicted as a dot. The city map is automatically displayed when the colorgraphics software is initiated.

In the section display areas of the city map may be zoomed in on to enlarge a particular section. This display is dynamic and shows coordination along a particular corridor, such as Nicholasville Road or Richmond Road. The zoomed in area now depicts intersections as concentric circles containing information showing intersection status on the outer ring and intersection phasing on the inner ring.

The individual intersection display depicts real-time activity for each intersection in the traffic system. In this impressive display, each intersection has been geometrically drawn and contains dynamic, real-time indicators displaying intersection status, vehicle phasing and timing, pedestrian phases and detector information. This display may be accessed from the city map or the section display.

The colorgraphic software is currently being used on a 386/33 mhz personal computer and is mouse-driven but future plans are for it to be used in conjunction with a projection screen television.

Timing Plans

Each intersection is assigned timing plans which provide that location with data to control the cycle length, phase durations and coordination among adjacent intersections. This permits traffic to be progressed in the major direction and each phase to be timed according to the demand for that movement. Different plans are implemented to correspond to the traffic patterns at that particular time of day.

Timing plans are established for the arterial to accommodate eight different conditions each weekday. These plans move traffic differently to satisfy the pattern in effect for morning, noon, and evening peak periods, mid morning, mid-afternoon and early evening off-peak periods, and morning and evening rushes. The greater the traffic volumes, the longer the cycle length in most cases. This is done to move the traffic in the major direction of travel more quickly.

Weekends have a different set of plans which are generally shorter cycles, but attempt to accommodate the two-way progression and heavy side street movements associated with these times.

The immediate downtown area is comprised mostly of fixed-time signals which do not respond to traffic, but operate from one phase to the next strictly on timing. The pattern is the downtown is constant to provide movement form the one-way, grid system in place. This pattern is varied slightly for the morning and evening peak periods, when the flow on some two-way streets shifts major direction.

Special Patterns

Several events in Lexington lend themselves to special treatment by the signal system. The signals in the vicinity of the major shopping malls are adjusted to accommodate the traffic patters that occur as the malls close each day. These patterns are changed more drastically during the holiday shopping.

The Division implements special plans to disperse traffic following events at Rupp Arena and Commonwealth Stadium. These are primarily basketball and football games where savings are achieved which benefit the Division of Police significantly in overtime expenditures. The traffic is progressed away form the site more quickly, permitting the use of fewer officers for less time in the street following the events.

There are also locations where a few intersections may be timed differently to account for industry shift changes. These are handled on an individual basis as needed for the traffic.

Data Collection

A comprehensive traffic counting system was begun in January 1996. Traffic is counted at every signalized intersection at least annually for different periods of the day. The counts are made with computerized data collectors and subsequently uploaded to a microcomputer where they are converted for several uses. The data are reformatted for input into the traffic system where timing plans for the signal system are generated. These plans then be downloaded to the system and made operational immediately. This process allows the Division to maintain signal timing that accurately reflects current travel patters, modifying cycle lengths and phase durations as needed.

This information is also used to analyze intersection capacities, check for signal or phase warrants and for dissemination to other agencies. These data are used to make decisions on roadway design and as input to various research activities. The data are shared with state and other local agencies.

Traffic Responsive

The computerized signal system has the capability torespond not only to pre-determined timing plans, but to traffic levels that currently exist. The implementation of this traffic responsive function allows the traffic to dictate when the morning and evening rush plans go into operation.

The system also has the capability to alter phase durations at an individual intersection based on the amount of traffic on each approach and the previous cycle. The effectiveness is maximized where the specific intersection has no 'minor' street and is somewhat isolated in the system.

System Efficiency

The Division is constantly striving to improve the efficiency of the traffic system. As an example, the left turn phasing at twenty-one intersections was recently upgraded form protected only to protected / permissive. This allows left turns to be made with protection under an arrow and permissively under a green ball for more efficiency. The Division is working with the State toward more conversions on their system.

The operations staff continues to upgrade older equipment and enhance existing equipment to maintain the high level of effectiveness provided by the traffic system

Planned Improvements

The Division is working with the Division of Fire to develop afire routing system. Their control dispatch will be able to implement pre-defined signal patters within a few minutes of a call to clear traffic ahead of the fire run.

There are 150 locations where the system monitors traffic volumes and speeds 24 hours each day. This information will soon be integrated into the system capabilities to respond to changing traffic levels as they occur.

The system surveillance will be utilized to clear traffic that has backed up because of an incident, a train crossing or on a ramp from a controlled access highway. This can be done by extending a particular phase automatically.

The Division has been using a laptop computer with a cellular telephone in order to have a system terminal with the maintenance technician in the field. This will allow the technician to monitor, analyze and repair signal malfunctions from his vehicle at the site of a signal problem.

Capacity

The sophistication of the signal system is impressive. However, it can only maximize the efficiency of the existing roadway facilities. The capacity of the highway is a more critical factor in traffic congestion. Recent studies on several of Lexington's major arterial have shown significant increases in traffic in just the last two years and many are over capacity. The implementation of the signal system during this same time period has offset some of this growth. However, with the signal system working perfectly, congestion will still occur where there are more vehicles than lanes to carry them.